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EXECUTIVE COMMITTEE
SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH
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President:

Prof. Peter Burkill
Mount Clogg Farm
Shaugh Prior
Plymouth PL7 5HA
UNITED KINGDOM
E-mail: peter.burkill@plymouth.ac.uk

Secretary:

Dr. Mary (Missy) Feeley
ExxonMobil Exploration Company
P.O. Box 4778
GP8-896
Houston, TX 77210-4778
USA
E-mail: missy.feeley@exxonmobil.com

Past President:

Prof. Dr. Wolfgang Fennel
Baltic Sea Research Institute
Seestr. 15
Rostock 18119
GERMANY
E-mail: wolfgang.fennel@io-warnemuende.de

Vice-Presidents:

Prof. Satoru Taguchi
Department of Environmental Engineering for Symbiosis
Soka University
1-236 Tangi-Cho, Hachioji, Tokyo 192-8577
JAPAN
E-mail: staguchi@soka.ac.jp

Dr. John Volkman
Marine Biogeochemistry Program
CSIRO Marine and Atmospheric Research
GPO Box 1538
Hobart Tasmania 7001
AUSTRALIA
E-mail: johnkvolkman@gmail.com

Dr. Corina Brussaard
Royal Netherlands Institute for Sea Research, NIOZ
PO Box 59
1790 AB Den Burg, Texel,
THE NETHERLANDS
E-mail: corina.brussaard@nioz.nl

Ex-Officio Members:

Dr. Mark J. Costello (IABO)
Leigh Marine Laboratory
University of Auckland
PO Box 349
Warkworth 0941
NEW ZEALAND
E-mail: m.costello@auckland.ac.nz

Dr. Eugene Morozov (IAPSO)
P.P. Shirshov Institute of Oceanology
Russian Academy of Sciences
36, Nahimovski prospect
Moscow, RUSSIA, 117997
E-mail: egmorozov@mail.ru

Dr. Athena Coustenis (IAMAS)
LESIA (Bat. 18)
Observatoire de Paris-Meudon
5, place Jules Janssen
92195 Meudon Cedex
FRANCE
E-mail: athena.coustenis@obspm.fr

Co-opted Members:

Dr. Wajih Naqvi
Director
CSIR-National Institute of Oceanography
Dona Paula, Goa 403 004
INDIA
E-mail: naqvi@nio.org

SCOR Secretariat:

Edward R. Urban, Jr., Executive Director
College of Marine and Earth Studies
Robinson Hall
University of Delaware
Newark, DE 19716
USA
Tel: +1-302-831-7011
E-mail: secretariat@scor-int.org

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SCOR
College of Earth, Ocean and Environment
003 Robinson Hall
University of Delaware
Newark, DE 19716 USA
Tel: +1-302-831-7011, Fax: +1-302-831-7012, Internet: secretariat@scor-int.org
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SCOR Proceedings, Volume 50
REPORT OF THE 2014 ANNUAL SCOR MEETING

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XXXII SCOR GENERAL MEETING

Bremen, Germany
15-18 September 2014

1.0 OPENING

1.1 Opening Remarks and Administrative Arrangements

SCOR President Peter Burkill welcomed participants to the XXXII SCOR General Meeting (Appendix 1). An important objective of this meeting is to review proposals for new working groups and select which ones will be approved by SCOR to start in 2015. Burkill thanked the University of Bremen and its Center for Marine Environmental Sciences (MARUM) for hosting the meeting. He introduced Dr. Michael Schulz, the director of MARUM.

Dr. Schulz welcomed meeting participants to the University of Bremen, which was established in 1971. MARUM employs 350 people, mainly working on climate science and seafloor dynamics. A key focus area for MARUM is developing and operating facilities such as ROVs, AUVs, and remotely controlled underwater drill rigs. Forty percent of the users are external at the international level. The program on Thursday will provide an overview of marine sciences, reviewed by representatives from several different marine institutions in Germany. Schulz noted that the Oceanography Commission of Germany met at MARUM the previous week.

Peter Burkill opened a time of remembrance of SCOR colleagues who had died in the past year. Daniel Lluch-Belda was one of the co-chairs of SCOR/IOC WG 98 on Worldwide Large-scale Fluctuations of Sardine and Anchovy Populations, which produced one of the most-cited papers from a SCOR working group. Shirley Jeffrey played a major role in SCOR/UNESCO WG 78 on Determination of Photosynthetic Pigments in Seawater, which produced the 1997 book *Phytoplankton Pigments in Seawater*. This book became a standard in laboratories conducting pigment analyses. Dr. Jeffrey also helped stimulate the complete revision of the book in 2011 as *Phytoplankton Pigments: Characterization, Chemotaxonomy, and Applications in Oceanography*. Toshiro Saino helped guide the Joint Global Ocean Flux Study (JGOFS) and led Japanese involvement in JGOFS.

1.2 Approval of the Agenda

Additions or modifications to the agenda as distributed may be suggested prior to approval of the final version. Peter Burkill asked participants for any requests for changes in the agenda (Appendix 2). Ed Urban noted that the order of items in the block agenda was slightly different from the order in the background book sections to accommodate the schedules of speakers.

Burkill asked for meeting participants to introduce themselves.

1.3 Report of the President of SCOR

Peter Burkill briefly reviewed his activities for SCOR since the SCOR Executive Committee Meeting in November 2013 in Wellington, New Zealand, in his role as SCOR President. The first activity related to the Second International Indian Ocean Expedition. In March 2014, Burkill participated in the third meeting of the IOC Reference Group in Mauritius, which included about 30 participants, mostly from western Indian Ocean countries. Also in March, he organized a 2-day workshop near Plymouth to assemble the UK ocean science community to develop interests in IIOE-2. From March through September, Burkill participated in numerous discussions with IOC representatives and scientists from India regarding sponsorship of the 2015 symposium in Goa, the membership of the International Symposium Planning Committee, and the idea of a SCOR IIOE-2 Science Plan Development Committee. Burkill reported on the negative outcome regarding SCOR's application to become an official observer to the London Convention/London Protocol. SCOR withdrew its application after the approval was blocked for political reasons. Another major activity of Burkill on behalf of SCOR in the past year was in relation to Future Earth, to help smooth the transition of the IMBER and SOLAS projects to co-sponsorship by Future Earth and development of a Memorandum of Understanding between SCOR and Future Earth. In the coming year, much of Burkill's work on behalf of SCOR will continue to focus on SCOR's relationship with Future Earth and preparations for the Goa Symposium, in his capacity as a co-chair of the International Symposium Planning Committee.

1.4 Report of SCOR Executive Director

The Executive Director will report on his activities for SCOR since the 2013 SCOR meeting, and on the current condition of SCOR. Ed Urban reported that most countries had paid their 2014 dues and it appeared that two new working groups and some shorter-term activities could be started in 2015. SCOR maintains a healthy surplus to counteract any future shortfalls in dues income. Most working groups continue to make progress toward fulfilling their terms of reference on time, although a few groups have postponed their meetings. Several SCOR-sponsored international research projects are reaching the end of their 10-year lives. Two (SOLAS and IMBER) will be requesting extensions. GEOTRACES continues to deploy several national research cruises each year. The IQOE project is working on the response to review for its Science Plan. There is an uncertainty in ability of partner organizations to contribute adequate finances for joint projects, due to transition from IGBP to Future Earth and significant cut in funding by IOC for joint projects. The SCOR Secretariat moved locations on the University of Delaware campus in early 2014, to the main building of the College of Earth, Ocean, and Environment. SCOR continues to improve the visual image of SCOR products and is trying new means of outreach, such as a booth at Ocean Sciences 2014 and a Twitter account. Urban updated the figures on participation of developing country and female scientists on SCOR groups. The percentage of developing country scientists continues to vary around about 23% and the percentage of female scientists remains slightly above 30%. At the time of the meeting, Urban had issued 8 Tweets and the SCOR account had 18 followers.

Peter Burkill noted that SCOR is making efforts to improve its image among younger, “up and coming” scientists via the Twitter account. Paul Myers asked whether there was any thought to add younger scientists to Executive Committee. Ed Urban responded that there was a discussion at the Executive Committee meeting yesterday to assess the age structure of members of SCOR

working groups and there have been discussions of adding a younger scientist as a Co-opted member of the SCOR Executive Committee.

1.5 Appointment of an *ad hoc* Finance Committee

The SCOR Constitution requires that a Finance Committee be appointed at every SCOR Annual Meeting. The committee must consist of at least three Nominated Members of SCOR who are not members of the Executive Committee. The Finance Committee reviews the administration of SCOR finances during previous fiscal year and the current year, and proposed a budget for 2015 activities and dues for 2016. The Committee reported to the meeting under agenda item **8.3**. The membership of the 2014 Finance Committee included Colin Devey (Germany), Karen Heywood (UK), Motoyoshi Ikeda (Japan), and Paul Myers (Canada).

1.6 2014 Elections for SCOR Officers

The SCOR Secretary and all three Vice-President positions were open for nominations for the 2014 elections. One current Vice President (Corina Brussaard) was eligible to be re-elected to another 2-year term. Five candidates were nominated by national committees; all nominations were for Vice-President positions. The new SCOR officers were announced and commenced their terms at the close of the meeting:

- Corina Brussaard (Netherlands): Secretary (agreed to move from Vice-President position)
- Sergey Shapovalov (Russia): Vice President
- Sun Song (China-Beijing): Vice President
- Ilana Wainer (Brazil): Vice President

1.7 Capacity-Building Presentation

Venu Ittekkot presented the results of the 14 Sept. meeting of the SCOR Committee on Capacity Building. He began by listing the current SCOR capacity-building activities:

- SCOR Visiting Scholars
- Regional Graduate Networks for Ocean Sciences
- POGO-SCOR Visiting Fellowships for Oceanographic Observations
- Travel Grants
- Portal to Ocean CB activities
- Ocean Summer Schools Portal (IODE)
- Publications
- Meetings to coordinate international ocean CB activities

Three SCOR Visiting Scholars were appointed in 2014. Halima Kiwango (Tanzania) went to South Africa/Kwazulu Natal to mentor on the topic of eco-hydrology and bio-hydrodynamics of coastal ecosystems. Prasanna Kumar (India) taught physical oceanography at the University of Dhaka in Bangladesh and mentored graduate students there. Marcia Moreno-Baez (USA) taught and mentored students in Argentina on participatory geographic information systems and the application of geospatial technology to collect local knowledge from fishers.

The regional graduate network of oceanography concept is still being explored, with special attention focused for the next few years on southern Africa and the Indian Ocean region.

SCOR provided partial or full support for three POGO-SCOR Fellowships for Operational Oceanography in 2014: Ammamkuzhiyil Smitha (India) worked in the United Kingdom to learn satellite data processing, interpretation and the modelling of primary production. Cozzolino Ezequiel (Argentina) worked in the United States to obtain advanced training in the processing of remote sensed oceanographic data. Liu Zhiyu (China) worked in France to learn methods to study internal wave submesoscale eddy interactions.

In terms of travel support for developing country scientists, funds were allocated by the SCOR Committee on Capacity Building for the following meetings since the 2013 SCOR Annual Meeting: Gordon Research Conference on Interactive Effects of Multiple Global Change Variables, Margalef Colloquium, Challenger Society Conference, Workshop on the Second International Indian Ocean Expedition Research Plan, SCOR-relevant sessions at 2014 PICES annual meeting, the International Conference on Harmful Algae 16, the symposium on the Effects of Climate Change on the World's Ocean, and the workshop of SCOR WG 139 on Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean. The Committee on Capacity Building recommended funding for the following additional meetings: 9th International Flatfish Symposium, SOLAS Open Science Conference, SCOR-relevant sessions/workshops at the 2015 PICES Annual Meeting, IOCCP Summer School, IIOE-2 Symposium, and training on Ocean Governance: Policy, Law and Management. These recommendations were approved by participants in the SCOR General Meeting.

Venu Ittekkot also mentioned a form of SCOR capacity building that is not always recognized, the participation of scientists from developing countries and countries with economies in transition in SCOR activities. Scientists from Argentina, Brazil, China, Malaysia, Peru and South Africa are involved in SCOR-sponsored scientific research projects (GEOHAB, IMBER, SOLAS, GEOTRACES). Scientists from Brazil, Chile, China, India, Iran, Namibia, Russia, South Africa, and Ukraine are involved in SCOR working groups.

Ittekkot proposed some potential capacity-building activities that could be included in the IIOE-2:

- Training Programs in cooperation with IOC (e.g., Regional Training Centers in China, India & Iran)
- Participation of young scientists and students in IIOE-2 Cruises
- Offer of research projects leading to Master's/Ph.D. Theses related to IIOE-2 research
- IIOE Theme Workshops in Indian Ocean Rim nations
- Training cruises on ships of opportunity (e.g., ships in transit)
- Global Ocean Capacity-Building Meeting in the Indian Ocean Region?

It will be important that IIOE-2 capacity-building activities focus on elements of the IIOE Science Plan and meet national (regional) needs and priorities.

Other recommendations from the Committee on Capacity Building include the following:

- Discuss with POGO the POGO-SCOR Fellowships and initiation of a new SCOR-POGO-PICES Continuous Plankton Recorder Program
- Seek support of national representatives to disseminate information on capacity building-related activities
- Ensure wide and timely distribution of IIOE Research Plan among Indian Ocean rim nations
- Ensure sharing of SCOR capacity-building actions and experience among oceanographic community (e.g., publications)
- Consider focusing SCOR funding/sponsoring to participation by countries that may not have existing oceanographic programs

Ed Urban added that the deadline for new SCOR Visiting Scientists is 1 November 2014. SCOR accepts applications from scientists interested in serving as teachers and mentors, and from potential host institutions. SCOR also matches interested scientists with institutions.

Hal Batchelder noted that Kurt Hanselmann has been remarkably resourceful with only a small SCOR investment. Venu Ittekkot responded that it is important to get more national investments into the Visiting Scholar Program. Peter Burkill asked whether IOC would be interested in investing in this program. Henrik Enevoldsen from IOC responded that SCOR and IOC already have a partnership in relation to capacity building. IOC is updating its capacity-building plan, which will be complementary to SCOR activities, and invites SCOR to participate in development of the IOC capacity-building program as part of broader partnership with other organizations. IOC has proposed another capacity-building strategy meeting similar to one held in 2010 in Bremen, Germany to take place in the near future. Ittekkot responded that SCOR should participate in revision of IOC's capacity-building strategy. Ed Urban added that SCOR maintains good communication with other organizations and combines efforts with other organization, when appropriate. Peter Burkill added that SCOR welcomes participation with IOC on capacity building and asked about the next steps. Henrik Enevoldsen responded that IOC would like to see continued involvement of SCOR in this process so we should continue discussions. Ittekkot added that each organization has its own strengths that may not be leveraged effectively. A single strategy, which includes each of these organizations with clear lines of focus, would be beneficial. Enevoldsen agreed that clear lines of responsibility need to be defined and communicated. Bernard Avril noted that IMBER developed a report of capacity building efforts which is integrated with SCOR efforts.

1.8 Second International Indian Ocean Expedition

Raleigh Hood provided an update about the development of the IIOE-2 Science Plan. He began with a brief account of the history of the development of the idea for the IIOE-2. Discussions began between Ed Urban and Hood at the IMBER SSC meeting in Marseilles in April 2011, and continued at the SIBER/IOP/IRF meeting in Chennai, India, in July 2011. The initial idea was focused on the idea of a 50th Anniversary Symposium, but it was learned at that time that some nations (e.g., Australia) were seeking funding to re-occupy some transects that had been a part of their IIOE work. An eastern Indian Ocean upwelling research initiative was proposed at the same

time as part of the IIOE-2.

In October 2012, it was suggested at the SIBER/IOP/IOGOOS/IRF meeting in Cape Town, South Africa, that a “Reference Group” be formed to convene meetings to explore the IIOE-2 idea. The first IIOE-2 Reference Group meeting was convened in Hyderabad, India, in May 2013, hosted by INCOIS. A symposium, summer schools, repeat lines, science questions, and research initiatives were discussed at that meeting. The second IIOE-2 Reference Group meeting was convened in Qingdao, China in November 2013, hosted by FIO. The science and societal drivers emerged at that meeting. The need for a western Indian Ocean research initiative (WIOURI) was discussed. The third IIOE-2 Reference Group meeting was convened in Mauritius in March, 2014, hosted by the Mauritius Oceanographic Institute. Planning for a WIOURI was initiated.

India formed and convened a national IIOE 50th Anniversary Planning Committee meeting in April 2013. IIOE-2 planning workshops and meetings were convened in Germany, United Kingdom, and the United States in January–March 2014.

A “decision” on the IIOE-2 was adopted by the IOC 27th General Assembly in Paris in June 2013. A “resolution” supporting the IIOE-2 concept was adopted at the 47th IOC Executive Council Meeting in June 2014, including plans to form an IOC IIOE-2 Interim Planning Committee.

SCOR formed a Science Plan Development Committee in April/May 2014. A draft IIOE-2 Science Plan was presented at the SCOR SPDC meeting in Bremen, Germany, 12-13 September 2014.

Hood then gave a summary of the content and status of the draft IIOE-2 Science Plan, including revisions made as a result of the planning meeting the previous week. The plan includes sections on general and historical background, scientific background and motivation (including physical oceanography and atmospheric science drivers, biogeochemical and ecosystem science drivers, and societal drivers), scientific themes, data and information management, and training and education. The scientific themes included the following:

1. Anthropogenic impacts
2. Boundary current dynamics, upwelling variability and ecosystem impacts
3. Monsoon variability and ecosystem response
4. Circulation, climate variability and change
5. Extreme events and their impacts on ecosystems and human populations
6. Unique geological, physical, biogeochemical and ecological features of the Indian Ocean

Hood concluded his presentation by noting additional accomplishments and action items from the Bremen SPDC meeting the week before. The meeting compiled current and planned research during the IIOE-2 time frame (2015 – 2020) for many countries and converted this information into a common format. Additional countries were identified where IIOE-2 still needs to capture this information and individuals were tasked to gather the information. The list of research activities will be maintained as a living document on the SCOR Web site. These activities will

constitute the initial phase of the IIOE-2. Meeting participants discussed and developed new ideas and recommendations to revise and finish the capacity building and data management sections of the Science Plan. They agreed on a timeline for the completion of the plan.

Peter Burkill asked for questions. It was asked whether the IIOE-2 will look at sea level rise. Hood answered that this was not mentioned in the Science Plan currently. It was asked how input could be provided to the Science Plan. Input is welcome from anyone and should be submitted to Raleigh Hood. Peter Burkill added that SCOR will lead the review process for the Science Plan which will include a public comment period. The Science Plan Development Committee includes members from the IMBER and other project communities. The northwest part of Indian Ocean is not politically stable, so IIOE-2 will attempt to engage countries in that region to help.

Nick d'Adamo presented remarks on behalf of IOC. He noted that IOC would like to thank SCOR for leadership and coordination of IIOE-2. SCOR and IOC need to continue to work together to bring this project to fruition. IOC would like to invite SCOR to nominate two members to join the Interim Planning Committee. Peter Burkill noted that the SCOR Executive Committee had decided to nominate him and Raleigh Hood. Ed Urban was tasked with sending a formal letter to IOC with these nominations. D'Adamo noted that there will be an IIOE-2 agenda item for the IOC General Assembly meeting in June 2015. SCOR should work with IOC on development of a capacity-development strategy for the IIOE-2.

Satheesh Shenoi provided an update on planning for the 50th Anniversary Symposium at the National Institute of Oceanography and completion of the IIOE, which will be held in Goa, India on 30 November-4 December 2015. India will financially and logistically support the symposium. They expect a large attendance.

India will also offer ships and equipment for the IIOE-2. Capacity building in terms of data management can be provided at the national data center, which also includes a regional training center.

A symposium on Indian Ocean Dynamics and Biogeochemistry has been proposed at the IAPSO Assembly in June 2015.

Peter Burkill noted that IIOE-2 is a major activity for SCOR, co-sponsored with IOC and IOGOOS. IOC led Reference Group meetings, chaired by Nick D'Adamo and Raleigh Hood. SCOR has led the Research Plan Development Committee, chaired by Raleigh Hood. IOC is leading the Interim Planning Committee (with SCOR and IOGOOS), which will develop the IIOE-2 implementation plan. The dates for the International Ocean Science Symposium in Goa, India are set for 30 Nov.- 4 Dec. 2015. India, SCOR, and IOC are co-sponsoring this meeting. India is hosting the Web site for the symposium.

Michael McPhaden noted that the United States is interested in IIOE-2. NOAA has undertaken a significant amount of work in this region in the last few years and is investing in the observing system and tsunami early warning system. The United States can help support and promote the IIOE-2. NOAA is developing a budget initiative for 2017 for the duration of IIOE-2, including expanding the measurement of biogeochemical parameters. NSF and the U.S. Department of

State have also expressed interest in the initiative. Ed Urban added that there are activities planned to expand communication of IIOE-2 to broader community within the United States, such as a Town Hall session and side meeting at the December 2015 meeting of the American Geophysical Union (AGU).

Bernadette Sloyan added that the GO-SHIP project is active in the Indian Ocean, including U.S.-funded lines there. There is discussion with Japanese colleagues about supporting long repeat lines, with a 10-year repeat. GO-SHIP would like to extend western and southern boundaries of the lines and build up the capabilities for biological observations.

1.8 International Commission of History of Oceanography (ICHO)

Ed Urban reported that ICHO has contacted SCOR to explore cooperative activities, including in relation to the IIOE-2. Several groups are interested in the history of geophysics and oceanography. Mike McPhaden noted that there is a section of AGU that focuses on the history of geosciences.

2.0 WORKING GROUPS

2.1 Disbanded Working Groups

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

WG 132 group is still producing a variety of papers based on its work, which acknowledge SCOR support.

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

WG 136 has completed its work and was disbanded. The group provided a final report to the meeting regarding the Chapman Conference they led in South Africa in October 2012 and on continuing efforts to establish an observing system for the Agulhas Current System.

2.2 Current Working Groups

The Executive Committee Reporter for each working group (or group member) presented an update on working group activities and progress, and recommendations on actions to be taken. Working groups expire at each General Meeting, but can be renewed at the meeting and can be disbanded whenever appropriate.

2.2.1 SCOR WG 134 on The Microbial Carbon Pump in the Ocean

Ed Urban noted that this working group was formed in 2008 and is planning one final meeting later in 2014. He recommended that the group be disbanded and members thanked for their service after their final meeting. This recommendation was approved.

2.2.2 SCOR/InterRidge WG 135 on Hydrothermal energy transfer and its impact on the ocean carbon cycles

Athena Coustenis reported that this working group held its final meeting in conjunction with the 2014 European Geosciences Union meeting. It convened a special session at the meeting and used its meeting to complete work on an article that was submitted to the journal *Earth and Planetary Science Letters*. The group had planned to produce two papers describing new models of the influence of hydrothermal systems on the global carbon cycle, but decided that not enough field data were available to construct the second model. Coustenis recommended disbanding the group after the final article is completed and this recommendation was approved.

2.2.3 WG 137: Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation

John Volkman reported that this group met most recently in conjunction with the Coastal and Estuarine Research Federation meeting in 4-7 November 2013 and convened a special session at the meeting. The group is planning a meeting in November 2014 in Zhuhai, China to finalize papers for a special issue of *Estuarine, Coastal and Shelf Science*. Volkman recommended that the group be disbanded after its 2014 meeting and this recommendation was approved. (The group later requested approval to have one final meeting in conjunction with the 2015 SCOR Annual Meeting in Goa, India and this request was approved by the SCOR Executive Committee.)

2.2.4 SCOR/IGBP WG 138: Modern Planktic Foraminifera and Ocean Changes

Missy Feeley introduced Michal Kucera, one of the group's co-chairs, to give an update on the group's activities. Kucera reminded participants that the main goals of the working group are the following:

- synthesize existing knowledge on modern planktonic foraminifera,
- build on this knowledge to identify priority research, and
- transfer expertise to the generation of young researchers.

Kucera listed the meetings that have been part of the group's work:

- September 2011, Amsterdam: First meeting and mini-symposium for early-career scientists
- June 2013, Prague: Workshops on Methods and Taxonomy
- January 2014, Concepción: Special session at FORAMS2014
- June 2014; NIOZ: Workshop on Foraminifera Geochemistry
- September 2015, Catalina Island, California: Final Meeting and short course on culturing modern planktonic foraminifera

The group's Virtual Book is making progress and work is ongoing on some peer-reviewed papers from the group. A cruise is being planned to focus on some key questions related to forams.

Peter Burkill noted that the Indian and Pacific oceans appear to have poor data coverage. Kucera responded that the group is trying to integrate time series from various sources. Ed Urban

remarked that the YouTube videos produced by WG 138 are very interesting (see http://youtu.be/xfZ_9UWcAB8 and <http://youtu.be/6MakjP6MkdE>). SCOR contributed modest funds to this effort. Videos could be a good vehicle to broaden impact of SCOR WGs.

2.2.5 WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean

Ed Urban reported that this group met most recently in conjunction with the Ocean Sciences Meeting in Hawaii in February 2014 and convened a special session and Town Hall meeting there. WG 139 members have submitted papers for a special issue of the journal *Marine Chemistry* (deadline for submissions was 14 June 2014) and are planning their final meeting in Croatia in April 2015, including a workshop for early-career scientists. The best practices manual to guide future approaches in determining organic ligands is in progress and will be published on the WG 139 Web site. Funding was approved for the group's 2015 meeting.

2.2.6 WG 140: Biogeochemical Exchange Processes at the Sea-Ice Interfaces

John Volkman reported that the group met in conjunction with the International Symposium on Sea Ice in a Changing Environment in Hobart, Australia in March 2014. The group's review on sea-ice methodologies has been submitted to the journal *Elementa*. A special issue of an open-access journal is also almost ready for submission, on specific sea-ice parameters and processes. The next in-person meeting of the group is planned after the Gordon Research Conference on Polar Marine Science, which will be held on 15-20 March 2015 in Lucca, Italy. Funding was approved for the 2015 meeting of WG 140.

2.2.7 WG 141 on Sea-Surface Microlayers

John Volkman introduced Oliver Wurl, one of the two co-chairs of WG 141 (the other co-chair is Michael Cunliffe). Wurl reminded participants that the motivation for formation of the group is that recent studies indicate that the sea-surface microlayer (SML) covers the ocean to a significant extent, and evidence shows that it is an aggregate-enriched biofilm environment with distinct microbial communities. The redeveloped SML paradigm pushes the SML into a new and wider context that is relevant to many ocean and climate sciences. The overall objective of WG 141 is to increase awareness of the science community to the importance of the SML in a wide range of biogeochemical and climate-related processes. The group has 10 Full Members and 12 Associate Members, from 10 different countries. Wurl reported on the status of completion of WG 141's terms of reference:

- **TOR 1: Review sampling techniques and provide best practice sampling protocols—** The sample guide is completed (see http://scor-int.org/Publications/SCOR_GuideSeaSurface_2014.pdf), so this TOR is completed. The guide was to be used during the workshop on 13-17 October 2014.
- **TOR 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—** The group has scheduled two days during the workshop in October to write the paper, which should be completed and submitted for peer review by December 2014.
- **TOR 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—During the workshop in October 2014, the group will discuss potential major meetings at which to have the first SML session, and after consultation with all of the WG members, Cunliffe and Wurl will initiate the session.

- **TOR 4: Summarize and publish the latest advances in microlayer research in a special issue of a peer-reviewed journal**—During the WG 141 meeting held in Vienna in 2013, the group agreed that the journal for the special issue would be *Biogeosciences*. They will confirm this decision during the October workshop in Qingdao. Calls for papers will not open until after the SML special session at a major meeting.

Four WG 141 members (Cunliffe, Landing, Wurl, Zappa) have been preparing a proposal to the Schmidt Ocean Institute (SOI) for a collaborative research cruise on SOI's R/V *Falkor* in 2016. The initial expression of interest was accepted by SOI, and the members were subsequently invited to submit a full proposal. Wurl was asked what kind of attendance of WG 141 members would be at the Qingdao meeting. Wurl responded that 10 Full and Associate Members will attend. The group's Web site is still being developed. Wurl thanked SCOR for the funding and the opportunity to promote work on microlayers to the science community. Funding was approved for the 2015 meeting of WG 141.

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

Missy Feeley reported that the group met for the first time on 1 March 2014, immediately after the 2014 Ocean Sciences meeting in Hawaii. It is preparing an article for *Eos* regarding the group's plans and has established connections with Argo data managers. The group's 2015 meeting will be held with either GO-SHIP or the Argo Steering Team. Funding was approved for the 2015 meeting of WG 142.

2.2.9 WG 143 on Dissolved N₂O and CH₄ measurements: Working towards a global network of ocean time series measurements of N₂O and CH₄

John Volkman introduced Annette Kock. Funding was approved for the 2015 meeting of WG 143. Kock reminded participants of the major objectives and deliverables of WG 143:

- Intercalibration of oceanic N₂O/CH₄ measurements
- Develop recommendation for a standard measurement protocol
- Establish N₂O and CH₄ reporting procedures
- Establish a framework for an N₂O/CH₄ ocean time series network

The first intercalibration exercise was held in winter 2013/2014. Fourteen laboratories participated, analyzing samples from two depths (25 and 700 m) at Station ALOHA for CH₄ and N₂O analysis. A Web page was set up at <https://portal.geomar.de/web/scor-wg-143/home>. The group is planning its second intercalibration exercise in winter 2014/2015, followed by a working group meeting in September 2015 in conjunction with the SOLAS Open Science Conference. Recommendations for analysis and reporting will be published in Feb. 2016. Recommendations for a N₂O/CH₄ Time Series Station Network will be published in 2017. WG 143 is working with the Marine Methane and Nitrous Oxide Database (MEMENTO). Recommendations for data analysis and reporting as developed by WG 143 will be used as a

quality control criterion for data included in MEMENTO and WG 143 will recommend that N₂O and CH₄ data be archived in MEMENTO.

Funding was approved for the 2015 meeting of WG 143. Ed Urban commented that there need to be added more Southern Hemisphere stations and this indicates the need for capacity building in relation to this technology,

2.2.10 WG 144 on Microbial Community Responses to Ocean Deoxygenation

Ed Urban reported that WG 144 met on 14-18 July 2014 in Vancouver for the first time and conducted an intercalibration exercise in Saanich Inlet in conjunction with its meeting. Saanich Inlet is a seasonally anoxic fjord off the coast of Vancouver Island, British Columbia, Canada, and is a good location to ground truth common standards for process rate and molecular measurements and identify model ecosystems for future cross-scale comparative analyses. Data analysis and report preparation are ongoing. A group Web site has been set up at <http://omz.microbiology.ubc.ca/index.html>. In terms of capacity building, WG 144 members from Korea and India participated in the Saanich Inlet workshop. Members from Chile and Namibia are participating in Web site development. Funding was approved for the 2015 meeting of WG 144, which is planned to take place in Warnemünde, Germany at the end of August.

2.3 Working Group Proposals

As in recent years, the proposal discussions were in two rounds. The first round provided and opportunity for each national SCOR committee and each organization represented to present its views on each proposal, particularly whether each proposal should be rated as “Must Fund”, “May Fund”, or “Do Not Fund”. These ratings were used to divide proposals into those that were close enough to acceptable to be funded this year versus those that were not acceptable for funding as submitted or with small modifications. The second round of discussions made the final determinations of which proposals would be funded this year and compiled comments for modifications to be requested for each proposal. The SCOR Finance Committee advised meeting participants that three new groups could be funded.

2.3.1 Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC: Appendix 3)

Wolfgang Fennell presented the proposal and comments from national SCOR Committees. It was noted that this proposal had the largest number of “must funds” and many national committees believe that the topic is timely and important. The topic of this proposal is important because, as the ocean becomes more acidic, this will affect speciation and we will need to measure how speciation changes. The terms of reference are appropriate and the membership is good. The proposed Chair is very knowledgeable. Concern was expressed about funding for the Web site proposed by the group, but meeting participants concluded that the proposed group would still be successful if it cannot raise funding for the Web site during the life of the group because achievement of the other proposed tasks will be a significant accomplishment.

In terms of changes needed, it was suggested that the geographic diversity and gender balance be improved for both the Full and Associate members. The proposal would be improved if there were better links to other groups with interests in this topic. The links to GEOTRACES are

important. The capacity-building efforts are not well described.

Meeting participants agreed to fund this working group for start in 2015, with some changes requested.

2.3.2 Towards comparability of global oceanic nutrient data (COMPONUT: Appendix 5)

Peter Burkill presented the proposal and comments from national SCOR committees regarding the strengths and weaknesses of the proposal. The focus of the proposal is to establish a mechanism to standardize ocean nutrient data. This is a revised proposal from last year. The ratings from national SCOR committees were evenly distributed among “must fund”, “may fund”, and “do not fund”. It was recognized that standardization of ocean nutrient data is an extremely important task, although some doubts were expressed in the ability of this group to succeed in this task after other groups have not succeeded. It is not clear that a SCOR working group is the best way to achieve better nutrient standards. The proposed membership is well balanced. The final decision was to approve the proposal, with the terms of reference to be more ambitious. The protocols developed by the group should include sampling preservation protocols.

2.3.3 International Network for the Study of How Organisms Respond to Environmental change (INSHORE)

Missy Feeley presented the proposal and comments from national SCOR Committees. The proponents are approaching an important problem that has to be addressed, considering the ocean acidification issue. However, developing a model for multiple stressors is probably unrealistic with the diversity of research required. The proposal is too ambitious; just to review the climate models is a huge undertaking. The physical component of the proposal was weak. There was some discussion of whether this proposal could be linked to another of the proposals, for example, MARBIOG (see below). There is not enough emphasis on human effects, for example, fishing. It was decided to not fund the proposal this year. Comments were sent to the proponents in case they wish to resubmit in a subsequent year.

2.3.4 Patterns in global plankton biogeography (MARBIOG)

Satoru Taguchi presented the proposal and comments from national SCOR Committees. He noted that this was a resubmitted proposal. Many national SCOR committees did not think the proposal had been greatly improved. The key objective of the working group would be to understand planktonic biogeography. National committees were not sure there is enough science in the proposal. The capacity building plan is weak. The proposed members would be well qualified to do work on this topic, although they may need to add physical oceanography expertise. The terms of reference are not necessarily achievable in three years. Peter Burkill summarized that the linkage of biology to other variables, chemistry and physical parameters, is important. It is an ambitious proposal and the terms of reference will be difficult to achieve. Much of this work is already ongoing. It was decided to not fund the proposal this year. Comments were sent to the proponents in case they wish to resubmit in a subsequent year.

2.3.5 Radioactivity in the Ocean, 5 decades later (RiO5: Appendix 4)

John Volkman presented the proposal and comments from national SCOR Committees. The proposal is very timely and the TORs are very doable, with measurable milestones. There are ties

to GEOTRACES that should enhance the impact of the results and good connections to other programs. Links should be made to PICES, which has a new working group on radioactivity in the North Pacific Ocean. There were some questions about how much of the proposed work GEOTRACES or other groups are already doing. Ed Urban explained that GEOTRACES is handling some radioactive elements, but is not routinely measuring most of the important variables that will be addressed by the working group. GEOTRACES does not have a significant outreach component. However, there is enough joint membership with GEOTRACES that there should be no duplication of effort. The capacity-building activities need to be better developed. Peter Burkill summarized that the proposal has good outreach and it is certainly timely. The working group outputs are poorly defined. The group should be requested to develop stronger linkages to ocean modelers, provide a more detailed description of what they are going to do, specify communication tools, specify mechanisms to link academics with policymakers, ensure that the products are more than just a Web site, provide a global atlas of distribution of relevant measurements of isotopes, include more science products and not just outreach, and make outreach products accessible to laypersons. The gender balance of Associate Members should be improved. Permanent, long-term access to data available should be a priority. For outreach, it will be important to address some of the concerns of the general public. The proposal needs a focused set of questions and the outreach should be designed to address the questions. The first deliverable should address concerns of data access. The proposal was approved in principle, depending on revisions requested by SCOR.

2.3.6 Designing a biological observing system in the Southern Ocean to inform global ocean observing of marine ecosystems (SO-eEOV)

Missy Feeley presented the proposal and comments from national SCOR Committees. This is another proposal that was submitted previously. Some national committees thought that this is an important issue to be handled by a SCOR working group. It could be very useful to GOOS. Other national committees thought that the aims of the proposal did not fit the model of the typical SCOR working group, and that the group's work would result in incremental progress rather than a breakthrough. More observationalists are needed in the membership. The gender balance is good for the Full Members proposed, but not as good for the Associate Members. There is no definition of key science questions that will be addressed in the proposal. We do need to test EOVs somewhere and the Southern Ocean could be a good place. This proposal reads more like a request for research funding rather than SCOR WG. The proposal needs better linkage with other initiatives. Peter Burkill summarized that it is not clear that the proposal really fits SCOR and it appears to fall within the territory of other organizations, such as IOC. The terms of reference are not clearly articulated. It was decided to not fund the proposal this year. Comments will be sent to the proponents in case they wish to resubmit in a subsequent year.

2.3.7 Optimized design of an ocean observing system for biogeochemistry in a changing climate

John Volkman presented the proposal and comments from national SCOR Committees. It was not clear who would be the audience for the products of this group and whether GOOS would be able to respond to any recommendations from the group. The concept is important, though, because there has not been a careful analysis of how to optimally deploy observational assets through an Observing System Simulation Experiment (OSSE) approach. There is good overlap between the membership of the proposed group and the GOOS Scientific Steering Committee;

engagement of GOOS and POGO would be helpful for this proposal. Maybe a SCOR working group could handle a piece of the overall task. It was decided to not fund the proposal this year. Comments were sent to the proponents in case they wish to resubmit in a subsequent year.

2.3.8 Rheology, nano/micro-Fluidics and bioFouling in the Oceans (RheFFO)

Satoru Taguchi presented the proposal and comments from national SCOR Committees. National committees thought this was a potentially interesting, interdisciplinary proposal, but it is poorly presented with somewhat cryptic terms of reference. There are not enough members and the gender balance is very poor. The membership appears to be a self-selective group that is not broadly representative and there is a need for a broader range of expertise. The proposal reads as if the members are trying to sell the topic to community rather than further the research. This needs to be an explanation of why this topic is important. A SCOR working group should not start with a two-day brainstorming session. The proponents need to know what they want to do before the group is approved. This seems more an engineering project than scientific project. It was decided to not fund the proposal this year. Comments were sent to the proponents in case they wish to resubmit in a subsequent year.

3.0 LARGE-SCALE SCIENTIFIC PROGRAMS

SCOR currently sponsors four large-scale research projects; three of them are co-sponsored by other organizations. Each project has its own scientific steering committee (SSC) to manage the project on a day-to-day basis. SCOR and other co-sponsors are responsible to oversee the projects, which they do primarily through responsibility for the project SSC memberships and terms of reference, although sponsors also oversee the results of the projects' activities. Any proposed changes in membership or terms of reference are considered by the SCOR Executive Committee, in partnership with other co-sponsors, throughout the year. SCOR does not use discretionary funds (funds from SCOR member nation dues) for the research projects it sponsors, instead writing grant proposals to fund meetings and other activities of the projects. The SCOR Secretariat oversees the use of grant funds provided to the projects. Two additional projects, the International Quiet Ocean Experiment and the Second International Indian Ocean Expedition, are under development.

3.1 IOC/SCOR Global Ecology and Oceanography of Harmful Algal Blooms Program (Appendix 6)

Satoru Taguchi introduced Henrik Enevoldsen, who reported that GEOHAB continues to complete various synthesis products, including a final special issue and a summary for policymakers. The GEOHAB Scientific Steering Committee has proposed a follow-on project to continue helping the HAB research community support international activities to strengthen the scientific infrastructure of the field. This new activity is called GlobalHAB (see section 4.5). Enevoldsen conveyed a request to SCOR from IOC to become a co-sponsor of GlobalHAB. Ed Urban responded that the SCOR Executive Committee had approved co-sponsorship, contingent on receiving funding from the National Science Foundation, which will not be known until after the SCOR renewal proposal is submitted to NSF in February 2015. Bilge Tutak asked whether GlobalHAB will continue training on HAB science for new scientists in GlobalHAB, as

GEOHAB did. Enevoldsen responded that the intention to continue, but as targeted support based on the GlobalHAB implementation plan.

3.2 Integrated Marine Biogeochemistry and Ecosystem Research (Appendix 7)

Peter Burkill reported that IMBER is nearing the end of its first 10 years as a research project and is currently drafting a request for a 10-year extension to the project. A major event that was designed to help gather input for the next phase of IMBER was the Open Science Conference held in Bergen, Norway in June 2014. The Executive Committee will report on its review of a draft of the extension request. IMBER has requested sponsorship from the Future Earth initiative. Burkill introduced Eileen Hofmann, IMBER chair, who made a presentation about the project remotely.

Eileen Hofmann reminded meeting participants that IMBER currently has four themes:

1. Interactions between biogeochemical cycles and marine food webs
2. Sensitivity to global change
3. Feedbacks to the Earth System
4. Responses of society

IMBER work is carried out by a worldwide network of national committees and endorsed projects, supported by an International Project Office in Bergen, Norway and a Regional Project Office in Shanghai, China. IMBER includes four regional programs: (1) Ecosystem Studies of Sub-Arctic Seas (ESSAS), (2) Climate Impacts on Top Predators (CLIOTOP), (3) Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER), and (4) Integrated Climate and Ecosystem Dynamics (ICED). IMBER also supports cross-cutting working groups: Carbon Research (with SOLAS), Human Dimensions, Continental Margins (with LOICZ), Data Management, Capacity Building, and Upwelling (with CLIVAR).

IMBER has made progress in addressing its four research themes (science highlights are included in the report to SCOR). IMBER is approaching its ten-year mark since publication of its Science Plan/Implementation Strategy and it is time to reconsider science directions and to develop the next phase of IMBER research. IGBP, one of two IMBER co-sponsors, is ending at end of 2015 and being replaced by Future Earth after that. IMBER has been invited to add Future Earth as a co-sponsor, as a replacement for IGBP. IMBER has developed a strong and mature IMBER science community and has worked over the past several years to identify the key scientific issues and challenges relating to the ocean and global environmental change. It has identified a new science agenda and how IMBER can address the new items in the next ten years. IMBER convened an Open Science Conference (OSC) in June 2014 to solicit inputs from the IMBER science community regarding priorities for future IMBER science. They will use the inputs from the OSC to develop a research agenda and implementation plan for the next phase of IMBER research.

In early 2014, inputs were solicited from IMBER regional programs, working groups and partner organizations about achievements and suggestions for new research directions. These inputs were used to outline the key scientific issues and challenges relating to the ocean and global

environmental change and how IMBER can address these in the next 10 years. Five general research themes emerged and were used to develop a draft position paper. The position paper was given to OSC attendees and posted on IMBER Web site for comments. These comments provided the basis for breakout group discussions at the OSC.

Hofmann made some requests to SCOR meeting participants. First, she asked for guidance and feedback on the proposed IMBER Grand Challenges and Innovation Challenges. She also asked for SCOR approval for a ten-year extension of IMBER, based on the IMBER position paper that is being developed. Peter Burkill responded that the science contained so far in the IMBER document may be too much. Claudia Mengelt asked how much feedback has been received from social scientists in relation to the science plan. Hofmann answering that as IMBER is preparing for sponsorship by Future Earth, it is increasingly supporting social scientists to attend open science meetings and adding them to the IMBER Scientific Steering Committee. Reiner Schlitzer asked about the relationship between IMBER and Future Earth. Ecosystem research can have science questions that are only basic science without necessarily being societally relevant. Hofmann answered that there is no conflict with this. There is a place in Future Earth for science. A key focus of Future Earth will be continuing to evolve science at the interface of natural science and social science. IMBER is talking to people at Future Earth where there is an opportunity to define what IMBER can bring to Future Earth and what Future Earth can provide to IMBER.

The relationship between IMBER and Future Earth will be determined after the IMBER position paper is submitted to Future Earth. Peter Burkill asked whether IMBER is considering changing its name. Hofmann responded that there is not a lot of support for changing the project's name. Burkill noted that it might be difficult in some nations to receive continued funding with the same name. Hofmann acknowledged this issue.

Raleigh Hood asked if SCOR is expecting a full-blown science plan from IMBER. Burkill responded that SCOR and other sponsors will need a document that can be peer reviewed by an independent group of reviewers. Hofmann responded that before IMBER puts together a full document, it would like input on from SCOR if that plan is heading in the right direction. Burkill responded that at meeting of the SCOR Executive Committee tomorrow, it will discuss this and Ed Urban will provide feedback. Burkill added that SCOR will stand by IMBER and provide any help needed. Venu Ittekkot asked whether there are any thoughts among the ocean projects (IMBER, SOLAS LOICZ) about Future Earth, potential overlap among projects, etc. Hofmann responded that IMBER has talked about it and felt that it was beneficial that there were common cross-cutting science themes among these three projects. Burkill concluded by thanking Hofmann for her presentation. Ed Urban will get back to IMBER with advice from the SCOR Executive Committee in the next few weeks.

Motoyoshi Ikeda stated that the interaction of natural science and social science is an important issue. It may be valuable to have a discussion with national SCOR committee members so they can provide input. Burkill responded that this issue would be added to tomorrow's agenda.

3.3 GEOTRACES (Appendix 8)

John Volkman introduced Reiner Schlitzer (Germany), one of the co-chairs of the GEOTRACES project. (Ed Boyle (USA) is the other co-chair.) Schlitzer updated meeting participants about the project. GEOTRACES is an international program that aims to improve the understanding of biogeochemical cycles and large-scale distribution of trace elements and their isotopes in the marine environment. Scientists from approximately 35 nations have been involved in the program, which is designed to study all major ocean basins over the next decade. So far, 51 cruises (23 GEOTRACES Section cruises) have been completed.

The GEOTRACES Intermediate Data Product (IDP) 2014, containing the first data from GEOTRACES, was launched at a Town Hall session in February 2014 at the Ocean Sciences Meeting in Honolulu, Hawaii. More than 350 individuals attended the Town Hall session and the journals *Nature* and *Science Journals* reported on the release. The IDP-2014 includes hydrographic and marine geochemical data acquired during the first three years of the program. The aims of the product were to release a data product early in the program, strengthen the collaboration within the project by sharing data, and attract scientists from other communities (physical and biological oceanography, modelling) to participate in the project. The IDP-2014 consists of two parts: (1) a Digital Data Package including 205 parameters (available at www.bodc.ac.uk/geotraces/data/idp2014/) and (2) the eGEOTRACES Electronic Atlas (available at www.egeotraces.org). The IDP-2014 includes data from 27,387 samples, taken at 797 stations on 15 cruises, primarily in the Atlantic Ocean, but also including some data from the Southern, Arctic, and Indian oceans. The IDP-2014 was also demonstrated at the SCOR booth at the Ocean Sciences meeting. The GEOTRACES community thanked SCOR for this opportunity. Schlitzer noted that the IDP-2014 has been successful due to several factors: GEOTRACES spent significant time and money on intercalibration, reference standard materials were developed before the first official GEOTRACES cruises, other communities (e.g., modelers) got interested early on, and all the groups involved in producing the IDP were very engaged.

Schlitzer presented some GEOTRACES science highlights from the past year:

- Slow-spreading ridges could be major oceanic iron contributor—A large dissolved iron- and manganese-rich plume has been detected over the slow-spreading southern Mid-Atlantic Ridge. These observations call into question the assumption that deep-sea hydrothermal vents along slow-spreading ridges are negligible contributors to the oceanic iron inventory.¹
- Field data allow constraining the total ocean mercury budget—Estimates of the total amount and spatial distribution of anthropogenic mercury in the global ocean were substantially improved. Global budgets of total mercury suggest that there has been a tripling of the surface water mercury content and a ~150% increase in the amount of mercury in thermocline waters.²

¹Saito, M.A., A.E. Noble, A. Tagliabue, T.J. Goepfert, C.H. Lamborg, and W.J. Jenkins. 2013. Slow-spreading submarine ridges in the South Atlantic as a significant oceanic iron source. *Nature Geoscience* 6 (9):775-770 DOI: 10.1038/ngeo1893.

²Lamborg, C.H., C.R. Hammerschmidt, K.L. Bowman, G.J. Swarr, K.M. Munson, D.C. Ohnemus, P.J. Lam, L.-E. Heimbürger, M. Rijkenberg, and M.A. Saito. 2014. A global ocean inventory of anthropogenic mercury based on water column measurements. *Nature* 512(7512):65–68. doi:10.1038/nature13563.

- Dissolved iron sources in the North Atlantic Ocean quantified—Using a novel method based on the stable isotopic composition of dissolved iron, the relative importance of four different dissolved iron sources in the North Atlantic Ocean have been precisely determined for the first time: Saharan dust (71-87%), North American margin sediments (10-19%), African margins (1-4 %), and hydrothermal venting from the Mid-Atlantic Ridge (2-6%).³
- Copper and zinc oceanic mass balance revisited—With the original approach that takes into account the hitherto ignored constraint of their isotopes, copper oceanic mass balance appears to be roughly in balance, but the zinc is far from being constrained. Isotopes reveal that either an "isotopically light sink" or "isotopically heavy source" of copper is missing.⁴
- First simultaneous method for the determination of iron, zinc, and cadmium isotopes in small volumes of seawater— Designed for use on only a single liter of seawater representing a 1–20 fold reduction in sample size and a 4–130 decrease in blank, the procedure yields data with high precision, allowing estimation of natural variability in the oceans, which spans 1–3‰ for all three isotope systems.⁵

The GEOTRACES has two committees that were instrumental in producing the IDP-2014: (1) the Data Management Committee (DMC) and (2) the Standards and Intercalibration Committee. The GEOTRACES SSC and DMC will be meeting together in South Africa next month (October 2014).

In terms of publications, 475 GEOTRACES-related peer-reviewed papers are included in the GEOTRACES Database available on the GEOTRACES Web site at <http://www.geotraces.org/library/scientific-publications/peer-reviewed-papers>. 25 PhD GEOTRACES-related Dissertations are included in the GEOTRACES Database available on the GEOTRACES Web site: <http://www.geotraces.org/library/scientific-publications/phd-dissertations>. Several special issues of peer-reviewed journals have been published or are being developed:

- Special issue of *Limnology and Oceanography: Methods* entitled, “Intercalibration in Chemical Oceanography” devoted to GEOTRACES Intercalibration completed: <http://www.aslo.org/lomethods/si/intercal2012.html>
- 2011 GEOTRACES Data Model Synergy Workshop (Barcelona, 14-17 November 2011) in *Progress in Oceanography*
- U.S. GEOTRACES North Atlantic cruise Special Volume in *Deep Sea Research II*
- GEOTRACES KEOPS-2 project Special Issue in *Biogeosciences*
- Biogeochemistry of trace elements and their isotopes in *Marine Chemistry*

³Conway, T.M., and S.G. John. 2014. Quantification of dissolved iron sources to the North Atlantic Ocean, *Nature* 511(7508):212–215. doi:10.1038/nature13482.

⁴Little, S.H., D. Vance, C. Walker-Brown, and W.M. Landing. 2014. The oceanic mass balance of copper and zinc isotopes, investigated by analysis of their inputs, and outputs to ferromanganese oxide sediments. *Geochimica et Cosmochimica Acta* 125:673–693. doi:10.1016/j.gca.2013.07.046.

⁵Conway, T.M., A.D. Rosenberg, J.F. Adkins, and S.G. John. 2013. A new method for precise determination of iron, zinc and cadmium stable isotope ratios in seawater by double-spike mass spectrometry. *Analytica Chimica Acta* 793:44-52, DOI: 10.1016/j.aca.2013.07.025.

Ed Urban noted that SCOR Working Group 109 on Biogeochemistry of Iron in Seawater played an important role in demonstrating the lack of comparability in iron data obtained by different laboratories. This resulted in NSF funding for an iron intercalibration and two GEOTRACES intercalibration cruises. Bernard Avril asked whether there are repeat sections looking at seasonal variations. Schlitzer answered that GEOTRACES' main charge is for full coverage of the global ocean, not time series. However, process studies are addressing variation of trace elements and isotopes over time. It was asked whether previous data are being added to the GEOTRACES database. Schlitzer answered that GEOTRACES does not support adding old data, because they have not been intercalibrated with GEOTRACES data.

Hal Batchelder noted that a lot of the Pacific Ocean is not yet covered. What is the time frame for completing all transects? Schlitzer answered that it will take more than 5 years for Pacific data collection plus 2 years before the data are available. Claudia Mengelt asked how long it takes from data collection to when the data are publically available. Schlitzer answered that it depends on the element, but the time lag is typically 2 years. Colin Devey noted that looking at hydrothermal vents, iron appears to be coming out of ridges everywhere. Schlitzer answered that it could still be from point sources along the ridge, due to the sparse resolution of data collection.

3.4 Surface Ocean – Lower Atmosphere Study (Appendix 9)

SOLAS is nearing the end of its first 10 years as a research project and is currently drafting a request for a 10-year extension to the project. SOLAS has held several workshops to gather input for its extension request, including a workshop for young scientists. The Executive Committee will report on its review of a draft of the extension request. SOLAS has requested sponsorship from the Future Earth initiative.

Athena Coustenis introduced Emilie Breviere, the SOLAS Executive Officer, to provide an update about SOLAS. Breviere began by announcing the first SOLAS synthesis product, an open-access book entitled *Ocean-Atmosphere Interactions of Gases and Particles* by P.S. Liss and M.T. Johnson (see <http://www.springer.com/us/book/9783642256424>). This book is the first synthesis of a set of disparate topics into a coherent treatment of the exchange of matter across the sea surface. A considerable number of SOLAS scientists contributed to this major effort. SOLAS is contributing to the IGBP Synthesis effort. An article is in preparation for the *Earth's Future* journal. The paper outlines a brief history of SOLAS, reports on four selected major achievements of the project and its contribution toward Earth System science. It also presents the future ambitions of SOLAS. Breviere mentioned that another synthesis publication was awarded, in 2013, the Hutchinson Medal by the Institution of Chemical Engineers (IChemE).

In terms of communications, SOLAS uses the following approaches:

- The SOLAS Web site, which is smart-phone friendly
- A5 two-fold SOLAS flyer
- Annual newsletter and bi-monthly e-bulletins circulated to 2,200+ individuals
- Participation in the SCOR booth at the 2014 Ocean Sciences Meeting

SOLAS conducts a variety of capacity-building activities. The 6th SOLAS Summer School was held on 23 Aug.-2 Sept. 2013 in Xiamen, China. Sixty-nine PhD-level students were instructed by 15 world-leading scientists for two weeks of plenary talks and hands-on practical experiences in small groups.

Future Earth launched a call for Fast Track Initiatives and Clusters in Feb 2014. SOLAS was involved in two submitted proposals:

- an FTI with IMBER and CLIVAR essentially, on “Upwelling Systems in a Changing Climate: From Biophysics and Ecosystems to Marine Resource Management”
- a Cluster on “International, Interdisciplinary Polar Science Network” with IGAC, OASIS/AICI, HitT, BEPSII, ASP, ArcticNET, AINA, CRAICC, PEEEX, SVALI, DEFROST, NORDFROST, CliC, CLIVAR, ISAC, DBO, and SEARCH

In June, the FTI proposal was rejected and the Cluster proposal was partially successful: the proposers have a year and some funding to reformulate their proposal and submit it to the 2015 call.

SOLAS has been collaborating with the European Space Agency (ESA) on three OceanFlux projects (2011-2013) funded by ESA:

1. Greenhouse Gases
2. Upwelling
3. Sea Spray Aerosols

The projects ended with two topical workshops in fall 2013:

- The first two projects listed above co-organised one workshop in Brest, France.
- The third project organised its workshop in Galway, Ireland.

To identify the topics on which SOLAS and ESA would benefit the most from collaboration, ESA, SOLAS and EGU are co-organising a conference in Frascati, Italy in October 2014.

The first phase of SOLAS was launched with the SOLAS Science Plan and Implementation Strategy in 2004. In 2009, SOLAS produced White Papers on a series of Mid-term Strategy Initiatives. Progress on the Mid-term Strategy Initiatives was documented by a 2013 paper.⁶

SOLAS will make the case for a second 10-year phase. The rationale is that SOLAS covers a realm whose focus is on intense anthropogenic modification and geoengineering interest. There are institutional barriers between ocean and atmosphere scientific communities. International coordination is needed on field projects, data, and methodology. In terms of SOLAS v2 proposal development, white papers on SOLAS 2.0 science themes have been developed. An on-line community consultation has been conducted. An early career scientists’ workshop was held in

⁶Law, C.S., E. Breviere, G. de Leeuw, V. Garçon, C. Guieu, D.J. Kieber, S. Konradowitz, A. Paulmier, P.K. Quinn, E.S. Saltzman, J. Stefels, and R. von Glasow. 2013. Evolving research directions in Surface Ocean–Lower Atmosphere (SOLAS) science. *Environ. Chem.* 10:1–16.

Plymouth (UK) in December 2013; some attendees had attended the SOLAS Summer School 10 years earlier. They produced a document with recommendations on white papers and what SOLAS should be doing. A planning workshop was held in Galway, Ireland.

It is planned to submit the review draft of the SOLAS Science Plan/Implementation Strategy (SPIS) to current SOLAS sponsors in Fall 2014. The new SPIS has five themes:

1. Greenhouse gases and the oceans
2. The air-sea interface and fluxes of mass and energy
3. Atmospheric nutrient/particle supply to the surface ocean
4. Aerosols, clouds, and ecosystems
5. Ocean biogeochemical controls on atmospheric chemistry

There has been a change in the landscape of global change science coordination. IGBP is winding down in 2015 and the Future Earth initiative is focused on research for global sustainability, starting in 2013. SOLAS decided that it will transition from IGBP to Future Earth in the first half of 2014. In this new landscape, SOLAS v2.0 will have more emphasis on the human relevance of SOLAS science (e.g., geoengineering and ecosystem services). Breviere finished her presentation by reminding participants that SOLAS would be holding its 2015 Open Science Meeting in Kiel, Germany on 7-11 September 2015.

Discussion of the SOLAS project followed. Peter Burkill stated that SOLAS is an exciting project that has brought together two different communities, ocean and atmospheric scientists. Athena Coustenis added that SOLAS has had significant accomplishments in science, collaborations, and communication to the broader community. It was noted that capacity building is not yet developed in the draft extension report. Emilie Breviere responded that SOLAS is exploring different new capacity-building activities, in addition to the ongoing summer school. The next phase of SOLAS has unique aims and ambitions with exchanges of data across platforms. Athenis stated that the draft of the SPIS she reviewed is a good proposal and that the project extension is justified. She questioned whether SOLAS needs a new name or should stay with SOLAS V2. Breviere responded that there is no strong opinion on changing names, but the 'V2' will probably not stay. Burkill added that funders often don't want to fund the same program over and over. He added that SCOR will wait for the next draft of the SPIS and will communicate to other sponsors. Burkill added that the direction of the extension request is really positive. Continued funding from NSF will be important. He asked Breviere about her views of Future Earth. She answered that the core natural science is not going to change. Future Earth will facilitate getting science to policy makers. Ed Urban added that there is a risk of how much money will come from Future Earth and if it will be at same level of IGBP. There is no commitment yet from Future Earth on specific funding levels.

3.5 International Quiet Ocean Experiment (Appendix 10)

Missy Feeley reported that the International Quiet Ocean Experiment (IQOE) is a project under development by SCOR and the Partnership for Observation of the Global Oceans (POGO). Funding was initially provided by the Alfred P. Sloan Foundation, but that funding is now completed. Since the 2013 SCOR meeting, activities of the IQOE co-chairs and SCOR and

POGO staff has focused on review of the report and working on responses to the review. In addition, IQOE co-funded a workshop on Predicting Sound Fields—Global Soundscape Modelling to Inform Management of Cetaceans and Anthropogenic Noise” in April 2014 in The Netherlands. This workshop relates to one of the major IQOE themes. The IQOE Science Plan was reviewed by 5 individuals and the editorial team for the plan is creating a response to review for SCOR and POGO to review.

The timeline for the International Quiet Ocean Experiment (IQOE) has been as follows:

- 27-29 October 2010—Exploratory workshop at the University of Rhode Island
- 10-11 February 2011—Meeting at Florida Atlantic University to complete report from Rhode Island meeting and article for *Oceanography* magazine, and plan open science meeting
- 30 August-2 September 2011—Open Science Meeting at UNESCO Headquarters, Paris
- 15 June 2013—Science Plan sent to Review
- 24 January 2014—Last review received
- 1 September 2014—Response to Review sent to SCOR and POGO report monitors

It is planned to for the IQOE co-chairs to submit the response to review to SCOR and POGO around 1 September 2014. The SCOR Executive Committee will discuss the IQOE response to review in closed session and will announce the outcome of its discussions during the meeting.

Bernard Avril noted that the International Maritime Organization (IMO) may be interested in participating in this project. Peter Burkill suggested that SCOR member countries let Ed Urban know if there are scientists from their countries interested in IQOE. Urban added that more information about the project can be obtained from an article in *Oceanography* magazine.⁷ Avril noted that there is a European Union effort to look at sound in the ocean, which should be linked to IQOE.

3.6 Second International Indian Ocean Expedition (IIOE-2: Appendix 11)

SCOR formed a committee to draft a Research Plan for IIOE-2. An open workshop was held in Bremen on 12-13 Sept. 2014 to provide an opportunity for interested individuals to discuss the draft plan and for national research communities to inform each other about their research plans for the expedition. The draft will be revised following the Bremen workshop and provided to an IOC Interim Planning Committee for IIOE-2, which is being formed by IOC at this time. SCOR will nominate two members to this committee.

⁷Boyd, I., G. Frisk, E. Urban, P. Tyack, J. Ausubel, S. Seeyave, D. Cato, B. Southall, M. Weise, R. Andrew, T. Akamatsu, R. Dekeling, C. Erbe, D. Farmer, R. Gentry, T. Gross, A. Hawkins, F. Li, K. Metcalf, J.H. Miller, D. Moretti, C. Rodrigo, and T. Shinke. 2011. An International Quiet Ocean Experiment. *Oceanography* 24(2):174–181, doi:10.5670/oceanog.2011.37.

4.0 INFRASTRUCTURAL ACTIVITIES

4.1 IOC/SCOR International Ocean Carbon Coordination Project (IOCCP)

Toste Tanhua, chair of IOCCP, gave an update of the progress of this activity. IOCCP focuses on standards, data, and methods for ocean carbon and, more recently, for other aspects of ocean biogeochemistry. The IOCCP SSG held its 9th session in Honolulu, Hawaii, USA on 22 February, immediately preceding the 2014 Ocean Sciences Meeting. IOCCP activities are divided into 9 themes, with one SSG member leading on each theme: (1) Underway CO₂ Observations, (2) Ocean Interior Observations, (3) Time Series Efforts, (4) Synthesis Activities, (5) Ocean Acidification, (6) Nutrients, (7) Framework for Ocean Observing, (8) Data and Information Management, and (9) Instruments and Sensors. IOCCP has secured enough funding to organize the first-ever Sensor Summer School, to be held in late Spring 2015 in Europe. IOCCP has also agreed to take responsibility for international coordination of the Global Ocean Acidification Observing Network (GOA-ON).

Peter Burkill asked if there was a description of the IOCCP Summer School on the Web site. Tanhua responded that the description would be there soon. Satheesh Shenoi asked if IOCCP was working with Argo data management on biogeochemical sensors on Argo. Tanhua answered “yes”. Ed Urban noted that IOCCP has done an excellent job pulling together data and finding a home for the ocean carbon data. Colin Devey asked how close are IOCCP’s efforts on EOVs to being ready to distribute. Tanhua responded that IOCCP is in the second round of finalizing specifications and getting approval from the Global Ocean Observing System. IOCCP is still accepting suggestions. The global EOVs are mostly agreed, but there will probably be different ones for specific regions, for example, for the Southern Ocean Observing System. Burkill noted that, looking at the list of EOVs in the IOCCP presentation, some on the list are a surprise. There is nothing on the list reflecting photosynthesis. Tanhua answered that this aspect is being handled by the GOOS Biology and Ecosystems Panel. It also could have been in the Biogeochemistry Panel. Burkill continued by asking why the biological EOVs are separate from biogeochemistry EOVs? Tanhua answered that it is really about dividing the work. Claudia Mengelt expressed the same concern, about primary production measurements and carbon measurements not being overseen in the same panel. Paul Myers stated that it may give the wrong impression listing only 9 EOVs for biogeochemistry. Emilie Breviere asked about the collaboration of IOCCP, IOC, SOLAS and IMBER. Tanhua answered that the different groups are trying to divide the work by defining focus areas to limit overlap. It is unclear about such collaboration under Future Earth.

4.2 SCAR/SCOR Southern Ocean Observing System (SOOS)

John Volkman presented an update of SOOS activities. The 2014 SOOS Scientific Steering Committee meeting was held in Tromsø, Norway, in June. The meeting put in place a new governance structure to support implementation activities of SOOS. All SOOS activities (strategic or field; SSC-defined or bottom-up, community-driven) will be implemented through SOOS Working Groups. General Operating Principles and Working Group Terms of Reference are in development. Working Groups will need to be approved by the SOOS SSC, will generally be short-term outcome/product-driven, and will undergo annual review by the SOOS SSC. Leaders of all SOOS Working Groups will form an Implementation Panel. This panel will meet opportunistically for cross-fertilization of knowledge/ideas. It is proposed that this panel will meet officially once every three years.

Other SOOS Activities

1. Identification of ecosystem Essential Ocean Variables: This activity is absolutely imperative to the success of SOOS. In order to design and implement an efficient and internationally coordinated observing system we need to first identify what should be observed—Essential Ocean Variables and Ecosystem Essential Ocean Variables. SCOR, SCAR, and SOOS held a very successful international workshop at Rutgers University (USA) in March 2014. To follow up from the meeting, the chairs submitted a report to ICSU, presented the outcomes at the IMBER Open Science Conference, presented the outcomes at an ICED meeting, are holding a Town Hall meeting alongside a SCAR annual meeting (Aug. 27), submitted a SCOR Working Group Proposal, and submitted a paper to a peer-reviewed journal.⁸
2. PROPOSED West Antarctic Peninsula (WAP) Working Group: The terms of reference were still being developed, but it is planned for the group to coordinate activities, methods, plans, and data between all nations currently involved in observations on the WAP.
3. Open for Comment: SOOS International Strategy for Under Ice Observations. Currently requesting comments from the community (see www.soos.aq/science/under-ice).

Current IPO Activities

1. Mid-term Report of Achievements: The IPO has two years remaining of a 5-year contract with IMAS-UTas. We are preparing a Mid-Term Report of Achievements for all sponsors and stakeholders. Some achievements include the following:
 - Development of Governance (TOR, SSC, DMSC)
 - SOOS Brand (Logo, website)
 - Building sponsorship from 4 (SCOR, SCAR, IMAS-UTas, AAD Aug. 2011), to 11 international sponsors
 - Development and implementation of a Communication Strategy
 - SOOS Initial Science and Implementation Strategy (www.soos.aq/products/strategies)
 - SOOS 20-year Vision (www.soos.aq/products/publications)
 - Draft Strategy International Under Ice observations
 - Held 11 international SOOS workshops/Steering Committee meetings/Town Halls
 - Metadata Portal (hosted by NASA GCMD)
 - 9 publications (5 in peer-reviewed literature)
 - Inclusion of SOOS in National Science Strategies (U.S.A., UK, Brazil)
 - 7 SOOS Updates, newsletter issues
 - SOOS presentations at 84 international conferences and meetings

⁸Constable, A.J., D.P. Costa, O. Schofield, L. Newman, E.R. Urban Jr., E.A. Fulton, J. Melbourne-Thomas, T. Ballerini, P.W. Boyd, A. Brandt, B. de la Mare, M. Edwards, M. Eléaume, L. Emmerson, K. Fennel, S. Fielding, H. Griffiths, J. Gutt, M.A. Hindell, E.E. Hofmann, S. Jennings, H.S. Las, A. McCurdy, B.G. Mitchell, T. Moltmann, M. Muelbert, E. Murphy, T. Press, B. Raymond, K. Reid, C. Reissy, J. Rice, I. Salter, D.C. Smith, S. Song, C. Southwell, K.M. Swadling, A. Van de Putten, and Z. Willis. 2016. Developing priority variables ("ecosystem Essential Ocean Variables" - eEOVs) for observing dynamics and change in Southern Ocean ecosystems. *Journal of Marine Systems* 161:26-41. <http://dx.doi.org/10.1016/j.jmarsys.2016.05.003>

- Endorsed 10 successful research proposals for international field projects
 - 10 reports to Sponsors and Intergovernmental Agencies (e.g., CCAMLR, Antarctic Treaty, SCAR, SCOR),
 - 27 ~monthly reports to IMAS
 - 2 International calls for SSC members
2. National Capabilities and Observation Activities (funded by SCOR): This product will compile information on national capabilities and activities produced as a user-friendly, Web-based product that will enable all users to search and identify national efforts. It will utilize existing communities (e.g., CCAMLR, COMNAP, POGO, SCAR, SCOR) to gather the information. It will also work with other communities who have plans to produce a similar product (e.g., ICED). Dr. Tom Remenyi has been hired to produce this product. It is expected that it will be available online by the end of this year.
 3. Southern Ocean Satellite Data Requirements: Community Report to Data Providers (as requested by WMO PSTG). A SOOS-CliC joint effort to produce a comprehensive report of Southern Ocean requirements for satellite data and data products. A survey was released in early 2014. SOOS and CliC are currently in discussion with two researchers familiar with satellite data and data products. If agreed, these colleagues will help produce the report from the survey results and through additional discussions with the community. A timeline for product development and release will be discussed.

2015 SOOS SSC Meeting and Open Science Conference

The 2015 SOOS SSC Meeting will be hosted by the Institute for Marine and Antarctic Studies at the University of Tasmania, Australia (IMAS-UTas) (likely Apr.–May). IMAS-UTas will also host the first SOOS Open Science Conference alongside the SSC Meeting. The structure and focus of this meeting will be scoped over the coming months. SOOS acknowledges the support provided by SCOR for the annual Scientific Steering Committee meeting, and requests that this support be continued for 2015. Continuation of the support for the SSC meeting will ensure participation by all SSC members, which is imperative for planning and implementation of SOOS objectives. SCAR also provides support for the annual SOOS SSC meeting and continuation of this support for 2015 will be requested at the upcoming SCAR Delegates meeting in August 2014.

Missy Feeley asked if there are links between the U.S. NSF OOI effort and SOOS. Bernadette Sloyan answered that the Global Ocean Observing System (GOOS) is a very complicated space. SOOS should mention GOOS. Sophie Seeyave noted that POGO provides cruise information related to national capabilities and observation activities. Ed Urban added that the POGO cruise database has a nice interface: no reason to invent something new. Raleigh Hood asked what is the relationship between SOOS and ICED. Urban replied that the interactions are good.

4.3 Data Publication Activity

Ed Urban reported that this activity is conducted by an ad hoc group of representatives from SCOR, the International Data and Information Exchange of IOC, the British Oceanographic Data Centre, the MBLWHOI Library, and the U.S. National Oceanic and Atmospheric Administration. The group met by conference call twice this year and makes presentations (oral

and poster) when the opportunity arises. It is an activity looking at publishing data sets that have been used in publications.

Reiner Schlitzer noted that data centers are assigning DOIs to data, but it is not clear whether these data have been peer-reviewed. Reviewing datasets is difficult, so there needs to be more incentive for reviewers. *Nature* recently started a database journal to try to address this problem. Ed Urban added that there is an initiative to get data accepted as one parcel that can be cited and put on CVs. Typically, a data center disaggregates data and put them in a relational database, making it difficult to get data out in a particular area of focus. Bernard Avril asked whether social science data that are not geo-referenced are being considered. Ed Urban replied that this is difficult to do.

4.4 IAPWS/SCOR/IAPSO Joint Committee on Seawater

Eugene Morozov reported that the Joint Committee on Seawater (JCS) exists to advise the International Association for the Properties of Water and Steam on issues related to seawater in industrial uses, as well as the continued scientific implementation of the TEOS-10 equations of state developed by WG 127. The group is managed by an Executive Committee of three people and has another 13 members. The group meets opportunistically at events related to their three topics of interest: seawater salinity, pH, and the relative humidity of moist air. Occasional travel support is needed by members of the JCS Executive Committee to represent the committee in pursuit of its mission.

Peter Burkill asked whether IAPSO is interested in IIOE-2 as part of its forward look. Morozov reported that IAPSO is working with organizers of IIOE-2.

4.5 GlobalHAB

Henrik Enevoldsen reported that GlobalHAB is the follow-on to the Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) project. IOC has already endorsed GlobalHAB, which will focus on meetings and other activities to help the global community of scientists working on harmful algal blooms to address issues of cooperative planning, standards, data sharing, etc. IOC has invited SCOR to co-sponsor GlobalHAB. SCOR is awaiting a decision by NSF about whether they will provide funding for the project.

5.0 CAPACITY-BUILDING ACTIVITIES

5.1 SCOR Committee on Capacity Building

Venu Ittekkot reported that the SCOR Committee on Capacity Building oversees all capacity-building activities for SCOR and bears primary responsibility for reviewing and approving requests from organizations for travel support for scientists from developing countries and countries with economies in transition. The committee met on 14 Sept. in Bremen. Several members of the SCOR Executive Committee are members of Committee on Capacity Building to reduce costs of meeting in conjunction with the annual SCOR meetings.

SCOR capacity-building activities (funded by U.S. NSF, SCOR, hosting institutions, and co-sponsors) include the following:

- SCOR Visiting Scholars
- Regional Graduate Networks for Ocean Sciences
- POGO-SCOR Visiting Fellowships for Oceanographic Observations
- Travel Grants
- Portal to Ocean CB activities
- Ocean Summer Schools Portal (IODE)
- Publications
- Meetings to coordinate international ocean CB activities

The following sections will briefly describe the most active of these activities.

Capacity Building During IIOE-2 (2015-2020)

The SCOR Committee on Capacity Building proposed the following approaches to capacity building for the IIOE-2:

- Focus on Elements of IIOE Science Plan
- Compliance with national (regional) needs and priorities
- Training Programs in cooperation with IOC (e.g. Regional Training Centers in China, India & Iran)
- Participation of young scientists and students in IIOE Cruises
- Offer of research projects leading to Master's/Ph.D. Theses
- IIOE Theme Workshops in Indian Ocean Rim Nations
- Training cruises on ships of opportunity (e.g. ships in transit)
- Global Ocean Capacity Building Meeting in the Indian Ocean Region?

Other Recommendations/Decisions from Committee on Capacity Building from 14 Sept. Meeting

- Discuss with POGO-SCOR Fellowships with POGO, with the potential initiation of a new SCOR-POGO-PICES-CPR Program
- Seek support of national representatives to disseminate information on capacity building-related activities
- Ensure wide and timely distribution of IIOE Research Plan among Indian Ocean rim nations
- Ensure sharing of SCOR CB actions and experience among oceanographic community (e.g., publications)

5.2 SCOR Visiting Scholars

SCOR has sent 15 Visiting Scholars to 10 different countries in the first 6 years of the program. The program has resulted in a significant outcome for a moderate investment, including a four-year

Research Camp at the University of Namibia that has been developed by a two-time SCOR Visiting Scholar, Kurt Hanselmann.

2014 SCOR Visiting Scholars			
Name	Home Country	Host Country	Purpose
Halima Kiwango	Tanzania	South Africa/ Kwazulu Natal	Eco-hydrology and bio-hydrodynamics of coastal ecosystems
Prasanna Kumar	India	Bangladesh	Physical oceanography
Marcia Moreno-Baez	USA	Argentina	Participatory geographic information systems and the application of geospatial technology to collect local knowledge from fishers

5.3 POGO-SCOR Visiting Fellowships for Oceanographic Observations

SCOR has co-funded this program with POGO since 2001. The program has funded more than 125 fellows so far.

SCOR Support for SCOR-POGO Fellowships			
Name	Home Country	Host Country	Topic
Ammamkuzhiyil Smitha	India	UK	Satellite data processing, interpretation and the modelling of primary production
Cozzolino Ezequiel	Argentina	USA	Advanced training in the processing of remote sensed oceanographic data
Liu Zhiyu	China	France	Study of Internal Wave Submesoscale Eddy Interactions

5.4 NSF Travel Support for Developing Country Scientists

SCOR's grant from the National Science Foundation for travel of developing country scientists to scientific meetings was renewed for three years, earlier this year. The funding is used primarily for travel grants, but also for the SCOR Visiting Scholars and POGO-SCOR Fellowships. The SCOR Committee on Capacity Building will make recommendations for meetings to be funded.

Meetings Supported Since 2013 SCOR Meeting			
Activity Name	Dates	Location	Amount granted
GRC on Interactive Effects of Multiple Global Change Variables	6-11 July 2014	Waterville Valley, NH, USA	\$4,900
Margalef Colloquium	7-18 July 2014	Barcelona, Spain	\$4,900
Challenger Society Conference	8-11 Sept. 2014	Plymouth, UK	\$4,900
Workshop on IIOE-2 Research Plan	12-13 Sept. 2014	Bremen, Germany	\$10,000
SCOR-relevant sessions at PICES annual meeting	16-26 Oct. 2014	Yeosu, Korea	\$5,000
International Conference on Harmful Algae 16	27-31 Oct. 2014	Wellington, New Zealand	\$4,900
Effects of Climate Change on the World's Ocean	23-27 March 2015	Santos City, Brazil	\$5,000
WG 139 Workshop	2015	Croatia	\$5,000

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1 Intergovernmental Oceanographic Commission (IOC)

Henrik Enevoldsen presented information about IOC and its current activities and plans. SCOR continues to co-sponsor several activities with IOC, including IOCCP (see item 4.1) and the finishing GEOHAB project (see item 3.1). A new cooperative activity with IOC is the Second International Indian Ocean Expedition.

Enevoldsen reported that UNESCO and IOC are in a difficult financial environment, which has led to some restructuring.

IOC Medium-Term Strategy functions include the following:

- Foster ocean research to strengthen knowledge of ocean and coastal processes and human impacts upon them [*Ocean research*]
- Maintain, strengthen and integrate global ocean observing, data and information systems [*Observing system / data management*]
- Develop early warning systems and preparedness to mitigate the risks of tsunamis and ocean-related hazards [*Early warning and services*]

- Support assessment and information to improve the science-policy interface [*Assessment and Information for policy*]
- Enhance ocean governance through a shared knowledge base and improved regional cooperation [*Sustainable management and governance*]
- Develop the institutional capacity in all of the functions above, as a cross-cutting function [*Capacity Development*]

IOC ocean research activities include the following:

- Microplastics— IOC is the leading agency of the Group of Experts on the Scientific Aspects of Marine environmental Protection (GESAMP) WG 40 on ‘Sources, fate and effects of micro-plastics in the marine environment’. During the last workshop in London, in July 2013, it was noted that there has been a general surge of interest in microplastics in the past five years. With the increased interest, it was also realized that there remains considerable uncertainty about inputs, fate, and effects of microplastics.
- Ocean acidification—Ocean acidification is an emerging global concern and is a risk to marine biodiversity, ecosystems, and human society. In terms of new research and networking, IOC is co-leading the Global Ocean Acidification Observing Network (GOA-ON), which is aimed to coordinate and improve ocean observation to detect the impacts of ocean acidification.
- World Climate Research Programme—IOC support to the World Climate Research Programme (WCRP) continued in 2013–2014, at a reduced level.
- International Ocean Carbon Coordination Project—The International Ocean Carbon Coordination Project (IOCCP) launched the biggest global sea surface CO₂ data set on June 2013. The Surface Ocean CO₂ Atlas (SOCAT) v2 is an outstanding product of the international marine carbon research community that provides access to synthesis and gridded CO₂ products for the ocean’s surface.
- UNFCCC/COP21—Building on its advocating role and its contribution to new science on climate change, UNESCO (with assistance from IOC), is providing leadership and advice to the organization of the next UNFCCC/COP21 (Paris, November 2015) and has formulated several key proposals for consideration of the French authorities and the UNFCCC.
- Nutrients and Coastal Impacts Research/Harmful Algal Blooms— Nutrient over-enrichment of coastal ecosystems is a major environmental problem globally, contributing to problems such as harmful algal blooms, “dead zone” formation, and fishery decline. Yet, quantitative relationships between nutrient loading and ecosystem effects are not well defined. The IOC Nutrients and Coastal Impacts Research Programme (N-CIRP) is focusing on integrated coastal research and coastal eutrophication, and linking nutrient sources to coastal ecosystem effects and management in particular.
- Global Ocean Science Report— In response to Decision 5.5.2 adopted by the IOC Assembly at its 27th session (Paris, 26 June–5 July 2013), the IOC established an open-ended Intersessional Working Group to further review and improve the Global Ocean Science Report (GOSR). IOC Circular Letter No. 2506 was sent in January 2014 with 17 Member States responding and nominating a total of 29 experts. In mid-March, the Working Group initiated its work to provide advice on direction and priorities, taking the

broader ocean science community's view and advice on the potential effectiveness of the GOSR.

- 2nd International Ocean Research Conference—The 2nd International Ocean Research Conference (IORC), to be organized by the IOC, the Oceanography Society and hosted by the Fundacio Navegacio Oceanica, will be held in Barcelona (Spain) from 17 to 21 November 2014. The five-day Conference will provide an opportunity for the scientific community to come together to plan the coming decade of international collaboration in marine science and technology, with a view to improving ocean governance.
- Core Coastal Observing Capability for the Africa— The IOC Sub-Commission for Africa and the Adjacent Island States (IOCAFRICA) has initiated the development of a proposal for a Core Coastal Observing Capability for the African Ocean Observing System taking into account the previous work, including the Regional Ocean Observing and Forecasting System for Africa (ROOFS-AFRICA).
- IOCARIBE co-operation with UNEP/other UN agencies— IOCARIBE has strengthened its co-operation with UNEP and other UN agencies, particularly in the GEF-financed Integrating Water, Land and Ecosystems Management in Caribbean SIDS (IWEco) project, where the IOCARIBE Project "Demonstrate Approaches for Nutrient and Sediment Reduction at Selected Pilot Study Areas in the Wider Caribbean," is one of the key components.

IOC Observing System/Data Management Activities

- GOOS-Argo floats-JCOMM-DBCP—Monitoring statistics of the status of the in situ networks contributing to GOOS shows a relatively stable status, reflecting continued Member State investment, with full core coverage by Argo floats, the surface drifter network coordinated by the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Data Buoy Cooperation Panel (DBCP) edging back to full coverage after a period of problems with short drifter lifetimes, completion of repeat hydrographic stations, and continued maintenance of tide gauge stations.
- GOOS Physics Panel—The GOOS physics panel (formally the GCOS-GOOS-WCRP Ocean Observations Panel for Climate, OOPC) held its 16th session on 3–5 September 2013 (Washington DC, USA), seeking guidance on drivers and priorities from sponsors, revising its Terms of Reference, and developing a work plan for 2013–2018.
- GOOS Regional Alliances—GOOS Regional Alliances (GRAs) are a major vehicle for the GOOS program to achieve its goals at the regional level. While meeting physically only at a GOOS Regional Forum about once every two years, quarterly teleconferences have allowed the GRAs to work actively and independently in the sharing of best practices and in mutual assistance in observations, data sharing and management, the provision of services and in management and advocacy of sustained ocean observing systems within a national and regional context.
- JCOMM Observations Programme Area— The JCOMM Observations Programme Area (OPA) provides important implementation coordination for GOOS. The OPA Coordination Group met on 5–7 September 2013 (Washington, D.C., USA) and worked on reviewing the architecture of the observing network data management systems and their flow into IOC and WMO data management systems, promoting standards and best practice, developing links to ocean glider operators, links to the International Telecommunications Union (ITU)-IOC-WMO Joint Task Force for submarine cable

observations, and the management of the JCOMM Observing Programme Support Centre (JCOMMOPS).

- JCOMMOPS—JCOMMOPS has continued its technical support and coordination of in situ observing networks with its two former IOC/UNESCO coordinators now WMO employees. The French hosting of JCOMMOPS is planned, through agreement by the IOC and WMO, to move from Toulouse to Brest, France by the end of 2014, improving opportunities for coordination with national and European in situ networks.
- Global Climate Observing System (GCOS)—The WMO-IOC-ICSU-UNEP Global Climate Observing System (GCOS) underwent a review in 2013. The review found that GCOS should continue, that it was indispensable, but that it would benefit from a more succinct mission statement. The review proposed that a revised Memorandum of Understanding between its sponsors should reflect the environment in which GCOS operates today.
- International Training Centre for Operational Oceanography—During the 27th Session of the IOC Assembly, a Memorandum of Agreement was signed between the Government of India and the IOC for the establishment of the International Training Centre for Operational Oceanography (ITCOcean) in Hyderabad, India. The Centre will operate as a contribution to IOC's training and capacity-development activities mainly in the Indian Ocean rim countries. It will initially cooperate with the IODE program and focus on establishing a regional training center as part of the new OceanTeacher Global Academy.

Ed Urban asked about the timetable for announcement of the new IOC Executive Secretary. Enevoldsen answered that the short list has been completed and forwarded to the UNESCO Secretary General, who will make the final decision. Peter Burkill stated that the relationship between SCOR and IOC is going well, but are there any areas that could be improved. Enevoldsen responded that, since the inception of the relationship between SCOR and IOC, both organizations have had similar approaches to addressing key issues. It is important to keep our open dialog. It is recognized by the IOC Secretariat that the relationship with SCOR is important.

6.2 International Council for Exploration of the Seas

Wolfgang Fennel provided some brief comments about ICES. Their annual meeting conflicts with the SCOR meeting dates, so they could not send anyone to the SCOR meeting. The scientific aim of ICES is to understand how physical, chemical, and biological oceanographic processes affect fish stock dynamics. In the past, there was very good cooperation of SCOR and ICES in terms of working groups and GLOBEC. In the past two decade ICES was restructured several times. As a side effect, physical oceanographers lost interest. Among 18 theme sessions in the ICES Annual Science Conference in 2014, only one is dealing with physical oceanography. Fennel suggested that SCOR keep inviting ICES to participate in annual SCOR meetings. If a new working group proposal is submitted with a focus on the upper part of the food web, cooperation may become revitalized.

Raleigh Hood noted that there is a nice connection of IMBER and ICES, and that there could possibly be an IMBER session at an annual ICES meeting. Peter Burkill asked Bernard Avril if this would be feasible. Avril responded that ICES has supported some IMBER sessions at annual

meetings. Hal Batchelder responded that PICES also has an issue with maintaining the participation of physical oceanographers.

6.3 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)

GESAMP is a consortium of UN bodies that can ask for advice on a range of topics. NSF provide some funding to SCOR for GESAMP activities. Ed Urban reported that NSF provided funds for SCOR to co-sponsor GESAMP Working Group 38 on Atmospheric Input of Chemicals to the Ocean. The group is in its second phase, in which a workshop was held, which may result in as many as 8 peer-reviewed publications. Hal Batchelder noted that GESAMP is active with PICES, co-sponsoring joint sessions at 7 out of the last 8 PICES annual meetings.

6.4 North Pacific Marine Science Organization (PICES)

SCOR has long-standing cooperation with PICES, which has helped SCOR-sponsored international projects with implementation in the North Pacific region. PICES has sponsored Associate Members of SCOR working groups of interest to PICES and has cooperated with SCOR in various capacity-building activities. PICES just went through a program review that might result in restructuring of its governance. Peter Burkill stated that SCOR appreciates its partnership with PICES.

7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

7.1 International Council for Science

7.1.1 International Geosphere-Biosphere Program (IGBP)

Ed Urban attended the 2014 IGBP Science Committee meeting in Hyderabad, India, to represent SCOR. IGBP is working on synthesis of its second phase activities and assisting Future Earth in its development. IGBP currently is co-sponsoring the SOLAS and IMBER projects, and WG 138.

Peter Burkill stated that the greatest concern for SCOR with the transition to Future Earth is the impact of the Future Earth on SOLAS and IMBER. Wendy Broadgate responded that there is still uncertainty with this change. IGBP hopes to have an overlap with Future Earth. IGBP is trying to disseminate information about Future Earth to the broader community. Future Earth recognizes the need for fundamental science after some initial mixed messages on this point. The core science projects can decide to join Future Earth or not. Ed Urban added that over the last 14 years, SCOR has had a great relationship with IGBP. It is a good example of partnership between organizations within ICSU. Bernard Avril agreed with this comment

7.1.2 World Climate Research Programme (WCRP)

WCRP co-sponsors the SOLAS project and plans to continue as a co-sponsor after IGBP sunsets and the Future Earth initiative becomes a co-sponsor of SOLAS. Peter Burkill asked Wolfgang

Fennel, the SCOR Liaison with WCRP, whether he was satisfied with SCOR's relationship with WCRP and Fennel answered affirmatively.

7.1.3 Scientific Committee on Antarctic Research (SCAR)

SCOR cooperation with SCAR is particularly in relation to the Southern Ocean Observing System, but SCAR conducts several other activities that may interest SCOR. Peter Burkill noted that SCOR and SCAR are to be reviewed by ICSU at the same time. We need to make sure that we have a clear understanding of SCOR relationship with SCAR before the ICSU review and Burkill asked that participants let Ed Urban know if you have any comments or issues about this relationship. Maria van Leeuwe (Netherlands) remarked that WG 140 on Sea Ice is considering developing an Expert Group with SCAR.

7.1.4 Future Earth Initiative

Diana Greenslade, from the Future Earth Secretariat at ICSU, presented an update about Future Earth. The Future Earth initiative continues developing, including announcement of a permanent distributed network structure and awarding of a group of grants for fast-track initiatives/clusters, which are cross-cutting projects among several potential Future Earth co-sponsored projects. SCOR is working with Future Earth to develop a mutually acceptable working arrangement in relation to SOLAS and IMBER.

Motoyoshi Ikeda led a discussion of potential interactions between SCOR and Future Earth. Future Earth sounds reasonable but its actual actions are uncertain. Its initial research themes focus on transformation towards sustainability. However, sustainability is not defined clearly and Future Earth's scientific approach is not well identified. A central theme of Future Earth is that natural scientists should collaborate with social scientists, but how can this be accomplished?

Peter Burkill noted that this is an important topic. SCOR does have some interaction with social scientists through IMBER and IIOE-2. Raleigh Hood added that there is a danger that IMBER may be pulled in the social science direction more than it should. IMBER currently has a good balance between natural science and social science and it would be good to maintain the current balance. Bernard Avril noted the Human Dimensions Working Group of IMBER is becoming more active. IMBER is waiting to present a plan to Future Earth, but Future Earth may push IMBER too far. In the Human Dimension Working Group, IMBER needs more connections with social scientists. It is difficult to find social scientists to participate. Ed Urban noted that he had worked with social scientists in his previous job, so he understands the costs and benefits of natural science-social science interactions. There is a certain "transactional cost" in developing a shared language between the two fields. Funding from Future Earth is a "zero sum game" that will require taking money from fundamental science to fund more interactions with social scientists, unless more funding can be developed. SCOR national committees do not currently include social scientists. We have discussed adding a social scientist to the SCOR Executive Committee, although this may not be a high priority give other issues that the Executive Committee needs to handle. Colin Devey noted that Martin Visbeck is coming to the workshop tomorrow representing a German program called Future Ocean that links natural science and social science. We should ask Martin how Future Ocean works out this relationship. Emilie Breviere added that Future Earth provides opportunities for interactions with social scientists. Claudia Mengelt suggested that we need to recognize that there is a lot of social

science basic research going on, particularly around EOVS. Bernard Avril added that on the topic of ocean acidification, Future Earth has helped to build bridges between basic science and social sciences. SCOR should consider inviting a social scientist to SCOR annual meetings.

7.2 Affiliated Organizations

7.2.1 International Association for Biological Oceanography (IABO)

Sun Song presented an update about IABO. IABO's main activity this year is to help convene the World Conference on Marine Biodiversity 2014 in Qingdao, China, which will also serve as the IABO General Assembly. SCOR has provided some support to this meeting for travel of developing country scientists. IABO has requested SCOR working groups and other activities to help keep the World Register of Marine Species (WoRMS) updated, and welcomes new subscribers to the IABO email list. SCOR agreed to send a message to working group chairs alerting them to the offer from IABO to add them to the IABO email list.

7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS)

Athena Coustenis, the President of IAMAS, provided an update about the organization's activities. The international Commission on Atmospheric Chemistry and Global Pollution of IAMAS co-sponsors SOLAS.

7.2.3 International Association for the Physical Sciences of the Oceans (IAPSO)

Eugene Morozov, the President of IAPSO, provided an update about the organization's activities. SCOR and IAPSO have co-sponsored many working groups in the past, including the most recent ones noted in the IAPSO report: SCOR/IAPSO WG 127 on The Thermodynamics and Equation of State of Seawater and SCOR/WCRP/IAPSO WG 136 on The Climatic Implications of the Greater Agulhas System.

7.3 Affiliated Programs

7.3.1 InterRidge - International, Interdisciplinary Ridge Studies

Missy Feeley, SCOR Liaison with InterRidge, presented a report about the project. InterRidge has been a long-time affiliated program of SCOR, and the two organizations are co-sponsoring WG 135 on Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles. WG 135 has held its final meeting and will be disbanded after its second paper is completed.

Feeley noted that InterRidge did not submit an annual report. The InterRidge office moved from the United Kingdom to China in 2013, hosted by the Institute of Theoretical and Applied Geophysics, Peking University, Beijing, for a three-year term (2013-2015). The InterRidge co-chairs are Prof. John Chen and Dr. Jiabiao Li.

Colin Devey added that InterRidge may be a victim of its own success, in that the question is being asked if it still needs to exist because it has done so much. There is a steering committee meeting at the end of September 2014. National programs in United States and Germany have wound down. It is not clear whether InterRidge will continue. Raleigh Hood suggested that

InterRidge may be interested in interacting with IIOE-2 to provide a connection to the Indian Ocean community.

7.3.2 International Ocean Colour Coordinating Group (IOCCG)

John Volkman presented an update about IOCCG. SCOR co-sponsors various IOCCG activities through support from the U.S. National Aeronautics and Space Administration. Currently, the SCOR/IOC GEOHAB project and IOCCG are co-sponsoring a project on applications of remote sensing to detection of harmful algal blooms. SCOR recently provided support for developing country scientists to participation in the IOCCG Summer Lecture Series. Ed Urban noted that grants from NASA for IOCCG are managed by SCOR.

7.3.3 Global Alliance of CPR Surveys (GACS)

Peter Burkill presented an update about the Global Alliance of CPR Surveys (GACS), which is SCOR's newest affiliated program. GACS continues work toward fulfilling its goals of providing a global network of Continuous Plankton Recorder surveys and has achieved some success in helping establish new CPR surveys and providing training for people responsible for these new surveys.

Ed Urban noted that SCOR has approved a SCOR Visiting Scholar for training on the CPR in India, and has contributed funds for CPR training for one or two developing country scientists at SAHFOS in Plymouth. Raleigh Hood asked what would be needed to fund new lines. Peter Burkill responded that the best way to go is for a country to buy the CPR (US\$8,000), run the routes, and then send the data to SAHFOS. It is then evaluated for quality. The training of in-country staff in taxonomic analysis is very important. Satheesh Shenoi added that there are currently CPR lines being run in the Indian Ocean (near Chennai) to look at species compositions.

7.4 Other Organizations

7.4.1 Partnership for Observation of the Global Oceans (POGO)

Sophie Seeyave, the Executive Director of POGO, provided an update about the organization's activities. SCOR and POGO have many areas of mutual interest and have a good history of cooperation over the 15 years of POGO's existence. The two organizations have co-sponsored a fellowship program for ocean observations since 2001 and currently are working together to develop the International Quiet Ocean Initiative (see item 3.5). SCOR and POGO also work together in relation to global capacity building for ocean science.

Ed Urban presented some ideas for leveraging SCOR funding in capacity building and to create increased linkages with POGO. It could be possible to involve past POGO-SCOR fellows in SCOR as Associate members, as it would be difficult to add them as Full Members. POGO should be involved in IIOE-2 capacity building as a major contributor to ocean science capacity building worldwide. It would be a great idea to convene a strategy meeting in 2015, as SCOR has done previously, for which each organization provides funding for their participants.

Sophie Seeyave noted that POGO is going to re-examine its capacity-building investments. It currently costs about 3,000 euro for each POGO-SCOR fellowship recipient. Emilie Breviere asked how many applications are received for the POGO-SCOR fellowships. Sophie Seeyave responded that the number of applications has decreased in the past few years, indicating that the fellowships may not be financially attractive. For instance, cost for accommodations has increased. Peter Burkill suggested that Ed Urban and Sophie Seeyave continue this discussion offline.

7.4.2 Marine Working Group of the International Arctic Science Committee

Wolfgang Fennel noted that SCOR had occasional discussions with Arctic Ocean Science Board and its successor, the Marine Working Group of the International Arctic Science Committee about establishing a more formal liaison or relationship between the two organizations. Those discussions have not yet been fruitful, but we will continue to communicate with the MWG when SCOR approves working groups or other activities with Arctic elements.

Peter Burkill remarked that the “ball is in their court” to establish a more formal relationship with SCOR. Ed Urban added that SCOR is looking for a science link for the Arctic similar to the one we have with SCAR for the Antarctic. Paul Myers suggested that there may be a link through observing systems at the Atlantic and Pacific gateways to the Arctic Ocean. There is a high level of interest in observing systems with biogeochemical capabilities at these gateways.

New Activities / Discussion Topics

Some time was devoted to potential new topics that SCOR could undertake.

The first discussion was related to a workshop that SCOR is planning related to benthic environments. This was identified as a topic that is not being adequately covered by existing SCOR activities. Colin Devey remarked that it will be important to include participants from the Southern Hemisphere. Ed Urban replied that there is currently a big gap in proposed participants from the Southern Ocean. Bernadette Sloyan suggested that SCOR should take a look at the White Paper by Eric Lindstrom on Deep Ocean Observing. Peter Burkill noted that this community may feel “ostracized” by larger programs and organizations, which is why we are trying to increase SCOR involvement in this area. Bernard Avril suggested that SCOR take a look at PAGES and IODP efforts. Karen Heywood suggested that the workshop should include physical, biological, and chemical oceanography participants. Ed Urban responded that we want and need to go beyond discussions of marine biodiversity. Satoru Taguchi added that the workshop should also consider hydrothermal vents.

8.0 ORGANIZATION AND FINANCE

8.1 Membership

8.1.1 National Committees

Since the 2013 SCOR Annual Meeting, the following changes were made to national SCOR committees:

- AUSTRALIA: Bernadette Sloyan replaced Trevor McDougall as a Nominated Member
- ECUADOR: Edwin Pinto, Nikita Gabor, and M. Pilar Cornejo R. de Grunauer were replaced by Leonor Vera San Martin, Mario Hurtado, and Francisco Medina as Nominated Members.
- FINLAND: Timo Vesala replaced Kimmo Kahma as a Nominated Member

Peter Burkill remarked that SCOR is always interested in expanding the number of national SCOR committees. Please provide ideas on new countries to Ed Urban.

8.2 Publications Arising from SCOR Activities

SCOR projects and working groups have produced many publications in the past year. The following are some publications that resulted from SCOR working groups and other activities, but this list does not include the many publications that resulted from SCOR research projects.

- Denman, K., R. Feely, J.-P. Gattuso, H.-O. Pörtner, U. Riebesell, D. Schmidt, and A. Waite. The ocean in a high-CO₂ world III. Special issue of *Biogeosciences* http://www.biogeosciences.net/special_issue129.html.
- Liu, J., S. Swart, P.V. Bhaskar, L. Newman, M. Meredith, O. Schofield and J. He. 2014. The SOOS Asian Workshop on Southern Ocean research and observations. *Advances in Polar Science* 25(2):121-125.
- Morrison, R.J., J. Zhang, E.R. Urban Jr., J. Hall, V. Ittekkot, B. Avril, L. Hu, G.H. Hong, S. Kidwai, C.B. Lange, V. Lobanov, J. Machiwa, M.L. San Diego-McGlone, T. Oguz, F.G. Plumley, T. Yeemin, W. Zhu, and F. Zuo. 2013. Developing human capital for successful implementation of international marine scientific research projects. *Marine Pollution Bulletin* 77:11-22.
- Steiner, N.S., J.R. Christian, K.D. Six, A. Yamamoto, and M. Yamamoto-Kawai. 2014. Future ocean acidification in the Canada Basin and surrounding Arctic Ocean from CMIP5 earth system models. *Journal of Geophysical Research: Oceans* 119:1-16.
- Swart, S. J. Liu, P. Bhaskar, L. Newman, K. Finney, M. Meredith and O. Schofield. 2014. The SOOS Asian Workshop: Exploring possibilities for collaboration. *Advances in Polar Science* 25(2):126-132.

Several other special issues and papers have either been submitted or will be submitted soon, so they will be published in the coming year.

8.3 Finances

The SCOR Executive Committee approved a Finance Committee consisting of Colin Devey (German), Karen Heywood (UK), Motoyoshi Ikeda (Japan), and Paul Myers (Canada). This committee conducted its work during the SCOR meeting and reported near the end of the meeting on (1) findings related to the 2013 Audit report (Appendix 12), (2) recommendations for revisions to the 2014 SCOR budget, (3) recommendations for the 2015 SCOR budget, and (4) recommendations for dues levels in 2016.

The findings and recommendations of the SCOR Finance Committee, and decisions of meeting participants, are as follows:

- The final financial report for 2013 showed that the total discretionary income of about US\$380,000 was comprised of \$330,000 from membership dues and an additional \$50,000 from the U.S. National Science Foundation and other sources. Total discretionary expenses of about \$341,500 were comprised of administrative expenses of about \$280,000, working group expenses of about \$30,000, and other science expenses of about \$31,500. The excess of income over expenses increased the end-of-year cash balance from \$171,000 (end 2012) to \$212,000 (end 2013).
- The audited 2013 financial statements showed that total income (discretionary plus flow-through) for SCOR was US\$1,140,581 (\$1,529,211 in 2012) and the total expenses were US\$1,099,941 (\$1,509,976 in 2012). There was a US\$40,640 surplus (\$19,235 surplus in 2012) in accordance with 2013 audit. The end-of-year total assets in 2013 were US\$446,609 (this includes some money promised but not yet received, e.g. unpaid dues). The end-of-year cash balance for 2013 was US\$ 212,000 (up from US\$171,000 end 2012). The Finance Committee recommended that meeting participants accept the final 2013 financial report and meeting participants approved.
- The Finance Committee considered the report of the auditors on the 2013 SCOR financial statements. The auditor found no accounting discrepancies (and found SCOR a low-risk auditee). The Finance Committee found the Auditor's report in accordance with the SCOR financial report, and there are no special remarks in the Audit to consider.
- The Finance Committee presented proposed changes to the 2014 SCOR budget. The discretionary income for SCOR activities was budgeted to US\$461,000. The proposed revised budget would reduce income to US\$435,000. The difference was due to a reduction in estimated dues to be received, partly balanced by an increased use of NSF funds and co-funding from other organizations. The 2014 discretionary expenses were budgeted at US\$490,000. In the revised budget, expenses were reduced to US\$457,000, due to lower than expected working group expenses. The end-of-the-year cash balance 2014 was originally budgeted at US\$195,000. The proposed changes would reduce the ending cash balance to US\$180,000. The Finance Committee recommended approval of the revised budget and meeting participants approved.
- The Finance Committee examined the draft 2015 SCOR budget for discretionary funds. The cash balance is estimated to come down at the end of 2015 from the projected \$180,000 at the end of 2014 to US\$93,000 at the end of 2015. This is slightly below the set minimum cash balance of US\$100,000. However, the Finance Committee concluded that it is unrealistic to expect this decrease to occur fully and hence recommended that three working groups could be approved. The Finance Committee recommended acceptance of the proposed budget for 2015 and gratefully recognized the Executive Committee for taking pro-active measures to stimulate scientific research on the ocean by approving three working group proposals. Meeting participants approved the proposed 2015 budget.
- The Finance Committee summarized that the cash situation for 2014 allows the planned establishment of three new working groups in 2015 and we can expect to be able to fund at least two new working groups to begin in 2016. The working group underspending still continues, but not to the extent seen in 2013. SCOR has taken measures (new initiatives,

three working groups approved in 2014) to seize this opportunity to support more science activities.

- The Finance Committee recommended that the dues in 2016 be increased by 3% from 2015 levels, as has been the practice in recent years. Meeting participants agreed with this recommendation.

9.0 SCOR-RELATED MEETINGS

9.1 SCOR Annual Meetings

9.1.1 2014 General Meeting: Bremen, Germany

Peter Burkill thanked the German SCOR Committee and local hosts at MARUM for hosting the meeting and for providing excellent logistical support. Ed Urban presented gifts to the local hosts from SCOR in recognition of SCOR's appreciation.

Peter Burkill thanked those members who were rotating off the Executive Committee—Mary (Missy) Feeley (USA), Satoru Taguchi (Japan), and John Volkman (Australia), and Ed Urban presented them gifts from SCOR.

9.1.2 2015 Executive Committee Meeting: Goa, India

The SCOR Executive Committee meeting will be held in Goa, India on 7-9 December 2015, immediately following the symposium in Goa designed to celebrate the Golden Jubilee of the National Institute of Oceanography, the legacy of the International Indian Ocean Expedition, and the launch of the Second International Indian Ocean Expedition.

Satheesh Shenoi welcomed everyone to attend the 2015 SCOR Annual Meeting in Goa. The weather should be great. He stated that he hoped that everyone would enjoy their stay and would attend the IIOE-2 Symposium.

9.1.3 2016 General Meeting: Sopot, Poland

There was no discussion of the 2016 Annual Meeting in Poland.

9.1.4 2017 Executive Committee Meeting

Peter Burkill asked if there were any potential locations for 2017 SCOR Annual Meeting. SCOR has never met in Belgium, Taipei, Pakistan, or Turkey. Karen Heywood noted that an annual meeting could be held in the United Kingdom in the next few years. Ed Urban noted that SCOR tries to move its annual meetings around to different regions and different SCOR member nations.

Peter Burkill closed the meeting at 12:49 p.m. on 17 September 2014.

Appendix 1 Participants

SCOR Executive Committee:

President:

Peter Burkill (NM)

Drake Circus
Plymouth University
Plymouth PL4 8AA
UNITED KINGDOM
Email: peter.burkill@plymouth.ac.uk

Secretary:

Mary (Missy) Feeley (NM)

Exxon Mobil Exploration Company (ret.)
3016 Morrison
Houston, Texas 77009
USA
Email: maryfeeley@att.net

Past-President:

Wolfgang Fennel (NM)

Baltic Sea Research Institute
Seestr. 15
Rostock 18119
GERMANY
Phone: +49-381-51978
Fax: +49-381-51978-114
Email: wolfgang.fennel@io-warnemuende.de

Vice Presidents:

Satoru Taguchi (NM)

Department of Environmental Engineering for
Symbiosis
Soka University
1-236 Tangi-Cho, Hachioji, Tokyo 192-8577
JAPAN
Phone: +81 42 691 8002
Fax: +81 42 691 8002
Email: staguchi@soka.ac.jp

John Volkman (NM)

CSIRO Marine and Atmospheric Research
GPO Box 1538
Hobart, Tasmania 7001
AUSTRALIA
Phone: +61-3-62325281
Fax: +61-3-62325090
Email: johnkvolkman@gmail.com

Ex-Officio Members:

Athena Coustenis (IAMAS)

LESIA (Bat. 18)
Observatoire de Paris-Meudon
5, place Jules Janssen
92195 Meudon Cedex
FRANCE
Tel: +33145077720
Email : athena.coustenis@obspm.fr

Eugene Morozov (IAPSO)

Shirshov Institute of Oceanology
Pokrovka street 20 apt 27
Moscow 101000
RUSSIA
egmorozov@mail.ru
Tel: +7 967 133 1880

SCOR Secretariat:

Ed Urban

Executive Director
SCOR Secretariat
Robinson Hall
College of Earth, Ocean, and Environment
University of Delaware
Newark, DE 19716 USA
Phone: +1-302-831-7013
Fax: +1-302-831-7012
Email: ed.urban@scor-int.org

Other Participants:**Md. Kawser Ahmed**

University of Dhaka
Curzon Hall Campus
Dhaka 1000
BANGLADESH
kawser@univdhaka.edu

Riitta Autio (NM)

Erik Palmenin aukio 1, SYKE
Helsinki, 00560
FINLAND
riitta.autio@ymparisto.fi

Harold (Hal) Batchelder

North Pacific Marine Science Organization
(PICES)
9860 West Saanich Road
Sidney, BC, V8L 4B2
CANADA
hbatch@pices.int

Sukru Besiktepe

Dokuz Eylul University
Baku Bulvarı 100 inciralti
Izmir, 35340
TURKEY
sukru.besiktepe@deu.edu.tr

Emilie Breviere

SOLAS International Project Office
Duesternbrooker Weg 20
Kiel, 24105
GERMANY
ebreviere@geomar.de

Wendy Broadgate

IGBP Secretariat
Royal Swedish Academy of Sciences
Box 50005
Stockholm, SE 104 05
SWEDEN
wendy@igbp.kva.se

Nick D'Adamo

Intergovernmental Oceanographic
Commission of UNESCO
Level 5
1100 Hay Street
West Perth, Western Australia, 6005
AUSTRALIA
nick.dadamo@bom.gov.au

Colin Devey (NM)

GEOMAR
Wischhofstr. 1-3
Kiel, 24148
GERMANY
cdevey@geomar.de

Henrik Enevoldsen

Intergovernmental Oceanographic
Commission of UNESCO
Universitetsparken 4
Copenhagen, 2100 Ø
DENMARK
h.enevoldsen@unesco.org

Marta Estrada (NM)

CSIC
Institut de Ciències del mar, CSIC
Pg. marítim de la Barceloneta, 37-49
Barcelona, 08003
SPAIN
marta@icm.csic.es

Toshitaka Gamo (NM)

The University of Tokyo
5-1-5 Kashiwanoha
Kashiwa, Chiba, 277-8564
JAPAN
gamo@aori.u-tokyo.ac.jp

Karen Heywood (NM)

School of Environmental Sciences
University of East Anglia
Norwich, NR4 7TJ
UNITED KINGDOM
k.heywood@uea.ac.uk

Raleigh Hood

University of Maryland Center for
Environmental Science
HPL/UMCES
PO Box 775
Cambridge, MD 21613
USA
rhood@umces.edu

Motoyoshi Ikeda (NM)

Hokkaido University
Takatsu-ku, Shimosakunobe, 6-4-20
Kawasaki, 213-0033
JAPAN
miked@ees.hokudai.ac.jp

Venugopalan Ittekkot

Berner Chaussee 114
Hamburg, 22175
GERMANY
ittekkot@uni-bremen.de

Ian Jenkinson

Institute of Oceanology
Chinese Academy of Sciences
7 Nanhai Road
Qingdao, Shandong, 266071
PEOPLE'S REPUBLIC OF CHINA
ianjenkinson@qdio.ac.cn

Annette Kock

GEOMAR Helmholtz Centre for Ocean
Research Kiel
Duesternbrooker Weg 20
Kiel, 24118
GERMANY
akock@geomar.de

Yanwei Li

Institute of Oceanology
Chinese Academy of Sciences
7 Nanhai Road
Qingdao, Shandong, 266071
PEOPLE'S REPUBLIC OF CHINA
yanweili@qdio.ac.cn

Mike Lucas

University of Cape Town
Dept. of Biological Sciences
University of Cape Town
Rondebosch, Western Cape, 8801
SOUTH AFRICA
mikelucasuct@gmail.com

Giuseppe Manzella (NM)

National Research Council
Via Montefrancio 81
Castelnuovo Magra, 19033
ITALY
giuseppe.manzella@ettsolutions.com

Michael McPhaden

NOAA/PMEL
7600 Sand Point Way NE
Seattle, WA, 98115
USA
michael.j.mcphaden@noaa.gov

Claudia Mengelt

National Academy of Sciences/Ocean
Studies Board
500 Fifth Street NW
Washington, DC, 20001
USA
cmengelt@nas.edu

Paul Myers (NM)

University of Alberta
Department of Earth and Atmospheric
Sciences, 1-26
Edmonton, Alberta, T6G2E3
CANADA
pmyers@ualberta.ca

Johan Rodhe (NM)

Univ. of Gothenburg
Box 100
Göteborg, 405 30
SWEDEN
johan.rodhe@gu.se

Reiner Schlitzer

Alfred Wegener Institute
Am Alten Hafen 26
Bremerhaven, 27568
GERMANY
Reiner.Schlitzer@awi.de

Michael Schulz

MARUM - Center for Marine
Environmental Sciences
University of Bremen
Leobener Str.
D-28334 Bremen
GERMANY
mschulz@marum.de

Sergey Shapovalov (NM)

P.P. Shirshov Institute of Oceanology
36 Nakhimovsky ave
Moscow, 117997
RUSSIA
smshap@ocean.ru

Bernadette Sloyan (NM)

CSIRO Ocean and Atmosphere Flagship
GPO Box 1538,
Hobart, Tasmania, 7001
AUSTRALIA,
Bernadette.Sloyan@csiro.au

Song Sun (NM)

Institute of Oceanology
Chinese Academy of Sciences
7 Nanhai Road
Qingdao, 266071
PEOPLE'S REPUBLIC OF CHINA
sunsong@qdio.ac.cn

Xiaoxia Sun

Institute of Oceanology
Chinese Academy of Sciences
7 Nanhai Road
Qingdao, 266071
PEOPLE'S REPUBLIC OF CHINA
xsun@qdio.ac.cn

Toste Tanhua

GEOMAR Helmholtz Centre for Ocean
Research Kiel
Düsternbrooker Weg 20
Kiel, 24105
GERMANY
ttanhua@geomar.de

Bilge Tutak (NM)

TUBITAK
TUBITAK MAM CTUE
Kocaeli, Gebze, 41470
TURKEY
bilge.tutak@tubitak.gov.tr

Oliver Wurl

Institute for Chemistry and Biology of the
Marine Environment
Emsstrasse 20
Wilhelmshaven, 26382
GERMANY
oliver.wurl@uni-oldenburg.de

Sinjaee Yoo (NM)

KIOST
sungbog 1ro 300
Yong-In, 41 - Gyeonggido, 448140
SOUTH KOREA
sinjae.yoo@gmail.com

NM = Nominated Member

Appendix 2 Agenda

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2.2.5	WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean	Urban
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2.3.2	Towards comparability of global oceanic nutrient data (COMPONUT)	Naqvi
2.3.3	International Network for the Study of How Organisms Respond to Environmental change (INSHORE)	Feeley
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6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

- 6.1 Intergovernmental Oceanographic Commission (IOC) Enevoldsen, Burkill
- 6.2 International Council for Exploration of the Seas Fennel
- 6.3 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Urban
- 6.4 North Pacific Marine Science Organization (PICES) Batchelder, Taguchi

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- | | | |
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| 7.2 | Affiliated Organizations | |
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- | | | |
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| | Member Nations and Nominated Members | |
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- | | | |
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Appendix 3

Proposal for a Working Group on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)

1 Summary

Trace elements are important in the world's oceans and near-shore environments as nutrients, tracers, and contaminants. The dissolution of anthropogenic CO₂, a component in the oceanic carbon cycle, is a cause of ocean acidification. Despite the importance of chemical speciation in these marine biogeochemical processes and their consequences for global change, the available models and other calculation tools – often based upon the Pitzer equations – are relatively fragmented and are usually restricted to particular chemical compositions and ranges of temperature and pressure. The models are often neither user-friendly nor freely available, and the community lacks a comprehensive evaluation that relates the capabilities of speciation models to current needs in chemical oceanography (e.g., programmes such as GEOTRACES). To address these problems we will review and document the current status, uncertainties, and basis in laboratory measurements of Pitzer models of seawater and complexation of trace metals (including micronutrients such as Fe, Cu, and Zn). We will define their current capabilities and limitations for oceanographic and biogeochemical calculations, and establish requirements for the future. We will consult widely and develop a specification for a set of speciation models and associated documentation that will be interactive and web-based. Making use of our previous very successful work in this area (and with external funding) we will create the website and associated tools. This requires a coordinated international effort, particularly to ensure that the modelling tools meet the needs of a wide range of potential users in both research and capacity building. A SCOR Working Group is the ideal mechanism for this development.

2 [Background and Rationale](#)

2.1 Speciation models and data

Chemical speciation is defined as the distribution of a chemical element between different molecular and ionic forms in seawater. It determines the reactivity and bioavailability of the elements in seawater, and is key to our understanding of biogeochemical and acidification processes in the ocean. It is necessary to model speciation in order to predict how the rate and extent of chemical reactions in the global ocean will be affected by increasing temperature and decreasing pH.

The form in which a trace element or other component of seawater is present, and its tendency to react, depends on its *activity* (Clegg and Whitfield, 1991). This is the product of its concentration (usually molality) and an activity coefficient (γ) which is a complex function of temperature, pressure, and salinity (or, more generally, solution composition). Many of the important reactions in seawater involve acid-base equilibria, which introduces pH as a further variable. Changing pH is also at the heart of the process and effects of CO₂ uptake by the oceans, and of the speciation of dissolved inorganic carbonate. The definitions of pH and the use of buffers to calibrate pH instruments, and the relationship of measured pH to that calculated using thermodynamic models of seawater, are complex and not always appreciated.

It is desirable to be able to calculate pH, and the activities and speciation of all seawater components, within a unified framework that, (i) includes the major and trace elements in seawater and its mixtures with freshwaters, (ii) encompasses the buffers that are used to calibrate pH and other instruments, and (iii) can be extended to include other saline environments such as brines and pore waters. Progress has been made towards this goal, mainly in the 1980s and 1990s, and today the principal chemical speciation model of seawater is that of Millero and co-workers at the University of Miami (Waters and Millero, 2013, and references therein; see also Clegg and Whitfield, 1995). The model uses the equations of Pitzer (1991) to calculate activity coefficients, and is applicable primarily to major ion seawater (from 0 to 50°C, and 0 to >40 salinity) containing the species H⁺, Na⁺, K⁺, Mg²⁺, Ca²⁺, Sr²⁺, Cl⁻, Br⁻, OH⁻, HCO₃⁻, B(OH)₄⁻, HSO₄⁻, SO₄²⁻, CO₃²⁻, CO₂, B(OH)₃, and H₂O.

The measurements that are used to build models of mixtures such as seawater include: solvent and solute activities, apparent molar enthalpies and heat capacities (yielding the variation of the model parameters with temperature), apparent molar volumes (yielding the variation of the parameters with pressure), and other data. Complexation of trace metals by a number of ligands, both inorganic and organic, has been measured in artificial seawaters or simplified analogues (e.g., $\text{NaCl}_{(\text{aq})}$), but usually over restricted ranges of concentration, at a single temperature (often 20 or 25°C), and only at atmospheric pressure. The results often depend on the methods used to make the measurements.

The numbers of new studies yielding the activity, thermal, and volumetric data and stability constants needed to develop our quantitative understanding of speciation in the oceans have been in decline for many years, even as the need to model the biogeochemistry and especially the carbonate chemistry of the oceans has become greater. The numbers of skilled experimenters and modellers have also fallen. Furthermore, there is no comprehensive evaluation that relates the capabilities of speciation models, and the measurements upon which they are based, to current and future needs in chemical oceanography as exemplified in current programmes such as GEOTRACES. **Objective 1** of this working group is therefore to document the current status, and basis in laboratory measurements, of Pitzer models of seawater and estuarine water and the complexation of key trace metals including Fe, Cu, Mn, Cd, Mn, and Zn. We will define current capabilities and limitations for oceanographic and biogeochemical calculations, and establish what is needed (in both laboratory measurements and modelling) to meet future requirements. The associated **Objective 2** is to provide a database of Pitzer model parameters and equilibrium constants for seawater (and their variation with temperature and pressure), including trace metal complexation, which can be used by skilled practitioners. The uncertainties, and the effects on calculated properties such as pH, will be evaluated.

2.2 Applications in research and capacity building

The use of computer programs to carry out chemical speciation and other complex calculations for aqueous solutions and natural waters has traditionally involved obtaining the program from the authors, understanding input and output facilities intended only for the authors' use, and learning to use the program with few instructions. These obstacles have hampered the use of state-of-the-art models and the spread of best practice in modelling.

The World Wide Web is the ideal means of making modelling tools universally available for interactive use – with a variety of user interfaces suitable for the problems being solved and the skills of the user – and for providing the supporting information and tutorials needed by both researchers and students. For example the ecological modelling package ERSEM (European Regional Seas Ecosystem Model) has just been released as a freely available download to the marine science community (see <http://www.shelfseasmodelling.org/>). One of us (SLC) has over 15 years' experience providing chemical speciation and gas/liquid/solid equilibrium models that can be used *interactively* on the web (the Extended Aerosol Inorganics Model (*E-AIM*: <http://www.aim.env.uea.ac.uk/aim/aim.php>, see Wexler and Clegg, 2002). Usage statistics for *E-AIM* demonstrate the benefits for research and capacity building that universal availability and ease of use can bring: in 2013 more than 32,000 individually entered calculations were carried out by users around the world (38% from the Americas, 35% from Europe, and 24% from Asia).

We believe that a similar website, for chemical oceanography applications related to the carbonate system and to trace metal speciation, could bring even greater benefits. **Objective 3** is to develop a written specification for such a website, based upon consultation within the group and with other programmes. This will, for example, define the range of chemical systems and types of problems to which the speciation models will be applied (hence the design of the user interfaces and supporting “help” information), and requirements for capacity building (tutorials and demonstrations). Other modes of use will also be considered (e.g., calls from users' own program code; generation of lookup tables for use in large scale models). **Objective 4** is to create the fully functioning website.

2.3 Why a SCOR working group?

The work that we propose cannot be driven solely by the modellers who are experts in their field. An in-depth understanding of the requirements of different potential user groups is essential. This will enable us to define the key equilibria and chemical species to be included, and give direction to the review of currently available data (on which current models are based). It will also enable us to specify the requirements for web-based modelling tools and associated training and teaching elements. SCOR, with its broad coverage and links to other international

programmes, provides the ideal basis for developing a consensus across the global chemical oceanography community. The outputs of this Working Group will both stimulate new measurements of physico-chemical properties to better understand chemical speciation, and advance our ability to model speciation and its role in oceanographic and biogeochemical processes. The work that we propose, including its strongly international element, is rarely fundable by standard research grants from national research agencies. That is why we are approaching SCOR.

3 Terms of Reference

- 1) To document the current status, and basis in laboratory measurements, of Pitzer models of seawater and estuarine water focusing on the chemistry of ocean acidification and micronutrient trace metals (including, but not limited to, Fe, Cu, Mn, Cd, Mn, and Zn). Current capabilities and limitations for oceanographic and biogeochemical calculations will be defined, and future needs established. Important gaps in knowledge, which should have high priority for new measurements, will be identified. The components to be covered will include the seawater electrolytes, the selected trace metals, and buffer solutions and key organic ligands such as those used in CLE-CSV titrations.
- 2) To publish the results of the first term of reference in the refereed scientific literature, and to introduce the conclusions and recommendations to the oceanographic community at a “town hall” event or special session at an international ocean sciences meeting.
- 3) To specify the functions and capability for a web-based modelling tool that will make chemical speciation calculations easily accessible for a wide range of applications in oceanography research and teaching, and thus improve understanding and spread best practice in modelling.
- 4) To implement the web-based tool for chemical speciation calculations, based upon the specification developed in the third term of reference which will also be used to obtain external funding to develop the programs, documentation, and site.

4 Work Plan

There are several parallel strands to the activities of the WG. The timetable is given below, after further details of the objectives.

In the review and database constituting **Objectives 1 and 2**, the range of physicochemical conditions to be covered will be those relevant to estuarine and oceanic waters: temperature -2°C to 40°C; salinity 0 to concentrated brines (but with a strong focus on salinity 35); pressure 1 to 1000 atmospheres. The matrix of Pitzer model parameters for a major ion seawater of the composition noted in section 2.1, even excluding Sr^{2+} and boric acid, is considerable: 40 sets of cation-anion interactions, and potentially 250 ternary or “mixture” parameters. Although some can be neglected where all the interacting species are at very low concentration, the large numbers of interactions and the fact that they can vary with both temperature and pressure in the oceans emphasises the need to: (1) assess the completeness of any model and its basis in measured thermodynamic properties, (2) carry out an uncertainty analysis for the calculated quantities, and (3) establish what further measurements are required to completely characterise the behaviour of the seawater/estuarine water for its major and minor components, and trace metals, for the ranges of conditions encountered at sites around the world.

Our survey will relate the modelling and data needs to current developments in marine biogeochemistry, including the consequences of climate change and other anthropogenic forcing functions. This assessment will result in a state-of-the-art, self-consistent, database. It will also identify knowledge gaps that limit our ability to complement current research programmes such as GEOTRACES, IMBER and SOLAS with relevant calculations of chemical speciation.

To attain **Objective 3** we will first review current calculation tools and programs, including their availability and use by oceanographers. These programs include Pitzer seawater and brine models, and those for specific problems such as *CO2SYS* for the inorganic carbonate system. We will define the scope of solution chemistry and speciation modelling to be implemented, the types of problems to which the speciation models will be applied (hence the design of the user interfaces and supporting “help” information), and requirements for capacity building (tutorials and demonstrations). We will develop the specification for the website and speciation tools,

matched to the capabilities, needs, and levels of expertise of users. Consultation between members of the WG, and with other programmes, will feed into this.

In the final phase, for **Objective 4**, we will create a fully-functioning chemical speciation site for oceanographers. Experience with the *E-AIM* aerosol chemistry website, developed partly with external funding, shows that this will require specialist expertise in web implementation that is not available within the WG. We will therefore seek the additional resources necessary for this work, and work on the speciation models, during second year of the WG. In this phase the WG members will act as a test and advisory panel, and help ensure that the supporting information (help texts and training material) is sufficient and correct. Success (or otherwise) in the funding effort constitutes a decision point in the timetable, which is shown below.

Month 1: 1st full WG Meeting.

- This will focus on planning. Issues include: the seawater components and trace elements, and ranges of physicochemical conditions, to be covered (based upon user needs); the allocation of tasks; compilation of a list of external contacts for consultation (in other programmes); and plans for securing additional funding for the web development.

Months 2 - 11

- Objectives 1 & 2: Collection and review of relevant physico-chemical information for the seawater electrolyte; analyses of current Pitzer parameter databases for data sources and coverage of agreed systems and environmental conditions; uncertainty analysis.
- Objective 3: User representatives defining requirements for the web-based speciation tools in research and capacity building (including external consultations); drafting of a proposal for funding to develop the web-based speciation tools and site.

Month 12: WG Sub-group Meetings

- There will be two sub-group meetings: the first will discuss progress on the Pitzer parameter database, and the second will agree the basic specification of the web-based modelling tools sufficient for a draft proposal.

Months 13 - 23

- Objectives 1 and 2: Collect and review all relevant information for trace components, and for pressure effects. Individuals will work on their sections of the draft paper and database. Assembly and completion of the draft paper, delivery to internal reviewers.
- Objective 3: Further consultations with working group members and participants in other programmes to define requirements for the user interface(s) of the web-based calculation tools and for associated teaching (capacity building) materials.
- Objective 4: Submission of proposal(s) to support the development of the web-based tools.

Month 24: 2nd full WG Meeting

- We will review the draft manuscripts of the chemical speciation review paper, and the Pitzer model database, in preparation for submission to a journal. This is also a **decision point** for the development of the web-based modelling tools: we will report on the results of efforts to secure funding, and future prospects. If we have been successful, the project will continue as indicated below. Otherwise, we will either request a postponement (to allow further time to obtain support), or end the WG with the publication of the review paper, Pitzer parameter database, and report defining the needs for web-based tools for speciation calculations. Thus, even if additional funds are not obtained, the WG will (i) produce products valuable for scientists in this field; (ii) establish needs and give direction to future research; (iii) document the tasks needed to complete a Web-based tool.

Months 25 - 47

- Objective 4: Development of the web-based modelling tools and supporting programs and website information, with internal testing and review by WG members and other individuals towards the end of this period.

Month 48: 3rd and final full WG Meeting.

- Members will report on their experiences testing the web-based modelling tools, from both research and capacity-building perspectives. We will agree any necessary revisions, and changes will be made within 2 months of this meeting. The website will then be made public.

We will, where possible, organise WG meetings to coincide with relevant conferences so that the normal SCOR funding for three meetings can be stretched to four, and will explore the possibility of co-sponsorship by IAPSO and IUPAC.

5 Deliverables

- 1) A review paper, to be published in an international chemistry journal. This will include a statement of current speciation modelling capabilities, a survey of the available physico-chemical data for the major and minor chemical components (particularly related to chemical speciation and equilibria), and the identification of gaps and needs for future models and measurements. (Objective 1)
- 2) Accompanying the paper, a database listing the currently available Pitzer model parameters and equilibrium constants for seawater and trace components, their variations with temperature and pressure, and their origins in laboratory measurements (how they were obtained, uncertainties, and the references). (Objective 2)
- 3) Presentation of the results and conclusions of the review paper, for discussion and to stimulate new work, at a talk or special session on chemical speciation at an international ocean sciences meeting. (Objectives 1 and 2)
- 4) A report defining (a) the scope and specification of speciation modelling tools needed by chemical oceanographers for research and teaching (capacity building); (b) how these tools should be implemented on a website to meet the needs of different potential user groups. (Objective 3)
- 5) A public website, with associated programs and documentation, meeting the specification set out in (4). (Objective 4)
- 6) Presentation of the website and its capabilities at a “town hall” meeting at an international ocean sciences conference. (Objective 4)

6 Capacity Building

There is an urgent need for capacity building in chemical speciation modelling. For example, many national and international research programmes are focused on Ocean Acidification (OA). Chemical speciation modelling is essential to an understanding of the development and consequences of OA, yet access to state-of-the-art chemical speciation modelling tools is effectively restricted to a small (and ageing) group of marine scientists who are active researchers in the area. This WG will address the need for capacity building – training, and providing practical tools – at several levels.

Our vision is that state of the art chemical speciation modelling should be easily available to all marine researchers and students, not just the select few who have active research projects in the area. This will be achieved by the development of a web-based modelling tool that builds on a published, consistent and quality-controlled Pitzer database. The active involvement of representatives of key user communities in the WG will ensure that the structure and function of the web tool is appropriate for both research and teaching. In the case of teaching, we already have experience in providing tutorials and instructional videos on the subject of solution thermodynamics. The web-based modelling tools, augmented by the teaching and training materials, will provide the route to the capacity building so urgently needed in this field.

The work and products of the WG will also help to stimulate future capacity building and research in chemical speciation modelling. Publication of the reviewed database and release of the web tool will focus attention its importance. This will encourage new research efforts in this area, and develop a younger generation of scientists who can maintain and develop the database and modelling tools.

Finally, it is anticipated that the identification of important knowledge gaps in the database will stimulate new research to fill those gaps. History suggests that this is more than an idle hope. A 1981 paper co-authored by two of us (Turner et al., 1981) that identified the dearth of data on the carbonate complexation of trace metals, did

indeed stimulate new measurements that now provide the basis for our understanding of this phenomenon in the oceans.

7 Working Group Composition

The WG will have 10 Full Members with the range of expertise needed to address the terms of reference, including speciation modelling, large scale biogeochemical modelling, metal-ligand titration techniques, chemical-biological interactions and teaching. Importance is attached to ensuring that the modelling tools to be developed are readily accessible to the whole community, thus “users” are in a majority in the WG membership. They represent a broad geographical spread, from Europe, North America, South America, China and New Zealand. Although the applications are not restricted to **GEOTRACES**, we see this project as an important complement to **GEOTRACES** that lies outside that programme’s field focus. The Full Members include four members of the **GEOTRACES** SSC (Turner, Hatje, Maldonado, Tagliabue), which will ensure effective coordination. The Associate Members provide additional complementary user expertise, together with experienced modellers (including 2 members of the related SCOR WG 127, see section 9.4) who can contribute to reviewing the database and model development.

7.1 Full members

Name	Gender	Place of Work	Expertise
David Turner (chair)	M	University of Gothenburg, Sweden	Physical chemist, oceanographer and modeller: chemical speciation in seawater
Simon Clegg (vice-chair)	M	University of East Anglia, UK	Modeller: chemical thermodynamic modelling (inc. Pitzer equations), development of web-based tools for research and teaching
Sylvia Sander (vice-chair)	F	University of Otago, New Zealand	User: experimental studies of trace metal speciation, focus on data analysis
Heather Benway	F	Woods Hole Oceanographic Institution, USA	Executive Officer, Ocean Carbon and Biogeochemistry Project Office; expert in communication and outreach.
Arthur Chen	M	National Sun Yat-sen University, Taiwan	User: CO ₂ system, estuarine, and marine and hydrothermal biogeochemistry
Andrew Dickson	M	Scripps Institute of Oceanography, USA	Physical chemist and modeller: CO ₂ system in seawater, reference materials for measurements
Vanessa Hatje	F	INCT Energy and Environment, Bahia, Brazil	User: trace metal accumulation in marine organisms
Maite Maldonado	F	University of British Columbia, Canada	User: biological oceanographer
Alessandro Tagliabue	M	University of Liverpool, UK	User: development of global biogeochemical models

Rodrigo Torres	M	Centre for the Investigation of the Patagonian Ecosystem (CIEP) , Chile	User: ocean acidification and iron
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7.2 Associate members

Name	Gender	Place of Work	Expertise
Eric Achterberg	M	GEOMAR, Kiel, Germany	User: chemical oceanographer, CO ₂ system and trace metals
Yuri Artioli	M	Plymouth Marine Laboratory, UK	User: ecosystem modeller, member of the ERSEM group
Giles Marion	M	Desert Research Institute, USA	Modeller: developed the FREZCHEM chemical speciation model for cold water systems (http://frezchem.dri.edu/main.html)
Peter May	M	Murdoch University, Australia	Physical chemist and modeller, author of Joint Expert Speciation System (JESS).
Frank Millero	M	University of Miami, USA	Physical chemist and modeller: many measurements of the thermodynamic properties of seawater, and long experience of applying Pitzer models to marine systems
Stan van den Berg	M	University of Liverpool, UK	User: competitive ligand titrations in seawater
Wolfgang Voigt	M	TU Bergakademie Freiberg, Germany	Physical chemist and modeller: properties of concentrated salt solutions and brines (THEREDA database). May also involve close colleague Helge Moog.
Christophe Völker	M	Alfred Wegener Institute, Germany	User: development of global biogeochemical models
Dewen Zeng	M	Institute of Salt Lakes, China	Physical chemist and modeller: expert in chemical speciation with a background in hydrometallurgy.

8 Working Group Contributions

David Turner contributes a broad-based understanding of the field, with experience in chemical speciation modelling, and also in field-based biogeochemistry as Chief Scientist on 3 JGOFS cruises. He also contributes experience as a former WG co-chair (WG109, co-sponsored with IUPAC).

Simon Clegg (modeller) has long experience in applying Pitzer equations both to seawater and atmospheric aerosols, and has an extensive knowledge of the data upon which they are based. His experience in developing the *E-AIM* modelling website (section 2.2) will also make an important contribution to the WG.

Sylvia Sander (user) is expert in competitive ligand titrations, which are used to characterize metal-organic binding in seawater: there is a clear need for improved speciation modelling in this area. As one of the leaders of WG139, she will be able to ensure that the two WGs complement each other effectively.

Heather Benway (capacity building) is an essential link to the Ocean Carbon and Biogeochemistry Programme, for which she is Executive Officer. She also brings a strong record of outreach and community involvement and will contribute greatly to the teaching and training elements of the web-based speciation tools.

Arthur Chen (user) contributes a wide expertise in marine, estuarine and hydrothermal biogeochemistry and the application of speciation modelling to these systems.

Andrew Dickson (modeller) is an expert in laboratory measurement and modelling of chemical speciation; and also in the development of standard materials, calculation methods and documentation for the marine CO₂ system.

Vanessa Hatje (user) contributes expertise in the study of the trace metal content of marine organisms, an area where improved chemical speciation modelling is needed.

Maite Maldonado (user) contributes expertise in the study of chemical-biological interactions, most particularly the uptake of trace metals by microorganisms. Understanding uptake processes is dependent on good chemical speciation models.

Alessandro Tagliabue (user) contributes expertise in global biogeochemical modelling where there is a clear need for improved descriptions of (particularly) iron speciation.

Rodrigo Torres (user) contributes expertise in studies of ocean acidification and its consequences for iron biogeochemistry

9 [Relationships to Other Programmes and SCOR Working Groups](#)

9.1 GEOTRACES

The data generated by the **GEOTRACES** programme, as exemplified by the recently released Intermediate Data Product, is a game-changer in marine biogeochemistry. **GEOTRACES** involves simultaneous sampling for key trace elements and supporting parameters with an accuracy, coverage and resolution far beyond that previously available for trace elements. However, the marine biogeochemistry community currently lacks readily available tools for complementing the **GEOTRACES** data with state of the art calculations of chemical speciation. This proposal aims to fill that gap.

9.2 Global change programmes

The need to understand the effects of climate change and other anthropogenic forcings on marine biogeochemistry is inherent in a number of international programmes such as **IMBER** and **SOLAS**, large scale models such as the **European Regional Seas Ecosystem Model**, and national programs such as the Ocean Acidification Programme in the UK (**UKOARP**, see below). This will continue as a priority within the Future Earth programme now under development. Within these programmes there is an increasing focus on multi- stressors, i.e. the way in which different forcings combine synergistically or antagonistically to produce a net effect. An understanding of chemical speciation is of key importance here. Iron, which is now known to be a limiting nutrient in large areas of the ocean, is one example. The proposed WG is highly relevant to these ongoing and future studies.

9.3 UK national programmes

Both the **UKOARP** and the Shelf Sea Biogeochemistry Programme (**SSB**) have been contacted, and common interests identified. A UK-hosted workshop in 2015 is likely to be attractive to **SSB**, and co-funding is possible. This will be requested later in 2014 when the announcement of opportunity for such 'added value activities' is made.

9.4 SCOR WG 127

The thermodynamic equation of state for seawater, 2010, was produced by this WG. It is a Gibbs function (an equation) from which the thermodynamic properties of seawater are calculated. Most relevant to this WG is the fact

that the osmotic coefficient, and also the density, of seawater can be calculated from TEOS 2010. These are important constraints for the speciation models, and should be adhered to.

9.5 SCOR WG 139

The current SCOR WG, entitled “Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean”, addresses the experimental characterisation of interactions between trace metals and natural organic matter in the ocean. There is a strong focus on the use of competitive ligand titrations, from which stability constants and concentrations are derived for a small number of “ligands”. Our proposal complements WG 139 by providing (i) a chemical speciation model for all other interactions affecting the trace metal in question; (ii) a chemical speciation model for the titrations that are frequently used to characterise the trace metal – natural organic interactions; and (iii) a framework for including the experimentally derived “ligand” concentrations and stability constants in a chemical speciation model. The leadership of WG 139 has confirmed that this proposal does not overlap WG139.

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Appendix: Key Publications of Full Members

David Turner

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Simon Clegg

- (1) C. S. Dutcher, X. Ge, A. S. Wexler, and **S. L. Clegg** (2013) An isotherm-based thermodynamic model of multicomponent aqueous solutions, applicable over the entire concentration range. *J. Phys. Chem. A* 117, 3198-3213.
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Appendix 4

Proposal for a Working Group on Radioactivity in the Ocean, 5 Decades Later (RiO5)

Summary Abstract

Over the past 50 years, natural and anthropogenic radionuclides have been instrumental in addressing many important questions in oceanographic research. Yet knowledge gaps remain regarding their spatial and depth distributions and the temporal evolution of many radionuclides of importance to both oceanographic and human health issues. The Fukushima Dai-ichi disaster has also recently heightened public and policy concerns related to the human health effects of radioactivity attributable to external exposure from ocean contact and internal exposure from seafood consumption. The timing is thus right for a new SCOR Working group- “Radioactivity in the Ocean, 5 decades later”. The goals of RiO5 are to synthesize in a series of papers, the latest scientific insights that have been gained from new global databases on natural and artificial radionuclide distributions, and to identify gaps in our current understanding and scientific knowledge of marine radionuclides. We also plan to create an online compilation of papers and lectures related to radioactivity in the marine environment that will assist in the education and training of the next generation of marine radiochemists and radioecologists. At the same time, we will develop tools to enhance public understanding of radioactivity. Finally, we will assist in the organization of an international symposium that would bring together academic, nuclear power industry and national laboratory experts working in this area.

Scientific Background and Rationale

The very first SCOR Working Group #1, entitled Radioactivity in the Ocean, was formed in 1958 and met in 1959. Chaired by the Japanese scientist, Dr. Yasuo Miyake, the primary objectives of WG1 were to standardize and improve analytical methods and coordinate world-wide measurements of artificial radioactivity. Indeed, when referring to radioactivity, most still focus on the immediate detrimental impacts of anthropogenic radiation and issues related to contamination. Yet since that time, there has been considerable advancement in the field of marine radioactivity, not only in the measurement and application of artificial radionuclides, but also of cosmogenic and U-Th series radionuclides to study ocean processes. Several SCOR WGs have taken advantage of these advances, such as in the use of thorium-234 as a particle export tracer (WG#116) and radium isotopes in the study of submarine groundwater discharge (WG#112). Many other radionuclides are instrumental in geochronology (^{210}Pb , ^{14}C , ^{137}Cs) or in studies on present and past ocean circulation (^3H , ^{129}I , $^{230}\text{Th}/^{231}\text{Pa}$). Regardless of the application, it is necessary to understand: i) the evolution of radionuclide sources (both natural and anthropogenic) over a range of temporal and spatial scales, ii) how to use their inherent geochemistries and decay rates to answer a wide range of oceanographic questions and iii) the potential human health effects of radionuclides in the marine environment.

We propose a SCOR Working Group to look at Radioactivity in the Ocean, 5 decades later (RiO5). RiO5 would provide a comprehensive evaluation of our current knowledge of radioactivity in marine systems. RiO5 would be comprised of an international consortium of radiochemists and ecologists whose major focus will be on increasing scientific and public understanding of the sources, fate, and applications of natural and artificial radionuclides in marine systems. This will be accomplished through updating and improving access to radionuclide databases, providing a synthesis and review of radionuclide distributions, and developing a strategic plan for filling missing knowledge gaps.

The timing is right for RiO5 for many reasons. In the aftermath of the Fukushima Dai-ichi disaster – and after years of relative complacency – the public and policymakers have new, heightened concerns about radioactive contamination and potential human health concerns. We are also still limited by where radioactive wastes may be stored, due to perceived and real threats to environmental safety. Nuclear- fueled ships and submarines ply our oceans. The number of nuclear power plants worldwide (>430) is expanding in many countries and is likely to continue as we replace other forms of power that produce greenhouse gases. There are continued concerns regarding the spread of nuclear weapons and “dirty” bombs. Yet, at the same time, Cold War-era nuclear scientists and radiochemists have retired, creating a need for training the next generation of marine radiochemists and radioecologists. As this is happening, a new global view of natural and artificial radionuclides is emerging through

programs such as the SCOR sponsored international GEOTRACES program. Although the isotopes measured by GEOTRACES are a limited set, this is the first such effort since the GEOSECS Program that mapped several radionuclide distributions in the oceans in the 1970's. Indeed, the time elapsed between both major efforts appear as a unique opportunity to examine not only how specific radionuclide inventories have changed, but what those inventory changes mean with regards to their marine geochemistry and implications for global biogeochemical cycles (e.g., Moore et al., 2014).

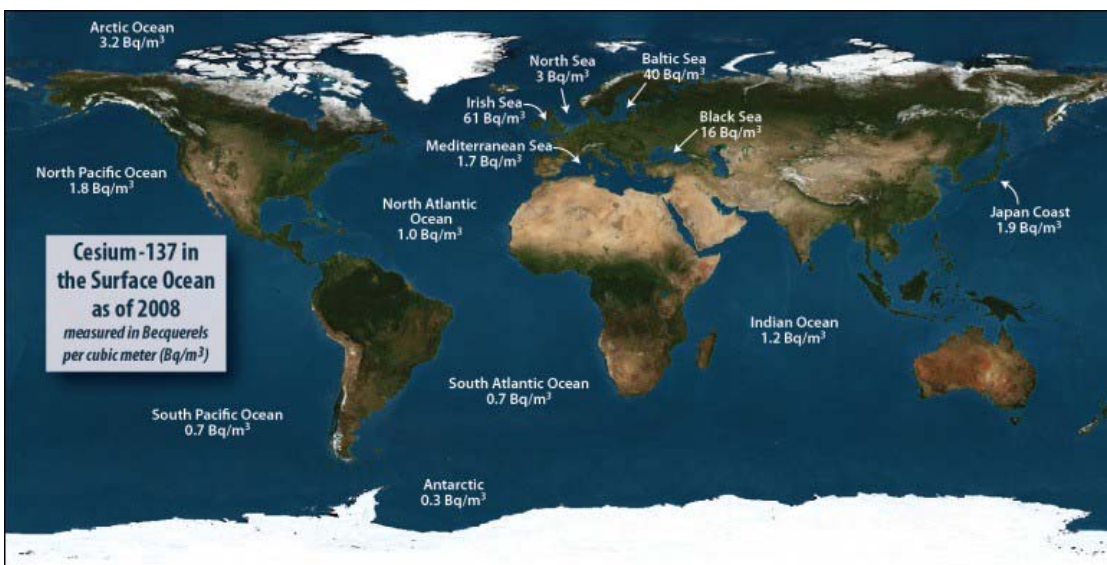


Figure 1. Example of recent compendium of ^{137}Cs activities in marine systems prior to the Fukushima accident. Data source: <http://maris.iaea.org> Available at: <http://ourradioactiveocean.org>

One example of the value of such a review of current knowledge is shown here by summarizing the global distribution of ^{137}Cs in the surface ocean (Figure 1). One can immediately observe the following:

- 1) 1960's fallout ^{137}Cs is rather uniform globally, with slightly higher values in the Northern Hemisphere (due to location of weapons testing) at background levels of 1-2 Bq m^{-3} ; 2) higher levels from Chernobyl fallout in the Baltic and Black Seas (20-40 Bq m^{-3}); and 3) perhaps the most surprising, or at least less well known, is that the Irish Sea still maintains the highest ^{137}Cs levels in the ocean due to prior nuclear fuel reprocessing releases from Sellafield. This map further enables the establishment of a baseline for oceanic ^{137}Cs activities prior to Fukushima. In contrast to these levels, ^{137}Cs in the ocean peaked at over 50,000,000 Bq m^{-3} close to the reactors in April 2011 (Buesseler et al., 2012), which was of direct concern to human health and marine biota, and far higher than the concentrations observed after weapons testing or the Chernobyl accident. Three years later, the public remains concerned about the predicted ^{137}Cs activities of 10-30 Bq m^{-3} within the Fukushima plume approaching the west coast of North America (Rossi et al., 2013). However, these predicted activities are in fact lower than that found today in some of the world's oceans and should not cause any measureable impact on human health. Compilations of global baselines such as that shown in Figure 1 are clearly necessary and allow for such assessments to be made. This and other maps are part of the first steps of RiO5.

Figure 2 is an exciting example of a natural radionuclide data set only recently available online as part of the GEOTRACES Program. While variable and high dissolved ^{210}Pb activities in surface waters are expected due to atmospheric inputs, high activities of ^{210}Pb at depth not only suggest substantial remineralization of sinking particles, but an additional source of ^{210}Pb that has not been previously observed (using mass balance). Such profiles therefore demonstrate how ^{210}Pb may be used to examine sources and cycling of other stable trace elements of similar particle reactivity that are more difficult to assess from their concentrations in seawater.

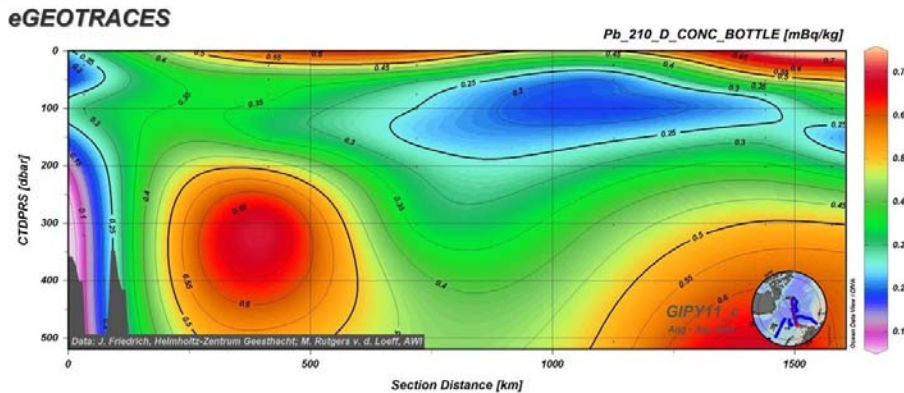


Figure 2. Example of radionuclide data available online as part of the GEOTRACES Program. Data source <http://www.geotraces.org/>

A final example showing the strength of pairing natural and artificial radionuclides is from Charette et al. (2014), who used ^{224}Ra as an indicator of coastal water ages (time since contact with sediments and/or groundwater) and found that in samples collected in 2013, the activities of ^{137}Cs near the coast of Japan remained higher than those offshore, similar to ^{224}Ra . Using a mass balance approach they estimated that continued release of ^{137}Cs from the Fukushima NPP site must be occurring (9 GBq per day), a key unknown in the ongoing evaluation of Fukushima ocean impacts.

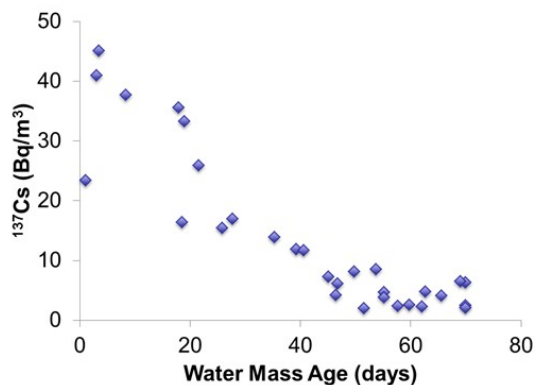


Figure 3. Plot of water mass age derived using ^{224}Ra versus ^{137}Cs activity off the coast of Japan. Source: Charette et al., 2014

These examples illustrate the breadth of new insights obtainable by synthesizing current radionuclide data sets (Figure 1); exploring new features in global transects (Figure 2); and combining studies that include both natural and artificial radionuclides (Figure 3). In addition, tremendous technological developments over the past decade have enabled the measurement of natural and artificial radionuclides at previously unattainable levels. This has revolutionized the radiochemistry field and has been instrumental in discovering new applications of radionuclides to address many important questions in oceanographic research.

RiO5 will bring experts together to review the current knowledge of radioactivity in marine systems and explore and identify research areas where new uses of radionuclides as tracers will be instrumental.

These processes include: 1) understanding the global ocean carbon cycle with regards to sources of carbon to marine systems (gas exchange, riverine and ground water, hydrothermal vents, etc.) , *in situ* cycling (nutrient turnover), the transport of material from the surface ocean to depth (biological pump- mediated particle export and remineralization), and burial in marine sediments (months to millennia); 2) understanding ocean circulation in current and paleo climates from coastal ocean currents to large-scale tele-connections between various ocean

basins; and 3) understanding contaminant sources, transport and removal of not only the radionuclides themselves, but other elements of similar chemistries, such as bioactive and particle reactive trace elements measured in the GEOTRACES program, some of which have their own pollution concerns (Pb, Hg, Cu, etc.).

Terms of Reference

We propose that SCOR establish a working group called “Radioactivity in the Ocean, 5 decades later (RiO5)” with the following terms of reference:

1. Combine and build upon existing global and individual databases of natural and artificial radionuclide distributions to make an user friendly and easily accessible on line product;
2. Summarize and publish review papers on these global radionuclide datasets and provide examples of how these can help improve our understanding of ocean processes and contaminant fate and transport;
3. Identify gaps in scientific knowledge in relation to radioactivity in the marine environment;
4. Bring together academic, nuclear industry and national laboratory expertise for an international symposium on radionuclides in the ocean;
5. Provide a warehouse of education materials to assist in the education and training of the next generation of marine radiochemists and radioecologists;
6. Develop tools to enhance public understanding of radioactivity, in particular in the ocean.

These activities would be achieved by convening WG meetings (1 per year for 3 years), exchanges among WG Members, building web-based informational resources, writing scientific manuscripts, and finding resources and partners for hosting a large international symposium.

Working plan

This Working Group is envisioned as a three-year activity that we hope will have a legacy beyond the funded study, to create a trusted resource for the ocean sciences and environmental community on matters related to radioactive substances, sources, and wastes in the oceans. The time-line delineated below outlines the major steps and their order to reach the deliverables (see below) according to the defined terms of reference. The timeline does not include much of the between-meeting activities and communications that are important to keep the WG going, which will be the responsibility of the two co- chairs to maintain.

Year 1

WG meeting #1- hosted by M. Dai, Xiamen U. (partial financial support in place through Xiamen U.). In conjunction with WG meeting, a two-day training workshop will be considered as part of the WG capacity building efforts (see Capacity Building below).

- Charge to WG participants- gather information on existing and ongoing radionuclide data bases, such as Marine Information System (MARIS) (IAEA- Morris lead), HAM (Japan- Aoyama lead) and GEOTRACES (Schlitzer Associate Member lead). Use Ocean Data View tools for visualization and use these data to develop global distribution maps (see Figure 2 as example)
- Outline synthetic papers to present the current state of the global oceans for natural and artificial radionuclides, based on the combined datasets achieved above. Spatial distributions and evolution as well as a global overview of potential risk will be the focus of the artificial radionuclide datasets, while objectives for naturally occurring radionuclides include their relevancy with regards to applications and newly available tools
- Discuss challenges and frontiers in marine radiochemistry and radioecology
- Discuss plans for WG web site and how to expand and build and disseminate education materials for public and students. Use WHOI’s Center for Marine and Environmental Radioactivity site as host and model of similar activities (<http://www.whoi.edu/cmer> ; web site costs supported by CMER)

- Introduce plans for an international symposium on marine radioactivity. Decades ago, similar efforts were hosted by UK (MAFF) and French (IRSN) ministries in Cherbourg in 1996 (Radionuclides: a tool in Oceanography 1987; Radionuclides in the Ocean- RADOc 96). IAEA has been approached to help support and host the symposium and welcomes additional discussion upon SCOR funding of this WG

Year 2

WG meeting #2- hosted by K. Buesseler (WHOI meeting facilities support in place); possible alternative is to hold in conjunction with international meeting such as Ocean Sciences to increase participation by Associate Members.

- Review progress done on the database efforts
- Review synthesis papers and prepare for publication
- Develop list of future challenge and areas of need
- Planning for international symposium on Radionuclides in the Ocean, including promotion and organizing co-sponsorship
- Review education and public outreach materials and discuss submission of e-lectures, fact brochures, hands on activities for primary and secondary education and coordinating ongoing hands-on training by various international groups of the next generation of radiochemists

Year 3

WG meeting #3- in conjunction with international symposium.

- International Symposium- collect extended abstracts & manuscripts
- Post conference publication/book and organize associated papers in open access format such as a **Frontiers Research Topic** (http://www.frontiersin.org/blog/What_is_a_Frontiers_Research_Topic_/620)
- Final preparation of wide release of educational materials- for both student and public audiences

Deliverables

1. Connect all available data bases via the IAEA's MARiS portal, including data collected via the GEOTRACES and HAM data bases and individual studies. MARiS is a publicly accessible database in the same spirit embraced by GEOTRACES (<http://www.egeotrac.es.org/>) and various time-series programs (HOT (<http://hahana.soest.hawaii.edu/hot/hot-dogs/interface.html>), PAPA (<http://oceanobservatories.org/infrastructure/ooi-station-map/station-papa/>), etc.) (WG Members lead: Morris, Aoyama, Masque; Associate Member: Schlitzer)
2. Review papers on ocean radionuclide distributions and future challenges in their measurement and application. (All WG Members)
3. Production of education tools at the primary school, undergraduate, and graduate level. This includes eLectures (<http://www.aslo.org/lectures/>), online course materials based on courses already being taught by SCOR WG Members (e.g. Johnson, 2014)
4. Public communication and dissemination (web tools and fact sheets) that include basic information on radiation literacy and marine radioactivity using lessons learned from Fukushima to motivate and attract attention (see example at <http://www.ourradioactiveocean.org/>) (WG Members lead: Benitez-Nelson, Masqué, Buesseler; Associate Member: Johnson)
5. International symposium in year 3 - Radionuclides and Marine Processes – attended by academia, industry, national laboratories, with published scientific abstracts, following the model of the MARC Applications of Radioanalytical Chemistry Conferences. Seek partnership with IAEA (WG Member-Morris) and other EU sponsors (WG Members lead: Oughton, Charmasson, Delfanti) and U.S. private foundations (WG Members lead: Buesseler, Benitez- Nelson)

Capacity Building

Members will participate individually and collectively in efforts to increase public and scientific understanding of marine radioactivity and radioecology. This SCOR WG will seek financial support as needed from the national agencies of WG Members, international organizations like the IAEA and IOC/UNESCO and groups such as, IUR, etc. and private funding sources. By developing tools for web based training, the next generation of graduate students will be exposed more readily to the concepts needed to understand radioactivity and radioecology in the marine environment. By increasing interactions among WG Members and knowledge of national programs, student exchanges and mentoring and sampling opportunities will be enhanced. With web-based sources to promote public understanding about radioactivity and open-access publication of synthesis papers and symposium volumes, there will be new resources to help expand the field and provide information to the public and policy makers.

Activities will include the web-based education materials and documents as well as online courses explained above. But more specifically, RiO5 will also work to

- Coordinate short term training of both junior and senior researchers at WG Member laboratories
- Facilitate participation of young researchers in oceanographic cruises to be trained in sampling and analyses
- Seek and facilitate appropriate ways of funding for young researchers, for attending research conferences, short-term stays at research centers or PhD or postdoc fellowships
- Approach the IAEA for Technical Cooperation for developing countries. Some of RiO5 Members already collaborate with the IAEA on this and the WG can work with the IAEA to identify future requirements for capacity building
- Pursue capacity building for developing country scientists through participation of developing country scientists in WG, holding first meeting in China in conjunction with a two-day training workshop, and seeking assistance from SCOR to involve participation of developing country scientists in WG activities
- Routine activities of outreach activities are also anticipated through national and regional user groups, such as COSEE China (China Ocean Science Education Excellence Partnership) which is located at Xiamen U.

Working Group Members

Full Members of this Working Group were selected based upon their scientific contributions, participation in educational activities, leadership as evidenced by participation and chairing national and international committees and symposium, editorships, career awards and recognition, experience in launching new initiatives and a willingness to participate in public and policy discussions on important issues related to marine radioactivity and radioecology. Proposed WG Members were also chosen to be widely representative of international expertise in the field and to span a range of skills and knowledge in marine radiochemistry and radioecology. Associate Members were considered important to expanding that scientific and regional expertise, and will be invited when possible to join us at WG meetings and will be called upon between meetings to assist with specific WG deliverables, as needed.

Full Members

Name	Gender	Place of Work	Expertise
Ken Buesseler*	M	WHOI, USA	Marine radiochemistry, C cycle, public education, EOTRACES
Minhan Dai*	M	Xiamen U., China	Coastal biogeochemistry, radionuclide applications, GEOTRACES
Michio Aoyama	M	Fukushima U., Japan	Marine radiochemistry,

Claudia Benitez- Nelson	F	U. So. Carolina, USA	global nutrient cycling Marine radiochemistry, methods and teaching
Sabine Charmasson	F	IRSN, France	Radioecology of natural and artificial radionuclides
Roberta Delfanti	F	ENEA, Italy	Radionuclides as ocean tracers of physical processes
Pere Masqué	M	UAB, Spain	Environmental radioactivity and nuclear physics, GEOTRACES
Paul Morris	M	IAEA, Monaco	Radium and thorium isotopes and radionuclide databases
Deborah Oughton	F	NMBU, Norway	Radioecology and radioecological risk assessments
John Smith	M	BIO, Canada	Radionuclides in Arctic and other basins
* = co-chairs			
Associate Members			
Andy Johnson	M	Black Hills State Univ., USA	Teaching radiation literacy
Reiner Schlitzer	M	AWI, Germany	Data management and visualization, GEOTRACES database lead
Gary Hancock	M	CSIRO Australia	Soil erosion and sediment transport
José Godoy	M	PUC, Rio de Janeiro, Brazil	Ra, Po, Pb isotopes and groundwater discharge
Nuria Casacuberta	F	ETH, Switzerland	Sr, U and other radionuclide tracers
Jordi Vives i Batlle	M	SKC-CEN, Belgium	Radioecology and radiological protection
Vladimer Maderich	M	Inst. of MMSP, Ukraine	Radioactivity dispersion and fate models
Sandor Muslow	M	ICML, U. Austral de Chile	Radiotracers, stable isotopes and benthic ecology

Working Group contributions

While all Members will participate in all activities of the group, a short description of each full WG Member's unique professional activities and interests, as well as contribution to the WG is provided below.

Ken Buesseler specializes in the study of natural and artificial radionuclides in the ocean and their application to better understanding ocean processes. He will serve as co-Chair of the WG. He leads the Center for Marine and Environmental Radioactivity, the goals of which include increasing scientific and public understanding of radioactive substances in the environment, and training the next generation of marine nuclear radiation experts -

all are key components of the RiO5 mission. Buesseler chaired SCOR WG 116 on Sediment Trap and ^{234}Th Methods for Carbon Export Flux Determination.

Minhan Dai uses a suite of radionuclides to examine carbon and trace metal biogeochemistry in marginal seas and estuarine systems, and investigates the geochemistry of radioactive elements in surface and ground water. He will serve as WG co-Chair and contribute by promoting links to research and radioecology in China and in Southeast Asia and will host a WG meeting at Xiamen University.

Michio Aoyama works on the geochemistry of ^{137}Cs in the world ocean from global fallout, and nuclear power plant accidents and has developed a marine radioactivity database, HAM, for artificial radioactivity in the world ocean. He will contribute by further developing and linking current databases of artificial radionuclides in marine systems.

Claudia Benitez-Nelson is an expert in the development of new radiochemical techniques and in the application of short-lived naturally and artificially occurring radionuclides in Marine Systems. A gifted teacher and mentor who has received numerous accolades for her ability to communicate her science to the broader community, she will contribute by coordinating the writing of the overview manuscripts and in the development of classroom and broader public education and outreach materials.

Sabine Charmasson's field of expertise is mainly radioecology with use of both natural and artificial radionuclides as tracers of transfer processes within ecosystems (primarily land-to-sea fluxes, sediment recording, food chain transfer). She will contribute by promoting links with EC research and radioecology, in the development of education and training tools, and with public dissemination.

Roberta Delfanti's research uses radionuclides as tracers of marine processes, including water dynamics in the Mediterranean Sea, and sedimentation and bioturbation in coastal and deep-sea environments. She will contribute by promoting links with eastern European research and radioecology, as well as education, training and public dissemination.

Pere Masqué's research focuses on using both natural and artificial radionuclides as tracers of processes in the ocean at various time scales, from present to paleoceanographic. A former member of the scientific steering committee of GEOTRACES, he will contribute by coordinating database efforts and in the development of education and outreach materials.

Paul Morris has worked with natural radionuclides to study ocean processes such as particle export and mixing rates. Currently, Morris works for the IAEA as the manager and coordinator of the Agency's Marine Information System (MARiS), and will contribute by further developing and linking current MARiS to other emerging data bases on artificial and natural radionuclides in marine systems.

Deborah Oughton's research includes the use of radioactive isotopes as environmental tracers as well as socio-ethical aspects of radiation risk assessment and stakeholder engagement. She will contribute by promoting links with EC research and radioecology, as well as education, training and public dissemination.

John N. Smith carries out targeted research focusing on applications of radioactive tracers to studies of sedimentation and particle transport, fish growth and other biological processes, biogeochemical cycling, ocean circulation and climate change. He will contribute by promoting links with North American research and radioecology, as well as education, training and public dissemination.

Relationship to other international programs and SCOR Working groups

We outline briefly below, some of the agencies and groups we have already spoken to, who will have a role to play in our WG activities. It is important to note that none of these organizations or groups have programs that would replace the need for RiO5, but they all can assist in those efforts in some way.

International Atomic Energy Agency (IAEA) and its Environment Laboratories in Monaco

One of the IAEA's mandates is to advise and assist Member States in building capacity for measurement and assessment of radionuclides in the marine environment and tracer applications to oceanographic, climate-related and pollution studies. Through its Marine Laboratories in Monaco

(<http://www.iaea.org/monaco/page.php?page=10>) the IAEA is the world's major producer of reference materials of marine origin, and organizer of interlaboratory comparisons and proficiency tests. The IAEA maintains the MARIS database, containing over 120,000 records on radionuclides in seawater, marine sediment, and biota. Also, the WG co-Chairs are in discussions regarding an International Symposium with the IAEA, which, pending funding and approval, may be in a position to collaborate through dedicated sessions at a larger conference on nuclear applications in the marine environment.

European Nuclear Safety Training and Tutoring Institute (ENSTTI)

ENSTTI (<http://www.enstti.eu/>) was founded in 2011 and offers applied training course and tutoring sessions in nuclear safety, nuclear security and human and environmental radiation protection. On this latter point links could be developed with RiO5 in order to provide ENSTTI with baseline studies worldwide, to underline various processes that may enhance radionuclide transfer in the marine environment, even to contribute to ENSTTI training course on marine radioactivity and radioecology.

Center for Marine and Environmental Radioactivity (CMER)

CMER (<http://www.whoi.edu/cmerr>) was established in early 2013 at the Woods Hole Oceanographic Institution with the goals of increasing scientific and public understanding of the sources, fate, and consequences of radioactive substances in the environment, and training the next generation of marine nuclear radiation experts. CMER will host this SCOR WG web site at WHOI, and assist in making links to public, student and academic audiences, building upon several efforts to pass on lessons learned from Fukushima, such as the *Oceanus* (<http://www.whoi.edu/page.do?pid=83397&tid=3622&cid=175809>) Japanese/English issue- *Fukushima and the ocean*- as well as a highly visited FAQ site (<http://www.whoi.edu/page.do?pid=83397&tid=3622&cid=94989>) on Fukushima ocean impacts. Also CMER can help organize and co-sponsor one of the WG meetings at WHOI.

Center for Environmental Radioactivity (CERAD)

CERAD (<http://www.umb.no/cerad>) is a Norwegian funded center of excellence hosted by the Norwegian University of Life Sciences and covering research and education on the sources, transfer, effects and risk assessment of radionuclides in the environment. In addition to fundamental research they are also engaged in stakeholder engagement and policy public issues. They are members of the Radioecology Alliance, and EC projects STAR, COMET, NERIS, DoReMi and OPERRA. They will contribute to training and education activities and links with EU radioecology and radiation protection

International Union of Radioecology (IUR)

The IUR (<http://www.iur-uir.org/en>) is an independent, non-political and non-profit scientific organization. Its first overarching role is to perpetuate a "think tank" capacity on radioecology issues through the maintenance of a network of scientists and professionals from around the world to foster communication between researchers from different fields and geographical regions through brain storming in task groups, the publication and circulation of technical papers, organization of conferences, training courses, and job alerts. At present there is no marine radioactivity task group, and this is something that RiO5 would be able to promote within IUR, and would be to the benefit of both organizations.

GEOTRACES

GEOTRACES (<http://www.geotraces.org/>) is an international and SCOR supported effort to map global distributions of selected trace elements and isotopes of key interest in ocean sciences. Two WG Members (Dai and Masque) are former members of the international GEOTRACES SSC, and Associate Member Schlitzer, is leading database efforts that we hope to incorporate into our WG to produce added-value to the efforts underway as part of this program.

Other collaborations

In addition to these groups, we will build relationships through our Full and Associate Members with a wider range of organizations, programs and working groups. Included among these are the Intergovernmental Oceanographic Commission (IOC-UNESCO) (<http://ioc-unesco.org/>) and the European ALLIANCE

(<http://www.er-alliance.org/>) network and associated COMET and STAR consortiums. These groups will help to identify appropriate ways to ensure and facilitate the accomplishment of RiO5 objectives, including the training of new researchers in the field. European RiO5 WG Members will be proactive in raising funds for training thorough adequate platforms and instruments such as EU-funded Marie Curie Training Networks and/or COST-Actions (European Cooperation in Science and Technology), on which they already have experience.

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Appendix 5

Proposal for a Working Group: Towards comparability of global oceanic nutrient data (COMPONUT)

Summary/Abstract (max. 250 words/246)

To better manage the global impacts of human activities on the world's oceans, it is necessary to have accurate observations of changes in carbon and dissolved nutrients in both upper and deep ocean waters. By establishing mechanisms for comparability of nutrient analyses, we will be able to detect changes in nutrient levels due to human impact and shifting physical processes.

Such changes could, either alter the supply of nutrients to the upper ocean directly or be from changes to ocean circulation. A recent Framework of Ocean Observing 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 information streams. Nutrients are identified as one of these EOVs. In 2014, two certified reference materials (CRMs) will become available for measurements of nutrients in seawater; a CRM provided by the National Metrology Institute, Japan, and MOOS-3, provided by National Research Council, Canada. The whole situation now calls for further international collaboration through SCOR, with a Working Group to establish the mechanisms for comparable oceanic nutrient data, using globally accepted CRMs. The primary goal is that for nutrient data collected anywhere by one individual laboratory, and data collected over long time periods by one or more laboratories, will be consistent and traceable with certified comparability. For future generations it is unacceptable to produce historical data sets without the absolute consistency necessary to assess spatial and temporal trends.

Scientific Background and Rationale (max 1250 words/1248)

Changes are occurring on a global scale in ocean biogeochemical cycles and much of the cause of these changes, directly or indirectly, is from human activities. Therefore, it is necessary to have accurate observations of trends in carbon and dissolved nutrients in both upper and deep ocean waters. For these observations, it is critical that we can reliably compare results from different laboratories, for geographically similar ocean waters with total confidence. To get a global consensus for nutrient data, it is necessary to both have accepted certified reference materials (CRMs) and to have the requirement to use the CRMs, and these can be established by the authority of a SCOR Working Group. The focus for this proposed Working Group is for oceanic waters, but because the ranges of nutrients expected are similar, the effort can be extended, at least partially, to coastal and estuarine waters. There are currently established certified standardizations for only a few marine parameters; 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 the carbonate system parameter measurements (comparability and traceability ensured using CRMs provided by Dickson's laboratory, SIO, USA, Dickson, 2003; 2010).

The 2007 IPCC Report highlighted the problem inherent in comparing 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). Results of nutrient concentrations from global crossover station analysis have shown 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 participant laboratories (Aoyama et al., 2007; 2008; 2010). This indicates that analytical problems may cause larger discrepancies for deep water nutrients, and these reported comparisons were from a small number of specific studies, whereas there are many oceanic nutrient data sets reported, published, and stored on international databases, with no references to CRMs at all. Although this situation has been improved somewhat, it is still difficult to ascertain with any certainty temporal changes in ocean nutrients.

We can now detect changes in deep ocean temperature (and hence heat content) (Levitus et al., 2009; 2012; Kouketsu et al. 2009; Rhein et al., 2013) from observations due to comparability of temperature measurements, on 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, Rios et al., 2012, Khatiwala et al., 2012). Similarly, changes to oceanic oxygen can now also be accurately observed (Stendardo and Gruber, 2012).

It is important to now establish mechanisms for improving the quality of reported oceanic nutrient data, which will then allow us to be able to more accurately detect changes in nutrient levels due to human impact and shifting physical processes, which might alter the supply of nutrients to the upper ocean in the future. Improved comparability of reported nutrient concentrations in the water column will also help us to improve estimates of the anthropogenic portion of the observed increase of total carbon in the water column.

To properly guarantee comparability of data from different laboratories, the precise mechanisms of a global consensus for reporting nutrient levels needs to be established. This will foster a move toward the comparability 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 by the use of CRMs for measurements of the CO₂ system, and the use of the IAPSO standard seawater for salinity measurements. A potential problem with using nutrient CRMs is similar to that with the use of references for dissolved organic carbon (DOC); that is, some form of enforcement for their use should be established.

There was significant improvement in community DOC measurement during the international JGOFS program due to encouragement by the US National Science Foundation and NOAA to participate in DOC comparability exercises (Sharp et al, 2002). A nutrient CRM SCOR working group should be able to provide the authority for not only certification of nutrient CRMs, but also for their use.

Historically, a U.S. National Research Council report (Dickson et al., 2002) clearly stated that certain key oceanic parameters lacked reliable and readily available reference materials. That report identified the most urgently required chemical reference materials based on certain key themes for oceanographic research. At the top of the list of the new reference materials needed were standards for the measurement of nutrients, with the statement: "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, RMs/CRMs for oceanographic use have been developed. These include a Danish RM, NRC-Canada CRM (MOOS-3), and one developed by KANSO-Japan. In 2014 NMIJ will start to provide CRMs (NMIJ CRM 7601-a, NMIJ CRM 7602-a, and NMIJ CRM 7603-a) with nutrient concentrations appropriate for the nutrient concentration ranges of Nitrate, Nitrite, Silicate and Phosphate found in the Pacific and Atlantic Oceans. MOOS-3 covers nutrient concentrations specifically for the Atlantic Ocean. Therefore, we now have the opportunity for traceability and comparability of nutrient concentrations throughout the globe, and a mechanism to provide RMs which is traceable to SI through CRMs. Global availability of the RM to traceable to NMIJ CRM will be made through JAMSTEC (Japan Agency for Marine-Earth Science and Technology), in a similar manner to the carbonate system CRMs from Dickson's laboratory (SIO, Scripps).

A nutrient CRM calls for further international collaboration through SCOR, and a Working Group to establish the mechanisms required to provide comparability of oceanic nutrient data, using globally accepted RMs/CRMs. A major challenge with this SCOR WG is to develop a system by which the comparability of data within and between laboratories is better than 1% at full scale of nitrate, phosphate and silicate concentrations. The levels of comparability achieved for the measurement of oceanic salinity and total inorganic carbon are considerably better than 1%. However, both of those parameters are comparatively simple, chemically, and exist in the open ocean in much narrower concentration ranges than do the inorganic nutrients.

The primary goal for the SCOR Working Group is for nutrient data collected at any one place by an individual laboratory and data collected over long time periods by one or more laboratories to be consistent with certified comparability. The experience of this SCOR WG will also give positive feed-back to the scientific community 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. Such feedback will move toward the goal of achieving comparability of nutrient data throughout the oceans, which will have been obtained by different methods, instruments, and technologies. This initiative will be based on previously developed collaboration with the IOC-ICES SGONS that ended in 2012. For future generations it is unacceptable to produce historical data sets without the absolute consistency necessary to assess spatial and temporal trends.

Terms of Reference (max. 250 words/177)

1. To establish mechanisms to ensure comparability of oceanic nutrient data
2. To assess the homogeneity and stability of currently available RMs/CRMs. It remains to determine whether the current producers are achieving a level of precision within and between laboratories which is comparable to or better than 1 %.
3. To develop standardized data-handling procedures with common data vocabularies and formats, across producers and users, and will 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.
4. To promote the wider global use of RM's by arranging workshops to actively encourage their use and to provide training in analytical protocols and best practice, particularly targeted towards developing countries.
5. To continue regular global inter-comparison studies, following on from the previous exercises in 2003, 2006, 2008 and 2012, with collaboration of IOCCP-SSG and RCGC- JAMSTEC.
6. To update the GO-SHIP nutrient measurement manual, which was originally a product of the IOC-ICES SGONS, (Study Group on Nutrient Standards).
7. To publish reports on this WG's activities and workshops.

Working plan (logical sequence of steps to fulfil terms of reference, with timeline. Max. 1000 words/446)

This Working Group will work 3 years after acceptance by the SCOR General assembly in 2014. The time-line shown below highlights only the main meetings/activities. We will have regular e- mail exchanges, Skype meetings, and a variety of workshops/meetings among the full and associated members that will occur on a regular basis.

Year 1: 2015

Kick-off Meeting: Upon funding, the WG will have a kick-off meeting in early to mid-2015. In order to provide good international visibility, the 2015 EGU General Assembly (April 12-17 2015, Vienna, Austria) is a good potential venue where a WG meeting #1 on changes of nutrients in the world's oceans and use of RMs/CRMs could be held.

Conduct an inter-laboratory comparison experiment of currently available RMs/CRMs by several selected key laboratories to assess the homogeneity and stability of currently available RMs/CRMs. This will be organized by a few of full/associate members of the WG. The results of this will be published as soon as possible after the experiment.

Year 2: 2016

A potential venue for the half-way meeting, WG meeting #2 will be the 2016 Ocean Sciences Meeting (21 February 2016 — 26 February 2016, New Orleans, Louisiana, USA). During the OSM 2016, we will propose a presentation session at the meeting, and we will also hold a workshop to promote the wider global use of RM's, to actively encourage their use. We will also review synthesis papers and previously published inter laboratory comparison study reports, and prepare a revised version of the GO-SHIP nutrients measurement manual during this workshop. One of key issues is to update/confirm basic analytical methodologies for nitrate, nitrite, phosphate and silicate. We will conduct a global inter-comparison study of RMs/CRMs following on from the previous exercises in 2003, 2006, 2008, 2012 and 2014, with the collaboration of IOCCP-SSG and RCGC-JAMSTEC.

In 2016 we will provide a training course in analytical methodologies and best practice of nutrient measurement, particularly for developing countries. Potential venues for this training course are NIOZ/The Netherlands, SIO/USA, or JAMSTEC/Japan. In this training course, participants will be given training by experienced analysts and the workshop will discuss the results of the global inter-comparison studies of RMs/CRMs so as to learn more about how to ensure comparability of oceanic nutrient data.

These opportunities, the training course and global inter-comparison study, will also contribute to building capacities in developing countries to measure nutrient concentrations in seawater.

Year 3: 2017

We will plan an international symposium “Towards comparability of global oceanic nutrient data”. This symposium is also WG meeting #3. Potential venues for this symposium are JAMSTEC/Japan, NIOZ/The Netherlands and SIO/USA. We will particularly focus on inviting scientists from developing countries, and encourage their involvement in this symposium.

Deliverables (state clearly what products the WG will generate. Should relate to the terms of reference. Max 250/163). A workshop is not a deliverable. Please note that SCOR prefers that publications be in open-access journals.

1. Assessment reports of currently available RMs/CRMs based on inter-laboratory comparison experiments which will be submitted to ‘Biogeochemistry’ or similar open access journal.
2. A "best practice" manual which will provide the community with a recommended consistent approach to the sampling, analysis, use of RM's, quality control of nutrients, and subsequent data handling which will be an update of the GO-SHIP nutrients manual (Hydes et al 2010). This manual will be available freely at the GO-SHIP website and will be able to be downloaded free of charge. A printed version of this manual may be published depending on additional funding availability.
3. A report on global inter-comparison studies of RMs/CRMs will be submitted to the journal “Earth System Science Data” published by EGU.
4. Synthesis papers on current nutrient measurements techniques/methodologies which will be submitted to the journal “Earth System Science Data” published by EGU.
5. A book will be published from the final International symposium “Towards comparability of global oceanic nutrient data”.

Capacity Building (How will this WG build long-lasting capacity for practicing and understanding this area of marine science globally. Max 500/277)

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 involvement and help of POGO. The second is to invite participating laboratories to a 3-day training course in 2016 planned to be held at JAMSTEC/Japan, NIOZ/The Netherlands or SIO/USA (depending on additional funding) to learn more about analytical methodologies, best practice, and to discuss and interpret results of the global 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 even greater participation in the future inter-laboratory comparison study of RM's proposed for 2016 from these developing countries. 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 requirements, this will all be accomplished with the help and advice of POGO.

The laboratories that took part in the 2012 inter-comparison exercise of nutrients in seawater are already 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. This proposed SCOR WG will endeavor to expand the global participation of developing countries from the current number of 2012/2014 representatives into the 2016 inter- calibration exercise with more participants from developing countries.

Working Group composition (as table). Divide by Full Members (10 people) and Associate Members, taking note of scientific discipline spread, geographical spread, and gender balance. (max. 500 words)

Full Members (no more than 10, please identify chair(s))

Name	Gender	Place of work	Expertise relevant to proposal
1 Michio Aoyama*	Male	RCGC-JAMSTEC/IER-Fukushima Univ., Japan	Geochemistry, global nutrients distribution
2 E. Malcolm S. Woodward*	Male	PML, UK	Nanomolar level precision measurements
3 Toste Tanhua	Male	GEOMAR, Germany,	Chairman of the International Ocean Carbon Coordination Project (IOCCP)
4 Karin Bjorkman	Female	Laboratory for Microbial Oceanography, Hawaii, USA	HOT time series
5 Bernadette Sloyan	Female	CSIRO, Australia	Co-chair of The Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP)
6 Anne Daniel	Female	IFREMER, France	French nutrient reference laboratory (DYNECO/PELAGOS, IFREMER)
7 Susan Becker	Female	SIO, USA	Repeat Hydrography
8 M. Dileep Kumar	Male	NIO, India	Chemical Oceanography
9 Claire Mahaffey	Female	University of Liverpool,	Nutrient Biogeochemist
10 Howard Waldron	Male	University of Cape Town, South Africa	Nitrogen dynamics in Ocean systems

* : Co-Chairs

Associate Member (no more than 10)

Name	Gender	Place of work	Expertise relevant to proposal
1 Alex Kozyr	Male	CIDIAC, USA	Multiple user database access
2 Karel Bakker	Male	NIOZ, The Netherlands	The Netherlands sea- going analytical facility
3 Takeshi Yoshimura	Male	CRIEPI, Japan	Organic Nutrients
4 Jonathan Sharp	Male	University of Delaware,	DOC RM experience
5 Andrew Dickson	Male	SIO, USA	Carbonate system RM experiences
6 Minhan Dai	Male	Xiamen University, China	Large global (LOICZ and Chinese programs)
7 Akihiko Murata	Male	JAMSTEC, Japan	Chemical oceanography, Global carbon/nutrient stoichiometry

8 Trevor Platt	Male	PKL, UK	Executive Director, POGO
9 Ralph Sturgeon	Male	NRC, Canada	CRM producer
10 Akiharu Hioki	Male	NMIJ, Japan	CRM producer

Working Group contributions (Max 500/500)

Michio AOYAMA organized the previous 4 Inter-laboratory comparison experiments for Reference Materials of Nutrients in Seawater, RMNS, in 2003, 2006, 2008 and 2012. He is working to develop RMNS, and has been PI of nutrients of 6 CLIVAR cruises in the Pacific Ocean. He is one of PIs of dissolve oxygen and nutrients part of Pacific Ocean Interior Carbon Data Synthesis project, PACIFICA. He has 104 publications in peer-reviewed journals and numerous reports.

Malcolm WOODWARD has worked as a Chemical Oceanographer for 35 years, and Head of the Plymouth Marine Laboratory Nutrients Facility for the past 20 years, has 100 publications in peer-reviewed journals and numerous reports. Has specialized and developed nanomolar nutrient analysis techniques and their applications in global oligotrophic oceans.

Toste TANHUA works on research fields of transient tracers in the ocean, ocean ventilation and mixing, tracer release experiments to quantify mixing. He also conducts CARINA Data Synthesis Project in the Atlantic Ocean. Now he works as a chair of The International Ocean Carbon Coordination Project (IOCCP). He has numerous publications in peer-reviewed journals reports and books.

Karin BJORKMAN works the field of microbial oceanography and nutrient dynamics with a special focus on phosphorus cycling in the oligotrophic North Pacific subtropical gyre. This work includes high sensitivity measurements low nano-molar concentrations of inorganic phosphate as well as the use of radioisotopes as tracers.

Bernadette SLOYAN works on International repeat hydrography and carbon program. She analyzes repeat hydrographic sections in the southern hemisphere oceans and simulation of deep ocean changes in climate models. She has numerous publications in peer-reviewed journals reports and books.

Anne DANIEL is in charge of the French reference laboratory (DYNECO/PELAGOS, IFREMER) for chemical measurement in marine and fresh waters. It supports laboratories by developing new methodologies, organizing performance tests and implementing quality system for accreditation according to the ISO/IEC 17025 norm. She also works in the implementation of the EU Water Framework Directive (WFD) and EU Marine Water Framework Directive (MSFD).

Susan BECKER is a manager and supervisor for the Oceanographic Data Facility within Shipboard Technical Support at Scripps Institution of Oceanography. She is responsible for overseeing the analytical analysis and data quality of inorganic nutrients, dissolved oxygen, and salinity. ODF provides the highest quality hydrographic data from CTD casts and discreet analysis of salinity, nutrients and dissolved oxygen for global repeat hydrography programs.

M. Dileep KUMAR is a Chemical Oceanographer focusing on nutrient and carbon biogeochemistry with particular reference to Climate Change. He has about 35 years of research experience at NIO (Goa) and has about 65 publications in peer-reviewed journals.

Claire MAHAFFEY is a nutrient biogeochemist and Senior Lecturer with over 10 years' experience studying the source, cycling and fate of nitrogen, phosphorus and carbon in the subtropical open ocean and coastal and shelf seas. Has been responsible for nutrient analysis both at the Hawaii Ocean Time Series (USA) and Liverpool Bay Coastal Observatory (UK).

Howard WALDRON works on nitrogen dynamics of ocean systems including Benguela Upwelling, Southern Ocean and Atlantic Meridional Transect.

Relationship to other International programs and SCOR Working groups (max. 500 words/78)

Toste Tanhua is a Chair of The International Ocean Carbon Coordination Project (IOCCP).

Bernadette Sloyan is a Co-chair of The Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP).

Trevor Platt is an Executive Director of the Partnership for Observation of the Global Oceans (POGO).

Michio Aoyama is a candidate of full member of SCOR WG proposal of marine radioactivity which will be submitted in 2014. Minhan Dai is also a candidate of co-chair of SCOR WG proposal of marine radioactivity.

Key References (Max. 500/497)

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Wanninkhof, R. et al., (2010), Detecting anthropogenic CO₂ changes in the interior Atlantic Ocean between 1989 and 2005. *Journal of Geophysical Research*, 115, C11028, doi:10.1029/2010JC006251.

Appendix

For each Full Member, indicate 5 key publications related to the proposal.

Michio Aoyama

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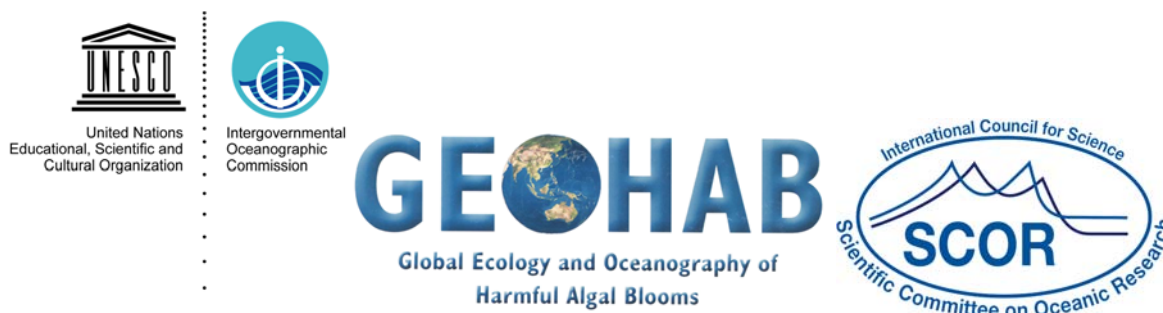
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Appendix 6

SCOR/IOC Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) project



SCOR-IOC Global Ecology and (GEOHAB) Program

The GEOHAB project is of 2014. GEOHAB-related part of a new initiative called

1. IPHAB and SCOR

GEOHAB was represented by Harmful Algal Blooms years was presented, and a international initiative called GEOHAB annual report at the declined to continue support

Oceanography of Harmful Algal Blooms Activities, 2013-2014

continuing to prepare a synthesis for completion of its first phase, at the end activities will be continued after the end of 2014, under a different format, as GlobalHAB (see Tab 4).

Meetings

the SSC Chair (Raphe Kudela) at the Tenth IOC Intergovernmental Panel on (IPHAB) meeting. An update on GEOHAB activities during the past two resolution was passed recommending support from IOC for a new GlobalHAB, with an invitation to SCOR to co-sponsor. Kudela presented the SCOR meeting in Wellington, New Zealand. SCOR thanked GEOHAB, but for GlobalHAB as a research project.

2. Synthesis of Core Research Projects (Science Highlights)

The GEOHAB *Implementation Plan*¹, published in November 2003, specified the formation of Core Research Projects (CRPs) related to four ecosystem types—upwelling systems, fjords and coastal embayments, eutrophic systems, and stratified systems. Since then, initiation and implementation of these CRPs has been the primary GEOHAB objective through open science meetings (OSMs) and other activities. A fifth CRP plan was published on Benthic HABs. All of the CRPs are continuing in some capacity, but the primary focus for this reporting interval is on synthesis activities.

A Science Highlights

Based in part on the successful collaboration between GEOHAB and the International Ocean Color Coordination Group (IOCCG), GEOHAB participated in the “Oceans and Society: Blue Planet Initiative” sponsored by the Group on Earth Observatories (GEO). Stewart Bernard (SSC member; South Africa) and Lourdes Velo-Suarez (Spain) represented GEOHAB, addressing the HAB observations and modelling needs within the GEO framework. While GEOHAB often focuses on science objectives, a significant contribution from this effort was the publication of recommendations for development of global HAB observation and prediction systems (Bernard et al. 2014). A significant highlight from that synthesis is the following:

“Global HAB-related economic losses across marine and freshwater systems can be estimated at +/-US\$10 billion annually. Using a typical Value Of Information (VOI) estimate of 1% of the “resource” (in this case HAB-related losses), a comprehensive HAB observing and forecasting

system would represent a value of +/- US\$100 million annually.”

IOCCG and GEOHAB are also co-funding a working group on HABs and Ocean Colour. The full group has met twice and is working on a monograph for the *IOCCG Report* series. A subset of the group met in Barcelona, Spain in December 2013, to finalize the monograph contents.

B. GEOHAB Open Science Meeting Report

The SSC convened a synthesis GEOHAB Open Science Meeting at IOC Headquarters in Paris, France in April 2012. Fifty-one scientists from the 5 continents attended the meeting. Participants actively evaluated the progress achieved by GEOHAB and its main limitations. Participants identified the main challenges for future research on HABs worldwide. The SSC is currently finalizing this report, and we expect to publish this in time for the International Conference on Harmful Algae, to be held in October 2014 in New Zealand.



“We all came to Paris because we recognize a fundamental problem (HABs), and cannot solve this problem in our individual laboratories. This requires an international approach.”



GEOHAB Global Ecology and Oceanography
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3. Publications and Endorsed Projects

A full list of GEOHAB reports, publications, and endorsed activities is available on the GEOHAB Web site (www.geohab.info/publications-66). Overall, GEOHAB generated considerable interest from the community during this interval, and GEOHAB-endorsed work has been conducted in Australia, Canada, Chile, China, France, Germany, Ireland, Philippines, Spain, South Africa, United Kingdom, and the United States. We continue to receive requests annually for project endorsements and are reaching out to the previously endorsed projects for inclusion in the GEOHAB synthesis activities.

Specifically, the newest publications during the 2013-2014 period include two new GEOHAB Reports, from the "HABs in Fjords and Coastal Embayments" and "HABs in Stratified Systems" CRPs:

GEOHAB 2013. *"Global Ecology and Oceanography of Harmful Algal Blooms, GEOHAB Core Research Project: HABs in Fjords and Coastal Embayments. Second Open Science Meeting.*

Progress in Interpreting Life History and Growth Dynamics of Harmful Algal Blooms in Fjords and Coastal Environments". S. Roy, V. Pospelova, M. Montresor, and A. Cembella (Eds.), IOC and SCOR, Paris, France and Newark, Delaware USA, 52 pp.

GEOHAB 2013. *Global Ecology and Oceanography of Harmful Algal Blooms, GEOHAB Core Research Project: HABs in Stratified Systems. Workshop on "Advances and Challenges for Understanding Physical-Biological Interactions in HABs in Stratified Environments."* M.A. McManus, E. Berdalet, J. Ryan, H. Yamazaki, J.S. Jaffe, O.N. Ross, H. Burchard and F.P. Chavez (Eds.). IOC and SCOR, Paris and Newark, Delaware, USA, 88 pp.

and a special issue with 21 papers in *Deep Sea Research, Part II*:

- R. Raine, E. Berdalet, M.A. McManus, H. Yamazaki (Guest Eds.). 2014. "Harmful Algal Blooms in Stratified Systems", special issue in *Deep-Sea Research, Part II: Topical Studies in Oceanography*, 101:1-254.
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- E. Berdalet, M.A. McManus, O.N. Ross, H. Burchard, F.P. Chavez, J.S. Jaffe, I.R. Jenkinson, R. Kudela, I. Lips, U. Lips, A. Lucas, D. Rivas, M.C. Ruiz-de la Torre, J. Ryan, J.M. Sullivan, H. Yamazaki. Understanding harmful algae in stratified systems: Review of progress and future directions. Pages 4-20.
- R. Raine. A review of the biophysical interactions relevant to the promotion of HABs in stratified systems: The case study of Ireland. Pages 21-31.
- T. Wyatt. Margalef's mandala and phytoplankton bloom strategies. Pages 32-49.
- Andrew J. Lucas, Grant C. Pitcher, Trevor A. Probyn, Raphael M. Kudela. The influence of diurnal winds on phytoplankton dynamics in a coastal upwelling system off southwestern Africa. Pages 50-62.
- J.P. Ryan, M.A. McManus, R.M. Kudela, M. Lara Artigas, J.G. Bellingham, F.P. Chavez, G. Doucette, D. Foley, M. Godin, J.B.J. Harvey, R. Marin III, M. Messié, C. Mikulski, T. Pennington, F. Py, K. Rajan, I. Shulman, Z. Wang, Y. Zhang. Boundary influences on HAB phytoplankton ecology in a stratification-enhanced upwelling shadow. Pages 63-79.
- H. Farrell, P. Gentien, L. Fernand, P. Lazure, M. Lunven, A. Youenou, B. Reguera, R. Raine. Vertical and horizontal controls of a haptophyte thin layer in the Bay of Biscay, France. Pages 80-94.
- W.O. Smith Jr., X. Liu, K.W. Tang, L.M. DeLizo, N. Hai Doan, N. Lam Nguyen, X. Wang. Giantism and its role in the harmful algal bloom species *Phaeocystis globosa*. Pages 95-106.
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- L. Velo-Suárez, S. González-Gil, Y. Pazos, B. Reguera. The growth season of *Dinophysis acuminata* in an upwelling system embayment: A conceptual model based on in situ measurements. Pages 141-151.
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- H. Farrell, L. Velo-Suarez, B. Reguera, R. Raine. Phased cell division, specific division rates and other biological observations of *Dinophysis* populations in sub-surface layers off the south coast of Ireland. Pages 249-254.

1. Implementation Activities and Plans for the Coming Year

A. CRP Activities

The final GEOHAB SSC Meeting was held in Barcelona, Spain on 3-5 December 2013, with many of the SSC members agreeing to an informal extension (December 6-8) to implement the GEOHAB Summary Outcomes. While GEOHAB is sunsetting, several potential implementation activities were discussed and prioritized if additional funds become available. This includes two projects that were highly ranked at the Paris OSM:

- 1) Linkages between HABs and Hypoxia (proposed by Grant Pitcher, South Africa)
- 2) Quantifying HAB resting stage emergence and deposition fluxes: A comparative workshop and training program (proposed by Don Anderson, USA)

A third proposed effort, addressing the linkage between HABs and caged fish activity, was recommended as a submission to SCOR as a Working Group.



The GEOHAB SSC recommended providing partial funding to the first two activities as part of the transition from GEOHAB to GlobalHAB. This recommendation is pending budget decisions about the synthesis publications. The full concept papers are provided in the Appendix.

As part of the synthesis, the GEOHAB SSC, in coordination with the CRPs, identified a series of publications (targeting the journal *Oceanography*) that are currently in preparation, pending identification of funds for publication:

1. Kudela, Berdalet, Urban, Enevoldsen. The Global Ecology of Oceanography and Harmful Algal Blooms Programme: History and Impacts.
2. Pitcher, Figueras, Kudela, Moita, Reguera, Ruiz-Villareal. The ecology and oceanography of HABs in eastern boundary upwelling systems: A GEOHAB Core Research Project
3. Glibert, Burford. Harmful Algal Blooms, nutrients, and eutrophication.
4. Reguera, Raine, Berdalet. Understanding harmful algae in stratified systems.
5. Roy, Cembella. HABs in fjords and coastal embayments.
6. Tester, Berdalet, Lemée, Litaker, Penna, Vila, Zingone. Harmful Algal Blooms in benthic systems.
7. McGillicuddy, Allen, Fernand. Advances in modeling harmful algal blooms.
8. Bernard, Velo-Suarez, Kudela. Developing Global Capabilities for the Observation and Prediction of Harmful Algal Blooms.
9. Bernard, Kudela, Roy, Glibert, Simis, Hu, Matthews, Moore, Werdell, Pitcher, Dowell. Assessing the utility of global ocean color for harmful algal bloom research and monitoring.
10. Usup, Liu, Furuya. GEOHAB Asia: Development, successes, and future steps.
11. Wells, Karlson, Kudela. Harmful Algal Blooms and Climate Change.
12. Berdalet, Magnien, Enevoldsen, Kudela. Establishment of the GlobalHAB International Coordination Effort: From Research to Mitigation.

B. Synthesis Activities

As discussed above, GEOHAB is in its final synthesis phase. The SSC agreed to utilize the 2014 ICHA meeting (16th International Conference on Harmful Algae, to be held in Wellington from the 27 to 31 October 2014) as a venue for dissemination of the Paris OSM Report, and for disseminating information about the transition from GEOHAB to GlobalHAB. GEOHAB will have a booth at the meeting where we can highlight accomplishments and activities. This will likely represent the final public outreach/meeting efforts for GEOHAB.

Furthermore, this information will be presented at the International Conference "One Ocean, One Planet", to be held in Barcelona on 17-21 November 2014 (<http://www.fnob.org/en/international-ocean-research-conference>). The poster (Berdalet et al.) is coauthored by the present GEOHAB SSC members.

C. GlobalHAB (see Tab 4)

2. Plans for the Coming Year

GEOHAB reaches the end of its current Terms of Reference and funding in 2014. We propose to carry forward our existing balance of NSF funds to complete synthesis activities during the transition to GlobalHAB. If SCOR chooses to endorse GlobalHAB as an infrastructural activity, GEOHAB will make recommendations to IOC and SCOR for implementation of that programme, but GEOHAB will wrap up its formal activities.

Appendix: Concept Papers Endorsed by GEOHAB SSC for Potential Funding

QUANTIFYING HAB RESTING STAGE EMERGENCE AND DEPOSITION FLUXES: A COMPARATIVE WORKSHOP AND TRAINING PROGRAM

Donald M. Anderson¹, Esther Garces², Suzanne Roy³, Marina Montresor⁴, Allan Cembella⁵, Akira Ishikawa⁶, Silvia Angles⁷, Anke Kremp⁸, Chris Gobler⁹, Cheryl Greengrove¹⁰, Stephanie Moore¹¹

¹Woods Hole Oceanographic Institution, Woods Hole MA USA <danderson@whoi.edu>

²Institut de Ciències del Mar, CSIC. Barcelona

³ISMER, Université du Québec à Rimouski, Canada

⁴Stazione Zoologica Anton Dohrn Italy

⁵Alfred Wegner Institute, Bremerhaven Germany

⁶Mie University, Kamihama Japan

⁷Dept. of Oceanography, Texas A&M University, Texas USA

⁸Finnish Environment Institute Helsinki, Finland

⁹State University of New York at Stony Brook, Stony Brook NY USA

¹⁰University of Washington Tacoma, Tacoma WA USA

¹¹Northwest Fisheries Science Center, Seattle, WA USA

Many harmful algal bloom (HAB) species produce dormant cysts or resting spores during their life histories. Some also produce temporary or “pellicle” cysts that are less resistant, but which still provide a refuge during difficult conditions. Hereafter, for convenience, these will all be included under the umbrella term “resting stage.” The resulting alternation between a dormant, resting stage and a vegetative existence in the plankton is critically important in many aspects of bloom dynamics. Resting stage germination provides the inoculum for blooms, and the transformation back to the resting state can remove substantial numbers of vegetative cells from the population and act as a major factor in bloom decline, while also providing the inoculum for future blooms.

As critical as these life history transformations are for many HAB species, quantitative data on many aspects of resting stage formation, deposition, and germination are lacking. Direct measurements of resting stage emergence and deposition fluxes are limited, as measurement methods are difficult, prone to artifacts, and for emergence fluxes, limited to shallow waters, leaving major deposition or accumulation zones in deeper waters unstudied in this regard. Several emergence trap designs have been proposed and used in field studies of some HAB species, but no concurrent measurements have been made to ascertain the similarity and differences between approaches. The measurements are indeed challenging, as it is necessary to isolate a portion of bottom sediments without altering the chemistry or physical environment, capture small numbers of newly germinated cells before they divide, all while avoiding contamination from potentially abundant vegetative cells of the same species in the surrounding water. Likewise, sediment traps with designs ranging from simple to sophisticated have been used but never evaluated or compared in terms of efficiency and accuracy in the context of HAB resting cell dynamics. Again, these devices are susceptible to artifacts depending on current speed, resuspension events and the swimming behavior of the cells of interest. As a result of these limitations in methodologies, progress towards one of GEOHAB’s major goals has been limited – namely the development of comprehensive models of the dynamics of cyst- or spore-forming HAB species.

Here we propose a series of community workshops that will compare and evaluate methods for direct measurements of the rates of major life history transitions in HAB resting stages. These include in situ measurements of germination rates and emergence fluxes, as well as encystment rates and resting stage depositional fluxes to bottom sediments. A related workshop activity would involve examination of the manner in which these rate measurements can be incorporated into HAB numerical models.

Two and perhaps three separate workshops are envisioned for this program. The first would convene interested workers at a site and a time where HAB resting cysts and spores are present in bottom sediments and are germinating, with relatively easy access in terms of water depth and research vessel availability, and with appropriate laboratory and field facilities for instrument preparation and deployment, and for analysis of samples. With concurrent deployment of devices of different designs and careful experimental planning with appropriate controls, comparative studies can be conducted and each of multiple approaches evaluated for a range of HAB species. Presentations and discussions will also be held on “best practices” for laboratory experiments that quantify

germination using cultures and sediment samples. Some characteristics of resting stage formation and germination will only be possible to resolve in the laboratory.

The second workshop would focus on quantifying the formation and deposition of resting stages in field populations. The site for the workshop would again be a location where blooms of the target species are recurrent, predictable, and accessible. Multiple designs of sediment traps and collection methods can be evaluated, concurrent with methods for assessing levels of sexual induction and resting stage formation in the plankton. The latter would include traditional cytological methods, as well as novel optical and molecular approaches.

The third workshop in this series would involve modelers as well as biologists in an effort to refine methods to incorporate resting stage dynamics into HAB population dynamics models. In addition to defining the critical processes that need to be parameterized, the meeting would help to identify common approaches and computer code that can be shared among species and applications.

Potential funding sources for this project could include international agencies such as IOC-UNESCO, SCOR and national funding agencies such as the U.S. National Science Foundation (NSF) and the U.S. National Oceanic and Atmospheric Administration (NOAA).

Note also that this proposed workshop series covers an important but relatively narrow area of HAB population dynamics, and thus could be combined with other GEOHAB concept proposals related to life history transformations.

LINKAGES BETWEEN HARMFUL ALGAL BLOOMS AND ANOXIA

Pitcher, Grant C.

Fisheries Research and Development, Private Bag X2, Rogge Bay 8012, Cape Town, South Africa
(GrantP@daff.gov.za)

Participants

The following participants are committed and funded to undertake this project within the southern Benguela upwelling system:

Durand, Pierre M., Department of Molecular Medicine, University of Witwatersrand and National Health Laboratory Service, Johannesburg, SA
Pitcher, Grant C., Fisheries Research and Development, Cape Town, SA
Probyn, Trevor A., Fisheries Research and Development, Cape Town, SA
Schroeder, Declan C., Marine Biological Association, Citadel Hill, Plymouth, UK
Sym, Stuart, School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg, SA

Other participants will be identified following establishment of other systems to be included in the project for the purposes of comparison.

Summary

Oxygen deficiencies in coastal environments have increased during recent decades and eutrophication is considered a causal factor. Here high biomass dinoflagellate blooms (red tides) are often deemed the cause of anoxia. However the transient character of these events has contributed to a poor understanding of the causes and timing of bloom mortality leading to anoxia. This study will seek to establish the nature of phytoplankton mortality within blooms and the role of microbial activity in carbon transformation and oxygen consumption. Quantitative estimates of these processes will contribute to the prediction of anoxia linked to HABs. St Helena Bay in the southern Benguela upwelling system offers a unique environment to further study and quantify these links and for the purpose of comparison it is intended that parallel studies are undertaken in other systems.

Project outline

Oxygen deficit in the oceans is a critical determinant of biological and ecological processes and the expansion of hypoxia and anoxia represent major perturbations to the diversity, structure and functioning of coastal marine ecosystems. Dissolved oxygen is now recognized as a property of the ocean that has changed dramatically, with oxygen deficiencies having increased in frequency, duration, and severity during recent decades. Rates of oxygen

decline are considered to be greatest in coastal regions and evidence for eutrophication as an important causal factor is increasing. Temperature also interacts through a multitude of processes to control the extent of oxygen depletion, and projected warming associated with climate change shows an increase in susceptibility of coastal marine ecosystems to hypoxia and/or anoxia.

Anoxia is regularly listed as a major consequence of harmful algal blooms (HABs), but the linkage of blooms to anoxia and consequent mortalities within ecosystems is poorly established. Four categories of anoxia have been defined: permanent, seasonal, episodic and diel. Events of anoxia linked to HABs are typically confined to the episodic and diel categories and their local and transient character has contributed to our poor understanding of these events. Specifically the causes and timing of bloom mortality leading to anoxia are unknown. In contrast to the efforts to establish the conditions, mechanisms and strategies that control phytoplankton cell growth and bloom development, considerably less effort has focused explicitly on phytoplankton mortality and as a consequence the mechanisms that control abrupt bloom termination in natural systems are not well understood. Until recently phytoplankton were considered somewhat immortal unless eaten by predators, but it is now known that spontaneous death may result, particularly under adverse environmental conditions, as a consequence of infection by viruses or as a result of programmed cell death, with significant ecological impact. To date our studies have focused on the role of nutrient input and limitation in bloom development and demise rather than the role of microbial activity in carbon transformation and oxygen consumption.

This study will seek to establish the nature of mass, episodic phytoplankton mortality within HABs leading to the transfer of organic matter to the heterotrophic microbial community. Quantitative estimates of these processes will contribute to the prediction of anoxia linked to HABs. Our approach will be to track bloom development and demise through moored instrumentation at sites known to be susceptible to anoxia. In addition to monitoring dissolved oxygen concentration, measurements will also be made to quantify micro-zooplankton grazing, virus-mediated cell lysis and programmed cell death, as plankton mortality processes. These measurements will be made before, during and after the onset of anoxia.

Upwelling systems are subject to the risk of hypoxia and anoxia, and of the world's four major eastern boundary current systems, water column shelf anoxia is best known in the Humboldt and Benguela Currents. Here episodic events of anoxia have been linked to red tides in areas such as Paracas Bay and St Helena Bay, respectively. In St Helena Bay recent observations have shown that these events are confined to relatively shallow waters during periods of downwelling, when subthermocline nutrients are inaccessible leading to bloom stress. St Helena Bay therefore offers a unique environment to further study and quantify the links between HABs and anoxia. For the purpose of comparison it is intended that parallel studies are undertaken in other systems, including other upwelling systems (e.g., Paracas Bay) and other systems subject to regular anoxia linked to HABs.

Timeline and deliverables

- 2013: Initiate project in the southern Benguela upwelling system.
Identify collaborators in other systems prone to anoxia associated with HABs.
Secure additional funding.
- 2014-15: Undertake field and experimental work.
- 2016: Conclude project through comparative assessment of findings and publication of results.

Relevance to GEOHAB

The project seeks to further our knowledge of the ecology and oceanography of HABs leading to events of anoxia in upwelling and other systems. Although bloom development will be tracked, the project will focus on the processes associated with bloom mortality and associated anoxia. Quantitative estimates of these processes will contribute to prediction of anoxia triggered by HAB events.

Funding sources

Funding to initiate the project in the southern Benguela upwelling system is secured. Funding to extend the project to additional systems will be accessed following identification of these systems. Extension of the project may be achieved by funding of co-supervised post-doctoral students through bi-national or bi-lateral agreements.

SEA-CAGE FISH FARMING AND HABs: EVIDENCE FOR CAUSALITY IN TEMPERATE COASTAL ECOSYSTEMS?

Lincoln MacKenzie, Cawthron Institute, Nelson, New Zealand

Presented by Dr Raphael Kudela, Ocean Sciences Dept., University Of Southern California, USA

Introduction

The rearing of finfish in sea-cages has many benefits including the creation of valuable high-protein food, reducing the pressure on wild fisheries and supporting economic development and employment. In some countries it is a significant contributor to the national economy. Nevertheless for a variety of reasons (environmental sustainability, disease and parasites, food and water quality, use of therapeutics, effects on the benthos, effect on wild fisheries, occupation of public space, landscape values etc.) the operation of sea-cages in temperate coastal waters is controversial. The effect of sea-cages on the benthic environment is well studied but the effect on the water column is less well understood. A frequently cited concern is the potential to cause eutrophication leading to the generation of HABs, as a result of the large quantities of combined nitrogen that are introduced into the water column in the fish feed. On the face of it this concern is justified, but when existing published evidence is examined, it is not at all clear that there really is a close association. Because of the rapid assimilation, dilution and dispersion of dissolved and particulate nutrients, in many situations it appears to be difficult to directly attribute a response by the phytoplankton to sea-cage effluents. Justified or not, the perception that sea-cage fish farming leads to increased problems with HABs invariably becomes an important environmental planning question on which it is difficult to confidently provide an expert opinion.

A brief review of the literature

Several studies have demonstrated that coastal eutrophication is associated with the increased incidence of HABs (Anderson et al. 2002, 2008; Heisler et al. 2008), but in none of these studies were sea-cages identified as a significant cause. Searching the international literature does not reveal a strong relationship between HABs and sea-cage fish farming, except in the most confined, poorly flushed and grossly polluted situations where the nutrient loads from the farms clearly far exceed the assimilative capacity of the water body (e.g. Romdhane et al., 1998). There is little published evidence that phytoplankton biomass is enhanced by nutrient inputs from fish farm cages (Beveridge et al., 1994; Pitta et al., 1999; Wu et al., 1994), even when these farms are in enclosed inland locations with restricted water exchange (e.g. Navarro et al., 2008). In the few countries (e.g. Scotland) where systematic evaluations have been made (e.g. Rydberg et al., 2002; Scottish Executive Central Research Unit, 2002; Gubbins et al. 2005; Smayda 2006,) no connection between the occurrence of HABs and fish farm wastes has been identified. In a large study of the nutrient impacts of farmed Atlantic Salmon on the pelagic ecosystem in Chile, Buschmann et al. (2006, 2007) stated that ““there is little scientific evidence that nutrient loading from salmon farms is sufficient to initiate and sustain harmful algal blooms...””, though they acknowledged that “... nearly all the rigorous pelagic ecosystem science related to HABs has occurred outside the areas directly influenced by salmon farms” In Korea and other regions where *Cochlodinium polykrikoides* blooms have caused serious problems, blooms originate offshore as the result of large scale oceanographic processes and there is no strong evidence that implicates coastal eutrophication in their origin and development (Kudela et al., 2008, Kim et al. 2010). *Heterosigma akashiwo* is notorious for its effect on salmon farms in the USA and Canadian Pacific North-West regions though Rensel (2007) stated that “It is evident that fish farms do not cause *H. akashiwo* blooms in marine waters of Western Washington and the data suggest that it is unlikely they exacerbate blooms.” Nutrient inputs from fish farms may have contributed to the well-known case of the eutrophication of the Seto Inland Sea, Japan in the mid-20th century (Okaichi, 1997; Imai et al. 2006) but the more influential factors were massive effluent inputs from urban and industrial sources.

Norway is the largest producer of farmed salmon in the world and although toxic and noxious algal blooms are a common problem in the coastal waters of Scandinavia there is no suggestion in the literature that sea cages cause or exacerbate this. The extensive problems with *Pseudochattonella* and *Chrysochromulina* in the 1990s has been attributed to oceanographic processes (Graneli et al., 1993). A recent risk assessment of the environmental impacts of Norwegian aquaculture (Taranger et al., 2011) reached the conclusion that the risk of regional eutrophication in all areas associated with sea-cage salmon farming was low. New Zealand and Australia both have rather small sea-cage salmon farming industries in sheltered fjord-like locations though in both countries these are about to undergo significant expansion. Toxic and noxious HABs are relatively common (e.g. MacKenzie et al. 2011) in salmon farming regions in New Zealand but there has been little if any convincing evidence of causality over the 30 year history of the industry.

The proposal

As the brief discussion above shows there is little convincing proof of a cause and effect relationship between sea-cage fish farming and HABs. This is contrary to the views of some in the HAB science community (e.g. Fukuyo 2012: “Development of fish aquaculture almost always accelerates eutrophication of culture area and consequent occurrence of HABs.”). In fact given that these sea-cages can be responsible for high rates of nutrient loading to enclosed waters, it is puzzling that their effects are not more obvious and well documented. There may be a considerable amount of information on this topic in the ‘grey literature’ such as locally commissioned environmental assessment reports that would shed more light on it. The proposal is to develop a project under the GEOHAB umbrella that would be aimed at drawing out this information so that a consensus can be reached on where HAB related problems associated with sea-cages occur and what can be done to mitigate them. The proposal does not aim to address issues surrounding intensive pond culture nor sea-cages in tropical systems where data would not be directly comparable with temperate coastal ecosystems.

This proposal encompasses aspects of at least three of the programme elements from the GEOHAB Science Plan, including: Nutrients and Eutrophication, Comparative Ecosystems and Observation, Modelling and Prediction.

The specific objectives may include:

- A comprehensive review of published and unpublished data and the knowledge and opinion of local experts in all countries (e.g. Norway, Scotland, Ireland, USA/Canada, Japan, Korea, China, Australia, New Zealand etc.) with significant temperate sea-cage fish farming industries. This review may ultimately comprise series of papers focussed on specific regions published as a special journal issue or stand-alone volume.
- Foster the development of novel technologies to track effluent plumes from sea-cages to enable direct observations of their effects on the water column (e.g. drone-mounted remote sensing).
- Provide guidelines for effective monitoring of water quality and HABs associated with sea-cages, encourage research on in situ autonomous instrumentation to achieve this.
- Development of biophysical simulation models to more accurately predict the impact of fish farm effluents on the phytoplankton in general and HABs in particular.
- Identify means by which the environmental effects of fish farms effluents and their potential for stimulation of HABs might be minimised.
- Provide guidelines for the attributes necessary for the optimum location and nutrient loading rates of sea-cages to minimise the risk of HABs. Generic guidelines could be published under the GEOHAB banner.
- Encourage multidisciplinary research to accurately quantify nutrient assimilation, remineralisation and loss rates in waters and sediments of fish farming regions to parameterize biophysical models.

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Appendix 7
SCOR/Future Earth Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)
Project



**Integrated Marine Biogeochemistry and
Ecosystem Research (IMBER)
Annual Report to SCOR, July 2014**

A. Introduction

The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project (www.imber.info) is an international global environmental change research project, co-sponsored by the International Geosphere-Biosphere Programme (IGBP) and the Scientific Committee on Oceanic Research (SCOR). IMBER science is directed at addressing the goal of developing a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society. The IMBER Science Plan and Implementation Strategy (SPIS) published in 2005 outlined science questions and approaches for addressing this goal. The SPIS was updated in 2010 when the Global Ocean Ecosystems Dynamics (GLOBEC) project ended and some of its activities were incorporated into IMBER. Thus, IMBER is now approaching its ten-year mark, and it is appropriate to assess project accomplishments, reconsider the project goal and science questions, and to develop an agenda that will form the basis for the next 10 years of IMBER research.

To assist in the process of project evaluation and future planning, IMBER convened an Open Science Conference (OSC) titled, '*Future Oceans – Research for marine sustainability: multiple stressors, drivers, challenges and solutions*', in June 2014 in Bergen, Norway. The goals of the OSC were to provide the opportunity for the larger marine science community to present key findings from IMBER-relevant research, to promote integrated syntheses of IMBER research, and to develop a science plan for future IMBER research. Prior to the OSC during spring 2014, a draft position paper was prepared using inputs gathered from IMBER regional programmes, working groups, and partner organizations. From these inputs, five research themes emerged:

- Continued integration of marine biogeochemistry and ecosystem research
- Impacts of global change and climate variability on marine systems
- Role of multiple drivers and stressors, and responses of society
- Integration of marine biodiversity and conservation
- Integration of ocean-human systems

Also data management and capacity building were highlighted as important mechanisms for facilitating and implementing the research challenges and questions included in the five themes.

The draft position paper was provided to participants prior to the OSC and presented in a plenary presentation. Each of the themes, data management, and capacity building were discussed in breakout groups during the OSC and the inputs from each were reported in a plenary session. In parallel, an online survey was implemented to allow for additional inputs from OSC participants and the community. The position paper is now being revised based on these inputs and subsequent discussions with the IMBER Scientific Steering Committee. The primary change is that the five themes will be incorporated into a small number of overarching grand challenges that provide direction for IMBER research beyond 2015. The intent is to have a draft of the revised paper available for community comments by mid- to late August 2014. A summary of the position paper will be provided to SCOR for discussion at the annual meeting in September 2014 with follow-on interactions with IMBER. The final version of the paper should be available by the end of 2014 and this will provide the basis a 10-year extension request to SCOR.

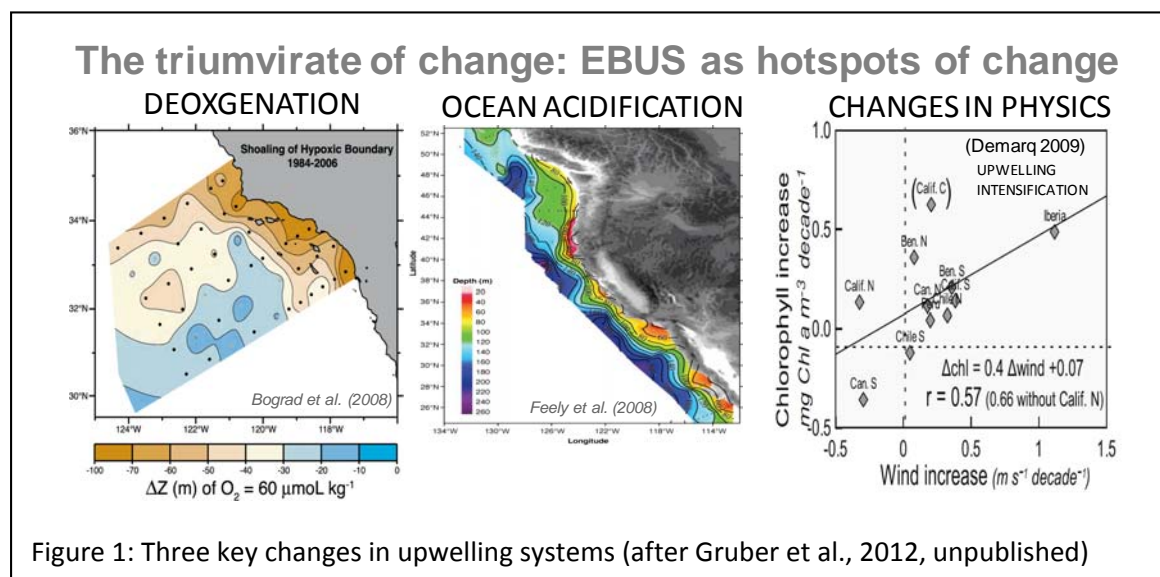
IMBER has a strong commitment to basic curiosity-driven science and this is the foundation on which an agenda for the next 10 years of research will be based. However, the environmental issues facing society, particularly those

relating to global environmental change, are at the interface between natural and social sciences and humanities, where the understanding provided by curiosity-driven, natural science merges with problem-driven, societally relevant and mostly integrated research. This is underscored by the science highlights presented in the next section, which are drawn from the plenary presentations given at the IMBER OSC. Each of these presentations focused on scientific achievements, but also provided a view to the future. For all, the research challenges that were highlighted involved some degree of coupling between natural, human, policy and governance systems related to the marine realm.

A clear message to IMBER from OSC plenary and contributed presentations, the inputs to the position paper, and feedbacks received from the OSC participants is that research that includes these interfaces must be part of any future science agenda. While the research landscape and its organisation are evolving at the global level, the IMBER community is well poised to take the lead in developing this area of marine research. Exciting changes and challenges are facing our community and dealing with these in a proactive, forward-thinking manner is key, both for now and the future.

B. IMBER science highlights from the Open Science Conference, 2014

The IMBER OSC was attended by about 485 participants, who represented 48 countries, including 16 developing countries. The final programme included 5 plenary sessions, 11 workshops and 21 contributed sessions, representing all IMBER science themes, regional programmes, working groups, and related communities. The science highlights presented in this section, which are drawn from the OSC plenary presentations, provide an overview of IMBER science achievements, highlight the rationale for the five themes in the draft position paper, and introduce new ideas for future IMBER research.



Plenary Talk, Nicolas Gruber: This presentation, “*Warming up, turning sour, losing breath – the regional perspective*”, focused on the consequences of pH changes, ocean acidification, and de-oxygenation using specific examples from the California Current, an eastern boundary current upwelling system (Fig. 1). Recent advances in observational capability have captured changes in the physical, biological and chemical characteristics of the California Current resulting from ocean acidification and low oxygen.

Advances in modelling capability and incorporation of new observations into models have allowed projections of these trends into the future, identification of important controlling processes, and attribution of uncertainty to the future projections. The latter effort has highlighted the importance of extreme and rare events in driving change in marine systems (Fig. 2). The combined modelling and observational efforts allow identification of marine ecosystems that are most vulnerable to the effects of changing pH and reduced oxygen and provide guidance about controlling processes.

Plenary Talk, Kon-Ke Liu: Research accomplishments and future research needs for continental margins were presented in, *“Anthropogenic impacts on biogeochemical processes and ecosystems in continental*

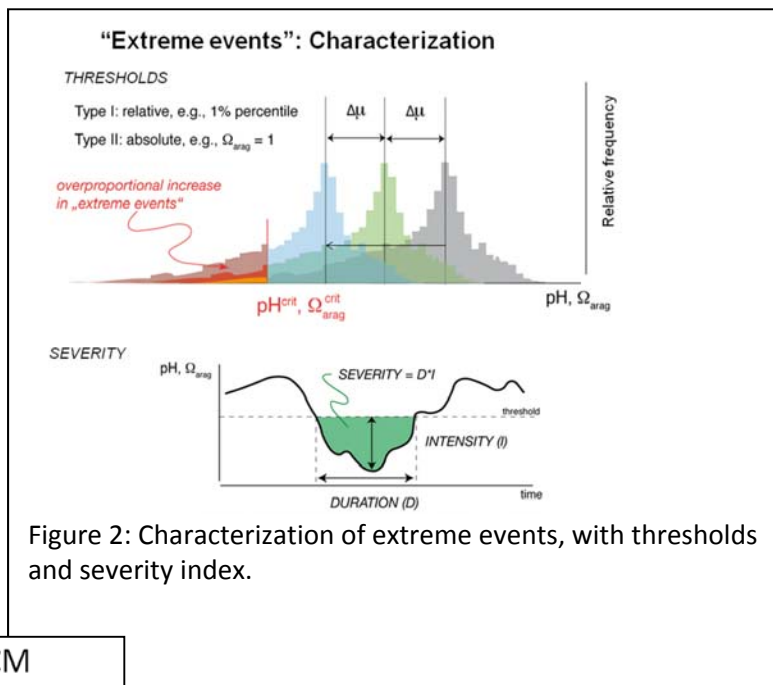


Figure 2: Characterization of extreme events, with thresholds and severity index.

Knowledge and understanding in CM

- From watershed to coastal ocean processes
- From ecosystem functioning to societal values
- From exploitable resources to governance arrangements

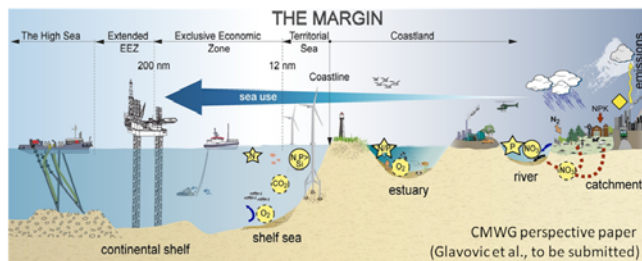


Figure 3: A representation of the continental margin, after Glavovic et al., in preparation.

margins – lessons learned from cases around the globe and future perspectives”. This presentation focused on the growing importance of continental margins for providing resources and services for human, marine and maritime activities. At the same time these systems are vulnerable, and climate-related changes are moving continental margins towards possible tipping points. New research strategies that foster sustainable use of continental margins are being developed that include from the outset consideration of innovation, risk and governance (Fig. 3).

Plenary Talk, Coleen Moloney: From its beginning, IMBER has had a focus on integrating marine biogeochemical cycling and food web dynamics. The presentation, *“Food webs and biogeochemistry in a changing marine environment”*, provided a synthesis of IMBER accomplishments in developing end-to-end views of marine ecosystems (Fig. 4). This approach is key to developing and exploring (e.g., climate and fishing) scenarios of future changes in the marine environment, understanding its resource and service provision, and to furthering predicting capacity at local and intermediate complexity/integration levels (Fig. 5).

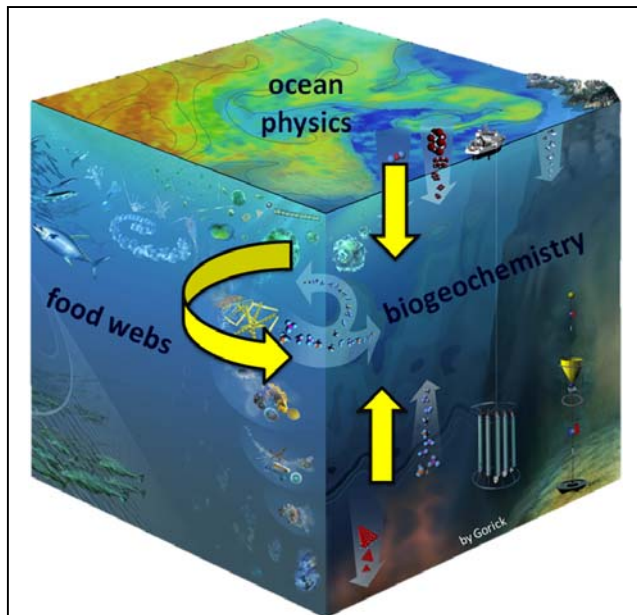


Figure 4: Gorick image with key oceanic processes

This presentation highlighted potential impacts of ocean acidification, but took the longer view that these impacts are acting in combination with other drivers and stressors (Fig. 6). The potential role of ocean acidification at local, regional and global levels is significant, but understanding of related physical-chemical, physiological, ecological, societal processes associated or depending on ocean acidification is still limited, especially when multiple drivers and stressors are considered (Fig. 7). This is an area for future research and the IMBER community is well positioned to take the lead.

New process understanding, such as mixotrophy and parasitism, remain to be incorporated into trophic process models. However, the progress that has been made is substantial and for some marine ecosystems, scenario testing and projections are a reality. Models of intermediate complexity for ecosystem assessments (Fig. 5), which extract information from a suite of models developed for different aspects of an ecosystem, were highlighted as the approach for scenario testing and projecting future states of marine ecosystems.

Plenary Talk, Jean-Pierre Gattuso: Advances in an area of marine research that has been a priority focus for IMBER (and SOLAS) were summarized in, *“Drivers of and responses to ocean acidification”*.

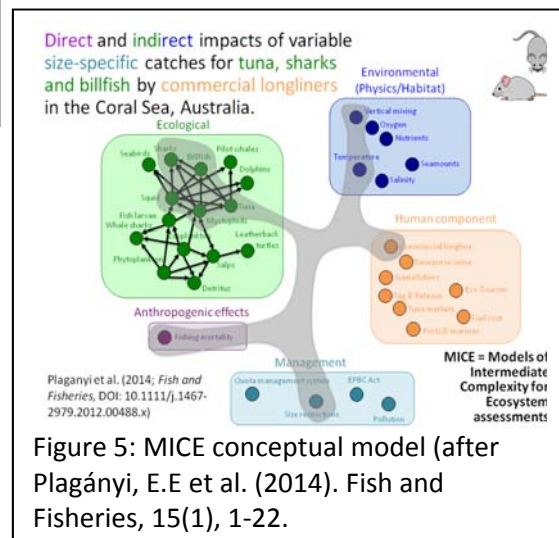


Figure 5: MICE conceptual model (after Plagányi, E.E et al. (2014). Fish and Fisheries, 15(1), 1-22.

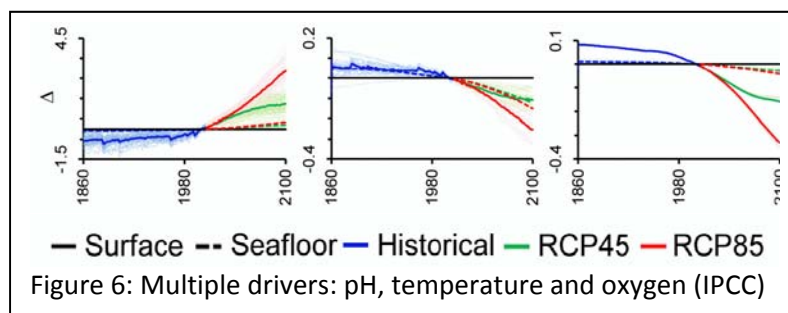


Figure 6: Multiple drivers: pH, temperature and oxygen (IPCC)

Plenary Talk, Claudio Campagna: The potential biodiversity crisis that the marine environment is facing in the coming decades was presented in, “*Marine Conservation in the time of Global Change*”. This potential crisis is associated with the values issues of human society in terms of how marine resources are viewed. Efforts are underway to explore the threats and trends for iconic species’ biodiversity.

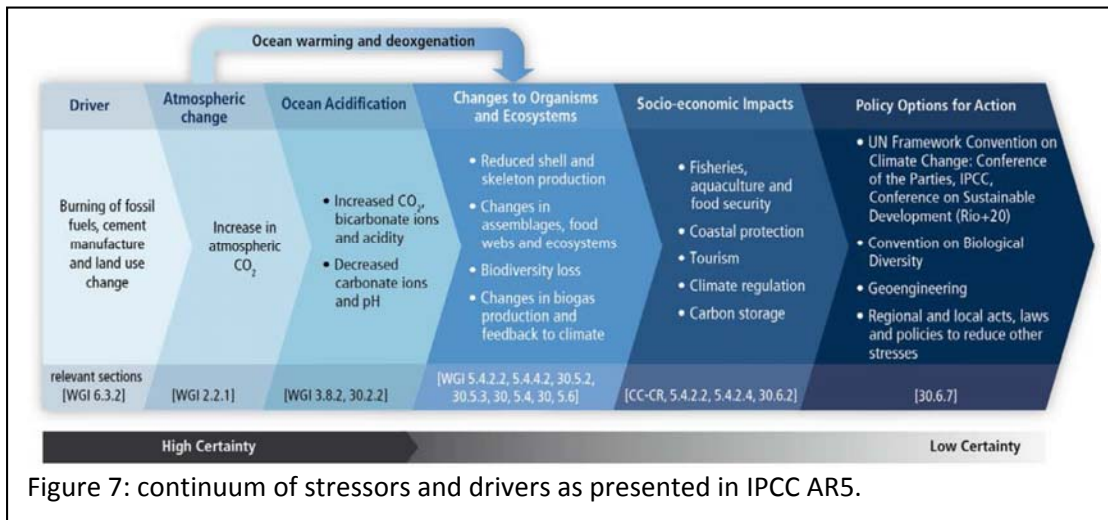
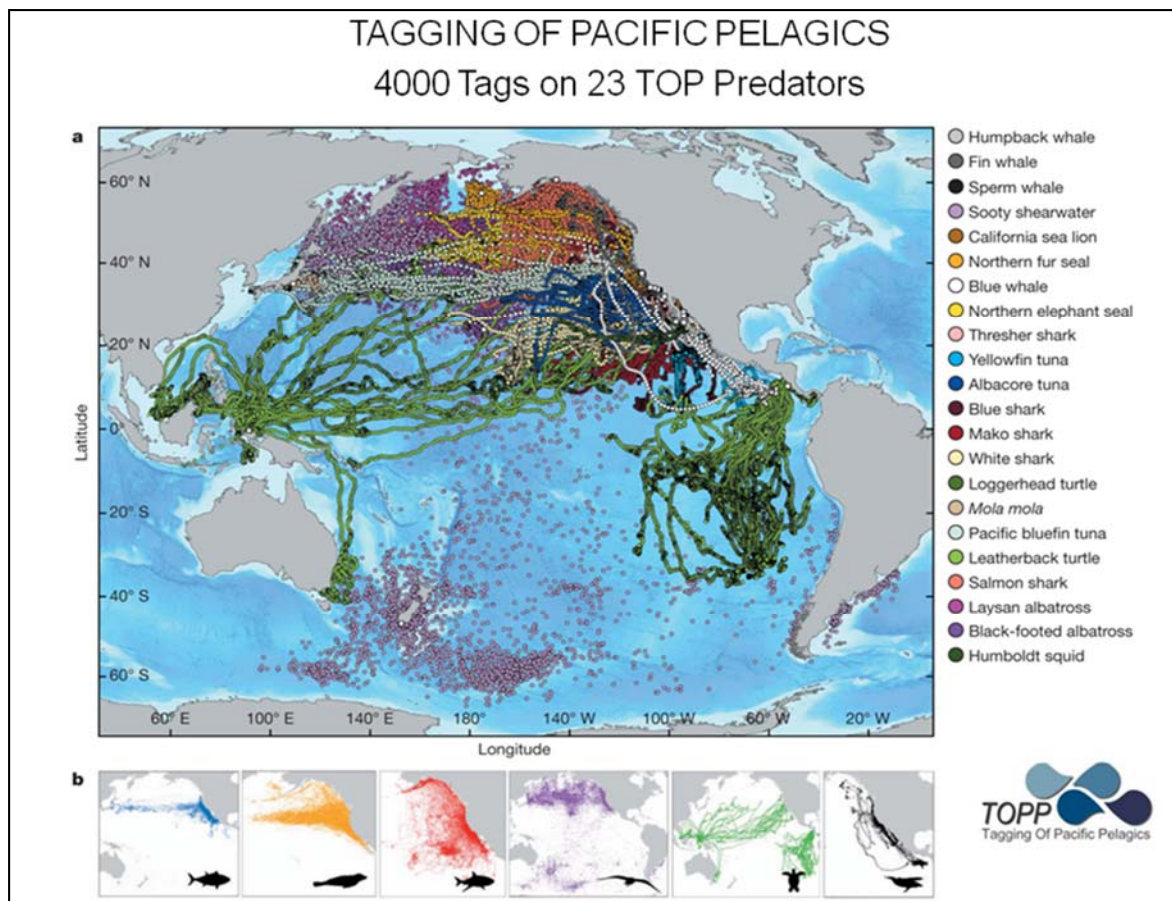


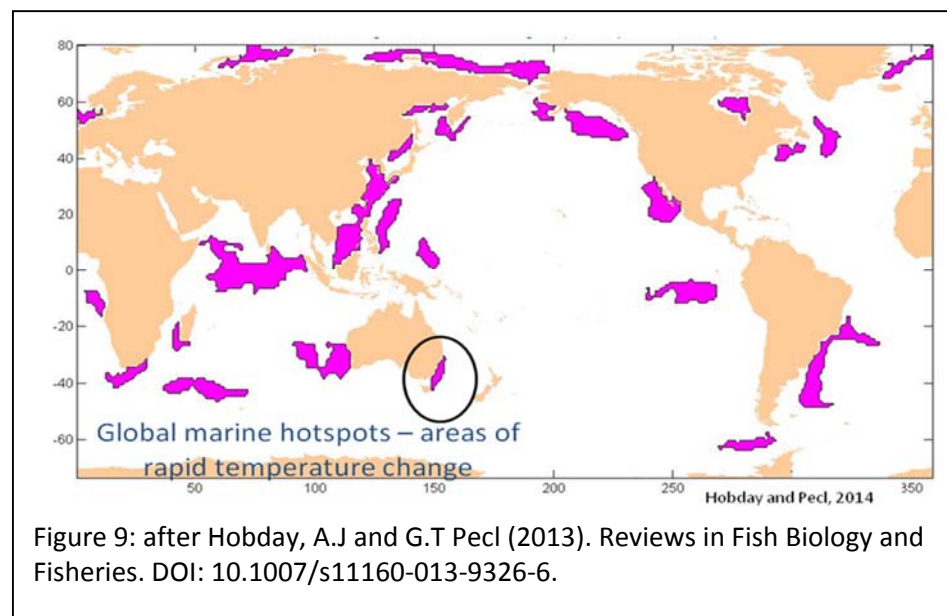
Figure 7: continuum of stressors and drivers as presented in IPCC AR5.

Among useful new methods and approaches are tagging and remotely sensed monitoring of individuals, which provides information on behaviours, habitat use, and species range (Fig. 8). The establishment of Marine Protected Areas provides one possible approach for conservation for marine biodiversity, but more evaluation and research are needed to determine the effectiveness of these regions. Limited progress has been made in terms of conserving



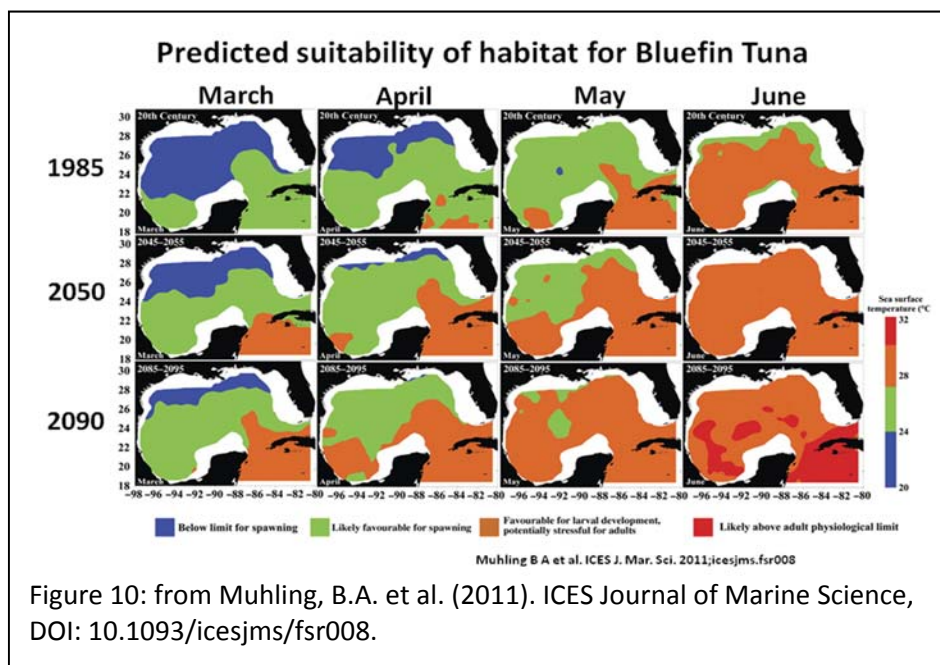
biodiversity in the marine environment, and much remains to be done. Marine biodiversity and conservation is an important area for future IMBER research and it is a natural extension of the research that is ongoing in the regional programmes.

Plenary Talk, Alistair Hobday: The contributions that IMBER research has made to the understanding of responses of top predators to global change were summarized in the presentation, “*Climate change impacts and adaptation options for high trophic level marine species*”.



adaptation options for high trophic level marine species”. New integrated approaches, methodologies used at the individual or species’ levels, and new data (e.g., inter-oceanic comparison of top predator diets and ecosystem trophic structure) have improved prediction capability for various scenarios of climate change, such as changes in habitat suitability for commercial species (Fig. 9) and allowed linkages to be made between areas of rapid temperature

change to threats to key marine species and fisheries (Fig. 10).

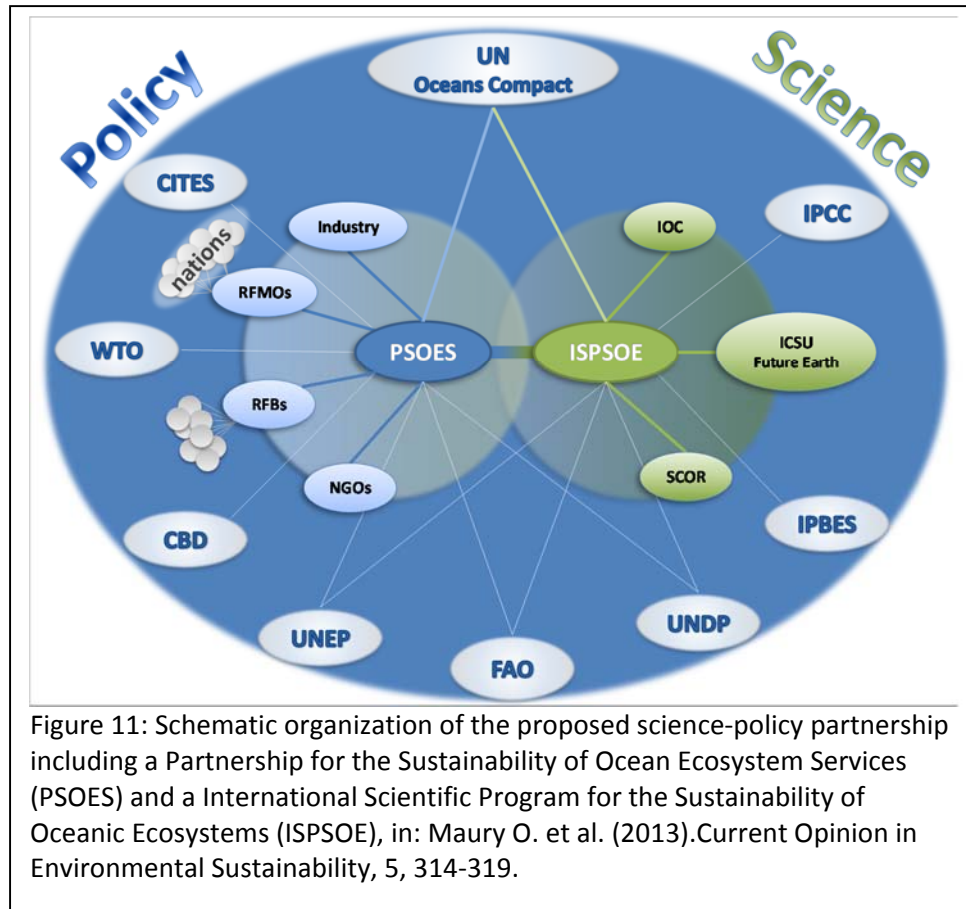


A new conceptual vulnerability research framework was proposed that explores adaptation options, applicable either locally or at the species level. The adaptation process is iterative, and closely links ecological and societal systems and their respective vulnerability. Changes are underway in many marine systems and change is predicted to continue. Continued documentation of these changes (e.g., fisheries decline) is important to developing the understanding and strategies needed to change the trajectory of

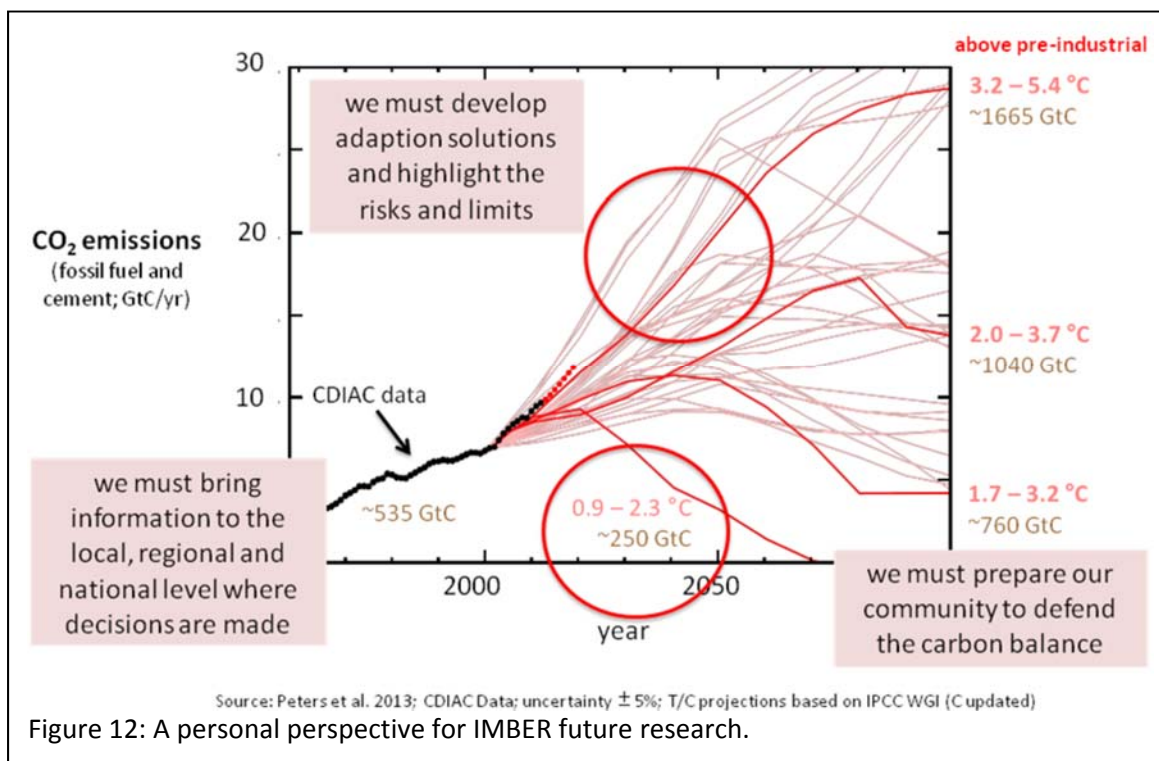
the change and to help species, people, and institutional systems to adapt to the change. Options exist to respond to climate change effects on pelagic top predators, but adaptation will be difficult for open ocean species, and will require the involvement of managers, policy makers, and institutions from the outset.

Plenary Talk, Alida Bundy: “*Dead ends and grasping hands: failed governance and the need to integrate human-ocean interactions into global change science*” focused on research needs for improving understanding of

human-ocean interactions, with specific examples drawn from marine fisheries. A social-ecological systems approach and a truly integrated dialogue across the natural and social science disciplines and among multiple stakeholders are needed, which requires a new integrated, co-designed research agenda (Fig. 11). Development of science-policy partnerships, through the institutions involved in the assessment and management of marine resources



and services, *and* also at the level of the individual research, is a start to this process. The IMBER-ADApT decision support tool was developed by the IMBER Human Dimensions Working Group. This tool will enable decision makers, researchers, managers and local stakeholders to improve responses, make decisions efficiently to transition towards marine sustainability, and evaluate where to most effectively allocate resources to reduce vulnerability and enhance resilience of communities to marine global change. This approach will advance and improve the impact of current research endeavours underway in the IMBER regional programs.



Plenary Talk, Corinne Le Quéré: Inputs from the Future Earth Scientific Committee, that also built upon recent progress by the IPCC from inputs by the marine research community, were provided in, “*From CO₂ surveys, nutrient budgets, ecosystem process studies and modelling, to the Future Earth era: preserving our strengths and shaping new opportunities for the IMBER community*”. The approaches used by IMBER and the IPCC are complementary to developing scenarios, projections and predictions, that help decision-making processes (as based on scientific evidence for environmental policy) and help promote sustainable societal transitions. The strengths of the IMBER community and the possible pathways for a strong IMBER-related contribution in Future Earth (Fig. 12) were highlighted.

C. IMBER Regional Programmes

Ecosystem Studies of Sub-Arctic Seas (ESSAS) Regional Programme

The ESSAS programme (www.imr.no/essas) focuses on the impacts of climate change on sub-Arctic marine ecosystems and their sustainability. In April 2014, ESSAS held its Annual Science Meeting (ASM) in Copenhagen, Denmark. The focus for this meeting was the paleo-ecology of the Subarctic Seas, biology and ecology of Arctic cod species, human responses to major shifts in fisheries, comparative and modelling studies, and the biological impacts of the Atlantic Multidecadal Oscillation. The ESSAS SSC met following the ASM to review recent ESSAS activities and to develop a future research plan. Following a request from ESSAS, Greenland appointed a new member, AnneDorte Burmeister, a crab biologist, as a replacement on the ESSAS SSC for Kai Weiland, who no longer is working in Greenland waters. The ESSAS co-chairs convened a session on, “*Changing ecosystems in sub-Arctic and Arctic regions*”, at the **IMBER OSC** in June 2014, Bergen, Norway.

ESSAS Working Groups

The *WG on Modelling Ecosystem Response* is involved in a special volume on *Modeling and observational approaches to understanding marine ecosystem dynamics* in *Progress in Oceanography* that is to be dedicated in memory of Bern Megrey, former chair of this ESSAS WG.

The *WG on Climate Effects at Upper Trophic Levels* completed its terms of reference with the publication of a special topic session in *Marine Ecology Progress Series* in 2013 and the WG was terminated.

The *WG on Arctic-Subarctic Interactions* has organized a theme session at the ICES ASC in Spain in September 2014 and a workshop at the PICES annual meeting in Korea in October 2014, both on advection and exchanges between the Arctic and Subarctic.

The *WG on Bioenergetics of Subarctic Fishes* aims to develop deeper understanding of climate's impact on the match between juvenile fish and their prey and the implications of that relationship for future production.

The *WG on Human Dimensions* formed last year under the leadership of Keith Criddle, who gave a presentation at the ESSAS ASM.

The *WG on Comparative Paleo-Ecology in Sub-Arctic Seas* sponsored a special session during the ASM. The WG will explore potential mechanisms linking climate, oceanographic, ecological and human system relationships from the Holocene to the Anthropocene.

Multinational Activities (endorsed by ESSAS)

A Norwegian and U.S. Climate Change and Marine Ecosystems (*NUCCME*) Workshop was held in May 2013 focused on the marine environment, fisheries management and human dimensions, jointly with CLIFFIMA, a Nordic Council Network that investigates climate change issues, including human dimension aspects. A related special issue in *Climatic Change* is in preparation.

The 2011 international Atlantic Multidecadal Oscillation (AMO) workshop published its special issue in the *Journal of Marine Systems* in 2014, describing the temporal variability of the AMO, the spatial structure of the SSTs within the North Atlantic, the possible mechanisms governing the AMO dynamics, the impacts on other physical characteristics such as currents and sea ice, past variability in temperature from paleo-records, the biological impacts of the AMO including effects on phytoplankton, zooplankton and fish stocks, and the links to temperature changes in the Antarctic and the Pacific.

The ESSAS-endorsed project *TROPHARCT* assembled a series of 5 joint papers from Canadian, U.S., Russian and Norwegian scientists plus an introductory paper, published during 2013 in a special section of *Marine Ecology Progress Series* under the title “*Harvested fish stocks in a changing environment*”.

Future ESSAS activities

The next ASM and SSC meetings will be held in June 2015 at the University of Washington in Seattle. In response to a new project initiated at the University of Washington, ‘Future in Ice’, a day to 1.5-day meeting on ice and its effects on biology will be held at the ASM. Additional potential session topics include paleo-ecology, human dimensions, and bioenergetics.

Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) Regional Programme

The ICED programme aims at a better understanding of the climate interactions in the Southern Ocean, the implications for ecosystem dynamics, the impacts on biogeochemical cycles, and the development of sustainable management procedures. www.iced.ac.uk/index.htm.

As part of a thematic workshop, “*Polar Marine Ecosystems Research: Strategic directions for the EU Research Area*” (Brussels, Belgium, May 2013), a joint ICED/EUR-OCEANS Consortium Flagship Project (Polar Ecosystem Change and Synthesis, PECS) strategy document for Polar Marine ecosystem research was presented to senior European Commission members. Such research should form an essential component of the EU Research Area funded by the EC Horizon 2020 funding programme. This is already promoting European and international collaborative research and some of the aims of the strategy have appeared in recent calls of Horizon 2020, thereby fulfilling the workshop's objective.

During the ICED Scientific Steering Committee Meeting (SSC), held in Cambridge, Maryland, USA in November 2013, progress over the last 5 years was reviewed and the key directions and priorities were agreed upon for the next 5 years. The ICED Workshop on ‘Southern Ocean Food webs and Scenarios of Change’ in Nov. 2013, focused on exploring quantitative, future scenarios based on the latest available climate models, ecological data and models, and information on fisheries and the associated critical challenges

The *Workshop on Ecosystem Essential Ocean Variables (eEOVs) for the Southern Ocean*, March 2014, focused on biodiversity indicators and indicators of marine ecosystem structure, function, and dynamics; composite indices; and expert advice to policymaker. A proposal for a related Working Group has been submitted to SCOR.

ICED scientists have participated in the SCAR Horizon Scan Retreat, April 2014, with 80 participants, for identifying the most important scientific questions in and from the southern polar regions over the next two decades. A series of documents have been submitted to the Commission for the Conservation of Marine Living (CCAMLR) Working Group on Ecological Monitoring and Management highlighting relevant ICED science and ways of interfacing with policy.

Several scientific papers were published that consider Southern Ocean change, ecosystem structure and function, links between ecology and biogeochemistry, and management of the Southern Ocean.

One ICED-related session was organised at the IMBER OSC (Bergen, Jun 2014), with a panel discussion on *‘Challenges for evidence-based management of Southern Ocean ecosystems’*.

The ICED community contributed to the forthcoming IPCC AR5 Report (Climate Change 2014: Impacts, Adaptation, and Vulnerability Working Group II), led by A. Constable.

An ICED stakeholder event (joint with WWF) was held in June 2014, which brought together key sectors with an interest in Antarctic krill: the fishing industry, scientists, and conservation organisations.

Future ICED activities

- A joint AnT-ERA/AntClim21/ICED session on ‘Impact of climate change on Antarctic biota’ will be convened at the SCAR Open Science Conference, Aug. 2014, New Zealand.
- An ICED community paper on scenarios is being developed. ICED will strengthen our science areas as outlined in the IMBER Position Paper and we will work to establish a clear and strong role for ICED within CCAMLR, SCAR and Future Earth.
- The re-development of the online fieldwork map tool is still underway, and a Southern Ocean wiki is developing, led by the ‘Sentinel’ programme.

CLimate Impacts on Oceanic TOP Predators (CLIOTOP) Regional Programme

The CLIOTOP programme aims to use a worldwide comparative approach to identify the impact of both climate variability and fishing on the structure and function of open ocean pelagic ecosystems and their top-predator species. See www.imber.info/CLIOTOP.html.

A *Deep-Sea Research II* special issue developed from the 2nd CLIOTOP symposium is now being edited by CLIOTOP SSC members. CLIOTOP Working Groups have held a range of meetings and have generated a large number of publications. The website hosted by IMBER IPO is allowing us to showcase CLIOTOP scientific outputs (www.imber.info/CLIOTOP.html).

The CLIOTOP SSC held its 9th Meeting in June 2014, in Bergen, just prior to the IMBER OSC. Osamu Abe (Japan) replaced Hideki Nagano (Japan) as an SSC member. Several of the working groups will soon be concluded, and the SSC is now discussing a new structure for a proposed CLIOTOP phase III, for the next five years.

CLIOTOP SSC members convened a workshop entitled “*Beyond ‘Z’: what modelers need and empiricists have to offer to better incorporate higher trophic levels and humans in end-to-end models*” and a session on “*The pivotal role of the mesopelagic functional groups in biogeochemical cycles*” at the IMBER OSC in June 2014, Bergen, Norway.

Selected Working Group Activities

- Co-sponsored session with Marine Bird Mammal – Advisory Panel at PICES FUTURE Open Science Meeting workshop in April 2014 entitled “*Top predators as indicators of climate change: statistical techniques, challenges and opportunities*”.

- “Diet Workshop: analysis of a full stomach contents dataset using classification tree methodology modified for complex diet data”, October 2013, Australia
- “Stable Isotope Workshop: Pelagic Top Predators and N Isotopic Baselines” February 2014, Hawaii, USA
- Website developed for ISOZOO programme investigating the role of lower trophic level dynamics in structure of pelagic food webs: <http://www.isofoo.org>.
- The CLIOTOP Scenario Group (involving also representatives from industry and RFMOs) first met in November 2013 and started to establish Oceanic System Pathways (OSPs). The objective is to develop model-based scenarios jointly with stakeholders.
- Participation in the IUCN workshop “*Multidisciplinary Workshop to Address Ecosystem-Level Impacts of Fisheries Bycatch on Marine Megafauna: Biodiversity Conservation through Mitigation, Policy, Economic Instruments, and Technical Change*” in October 2013; in the ‘*Building 21st century scenarios for global oceanic ecosystem and fisheries*’ meeting, in November 2013.
- Participation in several meetings about fishing capacity in various regions, with the International Seafood Sustainability Foundation, the European Commission, or the Inter-American Tropical Tuna Commission.

Science Highlights

CLIOTOP is now becoming better recognized within the open ocean research community, with increasing balance in research between tuna and fisheries, and non-exploitation issues with other top predators (seabirds, marine mammals and turtles).

Results from CLIOTOP activities were published in a special issue of *Deep-Sea Research II*, on the “Role of squids in pelagic ecosystems” (2013).

Future CLIOTOP activities

- Workshop on “Variability in the movement patterns of marine predator populations: physiological, behavioural and environmental drivers in the Bio-logging 5 Symposium, September 2014.
- Several sessions proposed for the ICES/PICES 3rd International Symposium on Climate Change Effects on Marine Ecosystems, March 2015.
- Participation in the Euro BASIN workshop ‘Futures of the North East Atlantic Ocean by 2040- a Stakeholder Consultative Workshop’, November 2014.
- Planned participation in several meetings related to seafood sustainability, fisheries economics and fishery management.
- The 3rd CLIOTOP Symposium is scheduled for September 2015.

Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) Regional Programme

SIBER is a basin-wide research initiative sponsored by IMBER and the Indian Ocean GOOS (IOGOOS) Programme, with close ties to CLIVAR’s Indian Ocean Panel (IOP), and focuses on understanding climate change and anthropogenic forcing on biogeochemical cycles and ecosystems in the Indian Ocean, in order to predict the impacts of climate change, eutrophication and harvesting (www.imber.info/index.php/Science/Regional-Programmes/SIBER and www.incois.gov.in/Incois/siber).

The SIBER SSC met in China, July 2013 following the Second International Symposium on Boundary Currents convened with CLIVAR’s Pacific Panel and Indian Ocean Panel (IOP) and the IndoOOS Resources Forum (IRF). A joint session was also convened with CLIVAR/IOP. The International Indian Ocean Expedition 50th Anniversary (IIOE-2) planning efforts have emerged as a major SIBER activity. The second IIOE-2 Reference Group meeting was convened in China, Nov. 2013 to help define the overarching science and societal drivers for IIOE-2, and assess planned and ongoing national activities in the IIOE-2 timeframe (2015-2020). In addition, a strategy was developed for promoting national IIOE-2 planning efforts and an IIOE-2 organizational framework/governance structure was adopted. Another Reference Group meeting needed for the East Africa/SW IO constituency for a more general IIOE-2 engagement was convened in March 2014 in Mauritius. The chair of SIBER, Prof. Raleigh Hood, is chairing a SCOR committee to draft a IIOE-2 Science Plan. This plan will be reviewed at a workshop in Bremen, Germany on 12-13 September 2014.

The Eastern Indian Ocean Upwelling Research Initiative (EIOURI) has also emerged as a major SIBER activity. This initiative, which is envisioned as a 5-year process study and program under the emerging IIOE-2 in the Eastern

Indian Ocean, embraces upwelling as a unifying IIOE-2 theme, with basin-wide relevancy. Three workshops have been convened so far (two in 2013 and one in 2014) with a final workshop was held at the IMBER Open Science Conference, June 2014.

SIBER-motivated biogeochemical sensor deployments are continuing in the Indian Ocean. A biogeochemical sensor package deployed on a RAMA mooring at the equator and 80°E on 22 May 2010 was recovered and the data have been analyzed. In addition, a CO₂ sensor package has been deployed in the Bay of Bengal with support from BOBLME, and a RAMA mooring has been deployed at the flux reference site at 26°S, 97°E equipped with a BGC sensor. Finally, a new SIBER/CSIRO Australian research initiative in the Eastern Indian Ocean is aimed at quantifying nutrient fluxes through the Indonesian Throughflow.

In addition to the SIBER International Project Office, located at INCOIS in Hyderabad, India, efforts are continuing to establish a Regional Program Office in Western Australia supported jointly by Australia's Integrated Marine Observing System (IMOS) and the IOC Office in Perth. The SIBER SSC has provided guidance documents on how to define responsibilities and tasks of this RPO and partition these between IMOS and the IOC Perth office.

A SIBER-related session on 'Biogeochemical and Ecological Impacts of Boundary Currents in the Indian Ocean' was held at the IMBER OSC in Bergen, Norway, June 2014.

Overall, SIBER has strong collaboration with various regional actors (e.g., Indian Ocean Panel of the Variability and predictability of the ocean-atmosphere system project CLIVAR, and IOGOOS) and in this respect has developed a useful model for CLIVAR-IMBER collaboration.

Future SIBER activities:

- The next SIBER SSC meeting will be convened in Phuket, Thailand, in October 2014, jointly with the IOGOOS Program and the IndOOS Resources Forum (IRF).
- The SIBER special issue in *Biogeosciences* on Current biogeochemical and ecosystem research in the Northern Indian Ocean is still in preparation.

D. IMBER Working Groups and Task Teams

SOLAS-IMBER Carbon (SIC!) Working Group

To oversee marine carbon process studies, there are currently three joint SOLAS-IMBER carbon (SIC!) groups dealing with carbon in the surface ocean systems (SOS), carbon in the interior ocean (IOC) and ocean acidification (SIOA). It has earlier been suggested that the remits of the existing SIC! Working Groups could be revisited to incorporate the topic of the Microbial Carbon Pump in the Ocean, its possible interactions with the existing SIC! WGs, and potentially improve the studies of the various forms, sources, sinks and interactions of all pools of organic matter. It was also agreed that this should be done in collaboration with SOLAS and GEOTRACES.

Surface Ocean Systems (SIC!-SOS)

This working group focuses on data synthesis for the carbon in surface ocean systems (SOS), and on instrumentation and technology development, Voluntary Observing Ships (VOS) and mixed layer sampling strategy.

SIC!-SOS members co-convened with SIC!-IOC and IOCCP, a session on '*The ocean carbon cycle at a time of change: Data syntheses, analyses and modelling*' at the IMBER OSC in June 2014, Bergen, Norway, to focus on surface-to-interior connections.

Interior Ocean Carbon (SIC!-IOC)

This working group co-ordinates international research on interior ocean changes in carbon and biogeochemistry, undertakes synthesis activities, and aims to develop sustainable observing systems, including the addition of oxygen sensors to the international ARGO float programme (ARGO-O₂).

The global synthesis of repeat hydrography initiative is progressing well since 2009 and has made major advances in the last year. The secondary data quality control effort of the GLODAP2 group is nearly completed and the data are planned to be released in June 2014. An ad-hoc steering committee with Masao Ishii (Japan), Jeremy Mathis (USA), Toste Tanhua (Germany), and Nicolas Gruber (Switzerland) was formed at a synthesis workshop in Beijing, held in

conjunction with the 9th International CO₂ conference, to oversee the work to determine the global-scale oceanic accumulation of anthropogenic CO₂ since the 1990s. The synthesis group held a workshop at the 2014 Ocean Sciences meeting in order to discuss the first results and agree on a draft outline of a high-profile paper. The final results will be presented at the IMBER OSC where this synthesis group is organizing a dedicated session on “*The ocean carbon cycle at a time of change: Data syntheses, analyses and modelling*” in partnership with SIC!-SOS and IOCCP. WG2 is also continuing to support the growing Bio-Argo programme, with A. Körtzinger and K. Johnson being in charge of SCOR WG 142 on sensor calibration. This group also held its first workshop at the 2014 Ocean Sciences Meeting.

Ocean Acidification (SIOA)

SIOA co-ordinates international research efforts and synthesis activities in ocean acidification. Within a single decade, ocean acidification research has grown from involving only a few scientists to a research topic that has recently been considered the #1 research front in ecology and environmental sciences. While exciting, this rapid expansion has not been without its problems. For example, it has not been easy for experts to share information and train newcomers from different countries, which is essential to avoiding unnecessary duplication.

The SIOA met in May 2014, in Villefranche-sur-mer and Monaco and SIOA members convened a session on “*Regional responses to climatic and non-climatic drivers in a high-CO₂ ocean*” at the IMBER OSC in June 2014, Bergen, Norway.

The Ocean Acidification International Coordination Centre (OA-ICC), initiated and mainly driven by the SIOA, is now half-way through its first three years of funding (2013-2015). It aims to foster scientific collaboration at the international level, promote best practices, improve observational capacities and databases, and facilitate communication and outreach. The OA-ICC is supervised by a Science coordinator (SIOA's current chair). The OA-ICC advisory board includes all SIOA members. The chair of the advisory board is Carol Turley, another SIOA member. The OA-ICC produced several key products that already have become fundamental building blocks for the ocean acidification research community and to ocean acidification science users, including the OA-ICC web site, www.iaea.org/ocean-acidification; OA-ICC news stream at news-oceanacidification-icc.org; OA-ICC bibliographic database, <http://tinyurl.com/oaicc-biblio>; OA-ICC data compilation at <http://tinyurl.com/oaicc-data> (now containing 409 datasets); an SIOA/IOCCP/CARBOCHANGE comparison study of the seven publicly available software packages that compute marine carbonate chemistry was published in *Biogeosciences Discussions*; and the OA-ICC slide set *Things you should know about ocean acidification*, produced for scientists to facilitate making presentations on ocean acidification to non-scientists <http://www.iaea.org/ocean-acidification/page.php?page=2189>.

Additionally, the OA-ICC helped support international scientific meetings where ocean acidification figures prominently, while also promoting understanding of ocean acidification at non-scientific meetings for international negotiations and discussions. The science meetings included the 2nd Global Ocean Acidification Observation Network (GOA-ON) workshop (July 2013) and the 6th SOLAS summer school (Xiamen, China, summer 2013). Additionally, the OA-ICC organized and funded a data curators' workshop (Monaco, April 2014) to move towards the goal of a “one-stop shop” for ocean acidification data. The OA-ICC brought ocean acidification understanding to policy-makers and negotiators by supporting and helping to run an international exhibition stand that highlighted ocean acidification at the UNFCCC COP19 in Warsaw. The OA-ICC also participated in and provided expertise at a UN Law of the Sea (UNICPOLOS) 3-day meeting on ocean acidification (New York, June 2013) and provided information to delegates through the GOA-ON side event at the GEO Summit (Geneva, Jan 2014).

Future SIOA and OA-ICC activities

The OA-ICC will continue to perform routine operations of data management and bibliographic organization, maintain its web site, and post articles to the new stream. Moreover, there are also plans in 2014 and 2015 to launch intercomparison of calcification and boron-isotope measurements, and discussions are underway to determine if the OA-ICC can provide new and consistent routines to propagate errors and compute buffer factors in the publicly available packages that compute carbonate chemistry. The OA-ICC is now in the advanced stages of planning of two training workshops on ocean acidification in late 2014 in Chile and Italy; in 2015, three others are planned to be held in Southeast Asia, Africa, and the Pacific Islands. Additionally, OA-ICC is helping to organize and fund a natural-social science connection workshop on the socioeconomics of ocean acidification (early 2015) as well as the

3rd international GOA-ON observational workshop (2015). Outreach will continue to grow, especially with regard to policymakers at the next COP meetings in Lima and Paris.

Continental Margins Working Group (CMWG)

The current Continental Margins Working Group (CMWG), co-sponsored by IMBER and LOICZ, held its third meeting before the IMBER Open Science Conference: Future Oceans in Bergen, Norway, June 2014.

As human activities dominate key global processes in the Anthropocene era, there is an urgent need to secure sustainability by implementing transformative governance strategies to safeguard Earth's life-support systems for long-term human wellbeing. Nowhere is this endeavour in greater demand than at the ocean-land interface – the continental margins, which are experiencing a quadruple squeeze:

- Population growth, development intensification and rising demands for energy-intensive resources.
- Ecosystem degradation and loss.
- Rising CO₂, climate change and alteration of marine biogeochemistry and ecosystems.
- Ecosystem tipping points and rapid and irreversible changes in social-ecological systems and societal responses.

In this respect, the CMWG is drafting a perspective paper, currently under review, intended as the manifesto for the great needs in future continental margins research. It stresses continental margins are an engagement arena for global sustainability research and action, because more than one-third of the world population resides within the coastal belts that have a direct dependence on marine ecosystem services in continental margins, which are threatened by multiple stressors, both natural and man-made. With the hope to implement the strategies laid out in the perspective paper in future research activities, a longer paper is also in preparation to expand on the five strategic points, illustrated with examples of real cases:

1. To build knowledge and understanding of social-ecological systems on continental margins that cover the spectrum from ecosystem functioning to exploitable resources, societal values, institutional frameworks and governance regimes;
2. To develop innovative methodologies, strategies, guidance and good practices that identify opportunities to unlock the potential of the resources of continental margins, on a sustainable basis, and promote risk reduction;
3. To design governance regimes that are inclusive, reflexive, adaptive and enforceable;
4. To test alternative place-based institutionalized structures and processes for securing equitable distribution of costs and benefits to users of continental margins while sustaining ecosystems; and
5. To experiment with and establish new research epistemologies, partnerships and practices on continental margins – the frontline of the sustainability crisis in the Anthropocene.

Besides the longer paper, an on-line version of a science plan and implementation strategy (SPIS) for future continental margins research is under development.

Following the IMBIZO III (Jan. 2013) Workshop 1 on “*Biogeochemistry – ecosystem interactions on changing continental margins*”, a special issue entitled “*Biogeochemistry-ecosystems interaction in changing continental margins in the Anthropocene*” is being published in the *Journal of Marine Systems*. The main conclusion is that ecosystem responses to biogeochemical change are complex and impact major margin services, including primary production, fisheries production, nutrient cycling, shoreline protection, chemical buffering, and biodiversity. Despite regional differences, complexities, and uncertain feedbacks, the societal consequences of these changes are unarguably large and mandate coherent actions to reduce, mitigate and adapt to multiple stressors on continental margins.

The CMWG members and colleagues convened two sessions on “*Impacts of anthropogenic stressors and climate change on biogeochemistry-ecosystem in continental margins and feedbacks to earth system and society: Challenges and solutions*” and “*Environmental changes in Eastern Boundary Upwelling Systems: drivers, mechanisms and implications for the ecosystems*” at the IMBER OSC in June 2014, Bergen, Norway.

Future CMWG activities:

- After three years of operation, the CMWG will undergo re-organization. Since IGBP, the common parent organization of IMBER and LOICZ, will stop operation at the end of 2015, CMWG will have to undergo a transformation following the two sponsoring projects. Future continental margins research will make significant contributions to the grand collective effort of transformation toward sustainability in the future.

Data Management Committee (DMC)

The DMC promotes a cooperative data management approach - involving experienced data management specialists, from the start of a project, and training young scientists in good data management procedures. The IMBER Data Management Committee (DMC) is composed by a mix of natural science scientists, sea-going scientists, and data experts.

A Data Management Workshop, co-chaired by C. Chandler, T. O'Brien and A. Piola, DMC members, was held as part of the IMBER Open Science Conference, <http://www.imber.info/index.php/Meetings/IMBER-OSC-2014/Sessions-Workshops/Data-Management-for-IMBER>. In order to facilitate the discussions during the workshop, an online survey was distributed before the IMBER OSC.

The IMBER DMC has recommended that IMBER adopt the Directory Interchange Format (DIF) as a discovery metadata standard. The advantage in using DIF is that records can be easily created and managed through NASA's Global Change Master Directory (GCMD). A customized metadata portal within GCMD has been set up for IMBER, which can be accessed at <http://gcmd.nasa.gov/portals/imber/>, with entries for 32 endorsed projects and related activities.

A survey of the GCMD holdings associated with IMBER is currently on-going to determine which Regional Programmes, Endorsed Projects and Contributing Projects have a suitable metadata record.

The DMC recommends:

- To fully integrate data management activities in all IMBER project-wide events;
- To assure that endorsed projects are prepared to comply with IMBER DM policies; and
- To organize a meeting of data scientists of IMBER-endorsed projects and regional programmes.

Capacity Building Task Team (CBTT)

The CBTT objectives are to enhance marine research capabilities in developing countries, enhance research capabilities globally in relevant IMBER activities, and strengthen graduate education in ocean sciences.

A Workshop held in Shanghai in March 2013 aimed at synthesizing the outputs of an international CB workshop (31 July 31–4 August 2012 in Shanghai, China), to finalize a strategic paper to be submitted to a peer-reviewed journal. This meeting was also dedicated to explore future actions of capacity building for marine research in the Asia-Pacific region.

The main outputs of these CBTT efforts included an *EOS* article (2013) and a synthesis paper on “Developing human capital for successful implementation of international marine scientific research projects” in *Marine Pollution Bulletin* (2013). Capacity building in marine sciences faces several challenges, such as the training in multidisciplinary research, increasing capacity for overall synthesis of scientific data, building the capacity of technical staff, keeping highly qualified personnel in marine scientific research roles, as well as the cross-cultural issues in training and minimizing duplication in training activities. Potential solutions to these challenges are provided, along with some priorities for action aimed at improving the overall research effort.

An IMBER Capacity Building workshop was held as part of the IMBER Open Science Conference (OSC) in Bergen, Norway in June 2014, to gain information, knowledge and experience from participants about how capacity building can be developed to support IMBER science for next 5-10 years. In order to facilitate the discussions during the workshop, an online survey was prepared before the Bergen meeting in June.

CBTT worked together with the IMBER IPO and RPO to secure external funding resources to support the IMBER ClimEco4 Summer School, which will be held at East China Normal University, Shanghai, in August 2014.

Future CBTT activities:

In 2014-2015, CBTT plans to organize a small workshop with 5-6 participants to work on the CB requirements for the future, sustainable IMBER studies. The expected output of this workshop will be a “White Paper”-type report for the new IMBER research agenda for the next 5-10 years.

Human Dimensions Working Group (HDWG)

The HDWG focuses on the interactions between human and ocean systems, and aims to create an integrated and interactive natural-social science marine research community within IMBER.

The first IMBER-ADApT paper was completed and submitted to the *Ghoti* section of *Fish and Fisheries* in November 2013. The special volume of *Regional Environmental Change*, resulting from the HDWG-led IMBIZO III Workshop “*Understanding And Forecasting Human-Ocean-Human Interactions, Drivers And Pressures, With Respect To Global Change*” is in preparation.

IMBER-ADApT templates were revised and starting in September 2013, invitations were sent out to collect more case studies for the development of IMBER-ADApT.

The 4th IMBER HDWG meeting was held in March 2014 in Canada. It was decided to further reduce number of questions in the IMBER-ADApT template, to revise and re-submit the *Ghoti* paper, to prepare several papers on shellfish mortality and on the conceptual approach to typology, and to develop a book on IMBER-ADApT case studies. Some changes in the HDWG leadership are anticipated in the future. One HDWG member, Sarah Cooley, stepped down in April 2014, due to a new job situation. One of the new IMBER SSC members, Eddie Allison, became a HDWG member in June 2014.

HDWG members and colleagues convened two sessions entitled “*Responses of society to marine and global changes as a core mandate for IMBER: ways forward*”, with co-sponsorship of PICES, and “*Future Oceans’ stewardship: roles, responsibilities and opportunities in small-scale fisheries*” at the IMBER OSC in June 2014, Bergen, Norway, and one of the HDWG co-chairs (Alida Bundy) gave a plenary presentation during the OSC.

Future HDWG activities:

- Next HDWG meeting planned to coincide with the PICES meeting in Santos City, Brazil.
- Hold workshop prior to the Too Big to Ignore (TBTI) meeting in Merida (Sept. 2014).

E. IMBER project-wide activities

Open Science Conference (OSC) 2014

The IMBER Open Science Conference, ‘*Future Oceans – Research for marine sustainability: multiple stressors, drivers, challenges and solutions*’, held from 22-27 June 2014 in Bergen, Norway (www.imber.info/index.php/Meetings/IMBER-OSC-2014), provided a venue to the larger marine science community for presenting key findings of IMBER-relevant research, for promoting integrated syntheses of IMBER research, and for developing a new research agenda to guide future marine biogeochemistry and ecosystem research.

The OSC helped disseminate IMBER science results to a broader community, with both natural and social science representation. The plenary presentations were broadcast live and subsequently posted on the IMBER website. Social media outlets (mainly Twitter) facilitated the involvement of a wider audience of marine researchers and research end-users, allowing a broader engagement in the strategic discussions.

Overall, the IMBER Open Science Conference attracted more than 720 contributions and gathered about 485 participants representing 46 countries, including 16 developing countries. The final programme included 5 plenary sessions, 11 workshops and 21 contributed sessions, representing all IMBER science themes, regional programmes, working groups, and related communities, with a total of 140 poster and 325 oral presentations. Results from the OSC will be published as peer-reviewed synthesis publications and special issues with contributed and solicited papers.

SCOR agreed to support the participation of several researchers from developing and emerging economies. Other sponsors included the following:

- Research Council of Norway (RCN);
- Institute of Marine Research (IMR), Bergen, Norway;
- University of Bergen (UiB), Norway, Norwegian Research School in Climate Dynamics (ResClim), and the City of Bergen, Norway;
- the State Key Laboratory of Estuarine and Coastal Research (SKLEC), East China Normal University (ECNU), Shanghai, China;
- the U.S. National Aeronautics and Space Administration (NASA);
- U.S. Ocean Carbon and Biogeochemistry (OCB) Program;
- Korea Institute of Ocean Science and Technology (KIOST);
- Academia Europaea (AE);
- European Geosciences Union (EGU);
- European Space Agency (ESA);
- International Council for Science (ICSU), Future Earth (FE) programme;
- Gordon and Betty Moore Foundation (GBMF).

Several sessions and workshops are co-sponsored by the following organisations and initiatives, including the Earth System Governance (ESG) project, Future Ocean Alliance (FOA), International Council for the Exploration of the Sea (ICES), North Pacific Marine Science Organization (PICES) and Variability and predictability of the ocean-atmosphere system (CLIVAR) project. Finally, several exhibitors contributed to the success of this event, including Aquatic Biosystems, Marine Harvest, National Geographic and Sea-Bird Electronics.

The funding provided by external sponsors aimed especially at facilitating participation of early-career researchers (32 were supported), thereby providing these individuals the opportunity to experience international science and to learn about advances in marine science that are being made as part of IMBER activities. They are potentially the next generation of leaders in marine science and entraining them in international science at an early stage benefit them and the larger marine research community, and helps ensure that all regional communities are an integral part of planning the future directions of a marine global environmental change research agenda.

ClimEco Summer Schools

IMBER ClimEco Summer Schools are held every two years and have proved to be a successful capacity building mechanism for students and early-career scientists. The ClimEco4 Summer School titled, '*Delineating the issues of climate change and impacts to marine ecosystems: Bridging the gap between research, assessment, policy and management*', will be held in early August 2014, in Shanghai, China (www.imber.info/index.php/Early-Career/IMBER-Summer-Schools/ClimEco4-August-2014-Shanghai-China). It will focus on indicators that inform us about the impact of global change on marine ecosystems and the human populations that depend on them, and on how to combine them so that they can be used to inform policy and decision-making.

Topics covered in lectures include an overview of climate change impacts on marine ecosystems from a biophysical and human perspective, information about indicators, models, analysis, linking indicators to a regulatory or management perspective, and bridging the gap between research and information that is practically useful for management. Practical sessions each afternoon will enable participants to try out the methods and techniques covered in lectures. Several participants are providing datasets, which will be augmented with additional data if necessary, so groups can select indicators and use them to evaluate the state of a system or species. Students will present their results at the end of the course.

Sixty-four participants from 30 countries were selected from the almost 170 applications received. The Scientific Committee on Oceanic Research (SCOR) agreed to support the participation of several researchers from developing and emerging economies.

The multidisciplinary lecturers are natural and social scientists: Alida Bundy (DFO, Canada), Laura David (University of the Philippines, Philippines), Beth Fulton (CSIRO, Australia), Eric Galbraith (McGill University, Canada), Xianshi Jin (Yellow Seas Fisheries Research Institute, China), Scott Large (NOAA, USA), Stéphane

Pesant (University of Bremen, Germany), Keith Sainsbury (CSIRO & University of Tasmania, Australia), Rashid Sumaila (UBC, Canada) and Ingrid van Putten (CSIRO, Australia).

China-Japan-Korea (CJK) IMBER Symposia

The 6th China-Japan-Korea (CJK-6) IMBER Symposium focusing on “*Ocean Ecosystem Dynamics and Integrated Marine Biogeochemistry and Ecosystem Research*” was held in October 2013, Tokyo, Japan

(www.imber.info/index.php/Meetings/IMBER-Sponsored-and-Endorsed-Meetings/2013/6th-China-Japan-Korea-IMBER-Symposium-3-4-October-2013-Tokyo-Japan), with the following goals:

- To advance our understanding of marine biogeochemistry and ecosystem dynamics for the sustainable use of ecosystem services;
- To understand the response of various marine ecosystems to multi-stressors and drivers, from climate change to anthropogenic forcing.

More than 50 IMBER scientists from the three countries participated in the Symposium, with 30 oral presentations and 16 posters showing IMBER-related research achievements.

A meeting report, ‘*Changes in Marine Environments and Responses of Ecosystem Dynamics in the East Asian Pacific*’, was published in *Eos* in February 2014 (DOI: 10.1002/2014EO070007), and the IMBER Update Newsletter issue n°25 included several science highlights from CJK-6.

Austral Summer Institute XIV

IMBER co-sponsored the Austral Summer Institute XIV (ASI XIV, www2.udec.cl/oceanoudec/asi-14/eng), held in January 2014 in Concepcion, Chile, which focused on *Coastal and Open Ocean Studies through Multiple Approaches*. One of the courses was taught by Kay-Christian Emeis (CMWG member), dealing with “Changing biogeochemical cycles in the coastal ocean”. Nineteen students, from Argentina, Chile, Brazil, Belgium, Colombia, Cuba, Germany, Uruguay and USA, attended.

Status of the International Project Office (IPO, Norway)

The IPO is hosted until April 2017 by the Institute of Marine Research (IMR) in Bergen, Norway. The IMR has recently indicated that the IPO should be soon relocated, more closely to the management team of the new formed *Johan Hjørt Centre for Marine Ecosystem Dynamics*, sponsored by four Bergen institutions: the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, the University of Bergen and its spin-off, Uni Research Ltd. This pro-active, positive aspiration is a positive sign and will be carefully considered and valued.

Continuation of the IMBER Regional Project Office (RPO, China)

The IMBER Regional Project Office (RPO), established under a Memorandum of Understanding between IMBER and its host institution, the East China Normal University, in 2010 for an initial three-year period, has been renewed for another three years (2013-2016). The RPO is an essential facilitator in the IMBER efforts to reach out to the IMBER-related research community in the Asia-Pacific region, and a very active partner with the International Project Office in many of its activities.

F. IMBER SSC membership

There are currently 15 IMBER SSC members. At the end of 2013, Javier Aristegui (Vice Chair), Carol Robinson (Vice Chair), Jean-Pierre Gattuso and Nicolas Gruber completed their second term of office on the SSC. In February 2013, IMBER solicited the research community for nominations for their replacements with the following expertise, identified by the IMBER Executive Committee: human-ocean interactions, marine anthropology; marine/environmental economics; microbial ecology and biogeochemistry, meso-pelagic processes; carbon fluxes and budgets; biogeochemical modelling, carbon-climate interactions and ocean acidification. Fifty-seven submissions were reviewed extensively and a short list of nominees presented to and later approved by SCOR and IGBP in late 2013: Edward H. Allison (M, US), expertise: human-ocean interactions, marine anthropology; Katrin Rehdanz (F, DE), expertise: marine/environmental economics; Gerhard J. Herndl (M, AT), expertise: microbial ecology and biogeochemistry, meso-pelagic processes; Laurent Bopp (M, FR), expertise: carbon fluxes and budgets; biogeochemical modelling, carbon-climate interactions and ocean acidification.

N.B.: the country codes mentioned after the names refer to the current country of affiliation of the nominees, not

necessarily their nationality.

At the end of 2014, Ken Drinkwater, Eugene Murphy, Hiroshi Ogawa, Alberto Piola and Sinjae Yoo will complete their second term of office on the SSC. Nominations for replacements were solicited from the research community through a call for nominations disseminated in March 2014. The required fields of expertise identified by the IMBER Executive Committee are:

- physical oceanography, satellite oceanography and climate interactions in changing marine environments
- marine biogeochemical cycles, and dynamics of organic matter and nutrients in changing marine environments,
- biological and ecological oceanography, and ecosystem dynamics in changing marine environments, and
- integrated studies of social, ecological and biogeochemical marine systems.

Fifty-one nominations were received and reviewed by the IMBER Executive Committee. A short list of 6 possible SSC candidates with the expertise that will be required by IMBER in the future was discussed during the SSC meeting in June 2014.

To more evenly distribute changes to the IMBER SSC, it was agreed to extend Eugene Murphy and Alberto Piola for one more year and continue Ken Drinkwater as an ex-officio member. This decision was made in consultation with the IMBER co-sponsors. This arrangement will avoid large changes in the SSC membership, especially now that IMBER is undergoing a transition and organization of the GEC projects is changing. The SSC discussed potential nominees for the three open positions. Discussions are ongoing and once the nominees have confirmed their interest in participating in the IMBER SSC, their nominations will be provided to SCOR and IGBP. It is anticipated that the nomination process will be completed in August.

G. IMBER cooperation

IMBER has been closely collaborating for many years with SOLAS (see SIC!) and LOICZ (see CMWG) and have ongoing joint activities. The IMBER-CLIVAR joint activity is relatively new and is now beginning to develop its own identity as described below.

Cooperation with the ‘Variability and predictability of the ocean-atmosphere system’ project (CLIVAR) on the IMBER/CLIVAR Joint Research Initiative on Upwelling

In 2013, a WG was assembled under the leadership of Ken Drinkwater to undertake joint research by CLIVAR and IMBER on upwelling ecosystems. One member from SOLAS was also included. This team was asked to develop an implementation plan to tackle 2-3 issues of joint interest through workshops and/or working groups. A research effort directed at upwelling in the Eastern Indian Ocean has been initiated through the joint efforts of IMBER’s SIBER programme and CLIVAR’s Indian Ocean Panel. Two workshops were held in 2013 to develop a Science Plan and Implementation Strategy and a third workshop entitled “*Eastern Indian Ocean Upwelling Research Initiative Planning Workshop Phase 3 – Physical Dynamics and Ecosystem Responses*”, and two sessions on “*Environmental changes in Eastern Boundary Upwelling Systems: drivers, mechanisms and implications for the ecosystems*” and “*Climate-biogeochemistry interactions associated with open-ocean oxygen minimum zones*” were co-convened by IMBER and CLIVAR researchers during the IMBER Open Science Conference in Bergen, June 2014.

Future IMBER-CLIVAR-related activities:

A workshop aiming at investigating the potential effects of climate change on upwelling systems will be held in conjunction with the PICES/ICES/IOC 3rd Symposium on Climate Change in the World’s Oceans in Brazil in March 2015. The most recent global and regional models will be used to determine future scenarios in the upwelling regions of the world’s oceans. These, together with information on the present trends in upwelling, will be used to determine the likely impacts on the primary and secondary production and further on fish and fisheries. Output from the workshop will be a report to IMBER, CLIVAR and SOLAS, as well as a primary publication comparing and contrasting the physical and biogeochemical (e.g., oxygen) scenarios in the major upwelling regions of the world under future climate change.

There is also a plan for further joint collaboration. Comparative studies will be conducted on major upwelling areas around the globe, for example, within eastern (EBCs) and western boundary currents (WBCs), along the equator, in the Indian Ocean, in polar regions, etc. and will cover physical, biogeochemical, biological, fish and fisheries processes and trends. Projection scenarios will be developed based on global and higher resolution regional models. Of major importance will be potential effects on fisheries resources that, in turn, will be used to explore the effects of different management strategies under climate change in order to maximize societal benefits. The results will be published in primary scientific and socio-economic journals together with research recommendations to improve estimation of ecosystem changes in upwelling regions under climate change and the potential effects on their dependent societies.

It should also be noted that IMBER has strong links with the observations community:

Indian Ocean Global Ocean Observing System (IOGOOS)

SIBER (under the sponsorship of IMBER and IOGOOS), the kindred physical oceanography alliance known as the Indian Ocean Panel of GOOS/CLIVAR (IOP), the IndOOS Resources Forum (IRF) (supporting SIBER and IOP in strategic and operational terms), are stimulating progress in specific components of GOOS contributing to building IndOOS, such as the Argo programme, XBT, SOOP, satellites, buoys etc. SIBER is especially involved in the on-going deployment of biogeochemical sensors on Indian Ocean Observing System (IndOOS) / Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA). Under the IOGOOS framework, relevant activities focus on issues of local or global importance, such as monsoons and ENSO, and also include capacity building, modelling and forecasting.

Contributions to international assessments

- Many SIC!-related research projects have contributed to a series of synthesis chapters for the Regional Carbon Cycle Assessment and Processes (RECCAP) effort (www.globalcarbonproject.org/reccap/).
- Many of these syntheses and other contributions from the IMBER-related research projects and IMBER regional programmes are included in the *fifth Intergovernmental Panel on Climate Change Assessment Report (AR5)* of the Intergovernmental Panel on Climate Change' (IPCC, www.ipcc.ch). IMBER-related researchers markedly who are significantly involved in the IPCC AR5 Work include Nicolas Bates, Laurent Bopp, Andrew Constable, Sarah Cooley, Scott Doney, Kenneth Drinkwater, Richard Feely, Jean-Pierre Gattuso, Nicolas Gruber, Christoph Heinze, David Karl, Corinne Le Quere, Salvador Lluch-Cota, Yukihiro Nojiri, James Orr, Svein Sundby, Toste Tanhua, Carol Turley, and Rik Wanninkhof.
- IMBER researchers are involved in the United Nations 'Regular process for global reporting and assessment of the state of the marine environment, including socio-economic aspects', aka, UN World Ocean Assessment (UN-WOA; www.worldoceanassessment.org).
- IMBER has provided comments on the European Space Agency (ESA) science strategy (2006), as inputs to the *ESA Living Planet Symposium* (www.livingplanet2013.org) that took place in September 2013, Edinburgh, UK.
- IMBER has also contributed to the activities of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, www.ipbes.net), especially through nominations of IMBER-related researchers for relevant IPBES activities and committees.

H. Selection of IMBER Publications

Overall, IMBER has produced about 1000 refereed research papers since its implementation, including about 150 papers and 12 special issues published in 2013-2014.

Special Issues

- Canadell, J., P. Ciais, C. Sabine, and F. Joos (2013). REgional Carbon Cycle Assessment and Processes (RECCAP). Biogeosciences, 9-11 (special issue 107) - www.biogeosciences.net/special_issue107.html
- Cowie, G., H. Kitazato, R.H. Hood, S.W.A. Naqvi, and A. Gooday (2013). Current biogeochemical and ecosystem research in the Northern Indian Ocean. Biogeosciences, 10-11 (special issue 138) - [6 papers. www.biogeosciences.net/special_issue138.html](http://www.biogeosciences.net/special_issue138.html)
- Denman, K., R. Feely, J.-P. Gattuso, H.-O. Pörtner, U. Riebesell, D. Schmidt, and A. Waite (2013). The ocean in a high-CO₂ world III. Biogeosciences, 10 (special issue 129) - [19 papers. www.biogeosciences.net/special_issue129.html](http://www.biogeosciences.net/special_issue129.html)

- Drinkwater, Ken and Pierre Pepin (2013). Norway-Canada Comparison of Marine Ecosystems (NORCAN). Progress in Oceanography, 114, 1-126. www.sciencedirect.com/science/journal/00796611/114
- Landry, Michael R. and Michio J. Kishi (2013). Sensitivity of marine food webs and biogeochemical cycles to enhanced stratification. Progress in Oceanography, 119, 1-108 - 10 papers. www.sciencedirect.com/science/journal/00796611/119
- Liu, K.-K., C.-K. Kang, T. Kobari, H. Liu, C. Rabouille, and K. Fennel (2013). Biogeochemistry and ecosystems in the western north Pacific continental margins under climate change and anthropogenic forcing. Biogeosciences, 10-11 (special issue 125) - 23 papers. www.biogeosciences-discuss.net/special_issue105.html
- Riebesell, U., J.-P. Gattuso, T. F. Thingstad, and J. Middelburg (2013). Arctic ocean acidification: pelagic ecosystem and biogeochemical responses during a mesocosm study. Biogeosciences, 10 (special issue 120) - 21 papers. www.biogeosciences.net/special_issue120.html
- Robinson, C., F. Azam, N. Jiao, H. Thomas, and G. Herndl. (2103). The impact of anthropogenic perturbations on open ocean carbon transformation, export and sequestration. Biogeosciences, 11 (special issue 148) - 6 papers. www.biogeosciences.net/special_issue148.html
- Young, Jock, Robert Olson and Paul Rodhouse (2013). The Role of Squids in Pelagic Ecosystems. Deep Sea Research Part II: Topical Studies in Oceanography, 95, 1-224 - 22 papers. www.sciencedirect.com/science/journal/09670645/95
- Zhang, Jing, Jilan Su, Ling Tong and Qisheng Tang (2013). Spring Bloom Processes and the Ecosystem: The Case Study of the Yellow Sea. Deep Sea Research Part II: Topical Studies in Oceanography, 97, 1-116 - 12 papers. www.sciencedirect.com/science/journal/09670645/97
- Zhang, Jing, John Morrison, Fernando Siringan and Thamasak Yeemin (2013). Coral Reefs under the climate and Anthropogenic Perturbations (CorReCAP): An IOC/WESTPAC Approach. Deep Sea Research Part II: Topical Studies in Oceanography, 96, 1-96 - 12 papers. www.sciencedirect.com/science/journal/09670645/96

Individual Publications

- Barrett P. M., Resing J. A., Buck N. J., Feely R. A., Bullister J. L., Buck C. S. & Landing W. M., in press. Calcium carbonate dissolution in the upper 1000 m of the eastern North Atlantic. Global Biogeochemical Cycles. DOI: 10.1002/2013GB004619
- Bell J. D., Reid C., Batty M. J., Lehodey P., Rodwell L., Hobday A. J., Johnson J. E. and Demmke A. 2013. Effects of climate change on oceanic fisheries in the tropical Pacific: Implications for economic development and food security. Climatic Change, DOI: 10.1007/s10584-012-0606-2.
- Bignami S., Sponaugle S. and Cowen R. K. (2013). Response to ocean acidification in larvae of a large tropical marine fish, *Rachycentron canadum*. Global Change Biology, 19(4), 996-1006. DOI: 10.1111/gcb.12133
- Bijma J., Pörtner H.-O., Yesson C. & Rogers A. D., 2013. Climate change and the oceans - what does the future hold? Marine Pollution Bulletin, 74(2), 495-505
- Bromhead D., Scholey V., Nicol S., Margulies D., Wexler J., Stein M., Hoyle S., Lennert-Cody C., Williamson J., Havenhand J., Ilyina T. & Lehodey P. (2014). The potential impact of ocean acidification upon eggs and larvae of yellowfin tuna (*Thunnus albacares*). Deep Sea Research Part II: Topical Studies in Oceanography. DOI: 10.1016/j.dsr2.2014.03.019.
- Carscadden, J.E., H. Gjøsæter and H. Vilhjalmsón. 2013. A comparison of recent changes in distribution of capelin (*Mallotus villosus*) in the Barents Sea, around Iceland and in the Northwest Atlantic. Progress in Oceanography, 114, 64-83.
- Carscadden, J.E., H. Gjøsæter and H. Vilhjalmsón. 2013. Recruitment in the Barents Sea, Icelandic, and eastern Newfoundland/Labrador capelin (*Mallotus villosus*) stocks. Progress in Oceanography, 114, 84-96.
- Gazeau F., van Rijswijk P., Pozzato L. & Middelburg J. J., 2014. Impacts of ocean acidification on sediment processes in shallow waters of the Arctic Ocean. PLoS ONE 9(4): e94068. DOI: 10.1371/journal.pone.0094068
- Guénette S., Araújo J. N. & Bundy A., 2014. Exploring the potential effects of climate change on the Western Scotian Shelf ecosystem, Canada. Journal of Marine Systems, 134, 89-100. DOI: 10.1016/j.jmarsys.2014.03.001
- Hobday A.J., Young J.W., Abe O, Costa D.P., Cowen R.K., Evans K., Gasalla M. A., Kloser R., Maury O. and Weng K.C. 2013. Climate impacts and oceanic top predators: moving from impacts to adaptation in oceanic systems. Reviews in Fish Biology and Fisheries, 23(4), 537-546.
- Jiang, Z. J., Fang, J. G., Han, T. T., Mao, Y. Z., Li, J. Q. and Du, M. R. 2013. The role of *Gracilaria lemaneiformis* in eliminating the dissolved inorganic carbon released from calcification and respiration process of *Chlamys farreri*. Journal of Applied Phycology. DOI: 10.1007/s10811-013-0110-8
- Keul, N., G. Langer, L. J. de Nooijer, G. Nehrke, G.-J. Reichart, and J. Bijma (2013). Incorporation of uranium in

- benthic foraminiferal calcite reflects seawater carbonate ion concentration, *Geochemistry, Geophysics, Geosystems*. 14, 102-111, DOI: 10.1029/2012GC004330.
- Lan K. W., Evans K. and Lee M. A. 2013. Effects of climate variability on the distribution and fishing conditions of yellowfin tuna (*Thunnus albacares*) in the western Indian Ocean. *Climatic Change*, DOI: 10.1007/s10584-012-0637-8.
- Lehodey P., Senina I., Calmettes B., Hampton J. and Nicol S. J. 2012. Modelling the impact of climate change on Pacific skipjack tuna population and fisheries. *Climatic Change*, DOI: 10.1007/s10584-012-0595-1.
- Leite M.C.F. and Gasalla M.A. 2013. A method for assessing fishers' ecological knowledge as a practical tool for ecosystem-based fisheries management: Seeking consensus in Southeastern Brazil. *Fish. Res.*, 145: 43-53.
- Levin L. A., Liu K.-K., Emeis K.-C., Breitburg D. L., Cloern J., Deutsch C., Giani M., Goffart A., Hofmann E. E., Lachkar Z., Limburg K., Liu S.-M., Montes E., Naqvi W., Ragueneau O., Rabouille C., Sarkar S. K., Swaney D. P., Wassman P. & Wishner K. P., 2014. Comparative biogeochemistry-ecosystem-human interactions on dynamic continental margins. *Journal of Marine Systems*. DOI: 10.1016/j.jmarsys.2014.04.016
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Communication and Outreach

The IMBER Website, www.imber.info, remains our main communication tool, with an average of about 250 unique visitors per day. It has received a lot of attention during the last reporting period because of the Open Science Conference.

The *IMBER Update Newsletter*, www.imber.info/index.php/News/Newsletters, is emailed to ~1,600 scientists three times a year, and re-directed through multiple channels to about 10,000 researchers:

- **Issue n°26** – May 2014, included articles about ESSAS and Arctic and Sub-Arctic research, Anoxia in the Far Eastern Marine Biosphere Reserve (Peter the Great Bay), Ocean Colour for Climate, the Austral Summer Institute XIV (ASI XIV) at University of Concepción, Chile, the comings and goings of IMBER members, and recent IMBER publications and events
- **Issue n°25** - December 2013, included articles about Science highlights from the 6th China-Japan-Korea IMBER Symposium (3-4 October 2013, Tokyo, Japan), the CLIO TOP *Deep Sea Research II* volume on the role of squids in pelagic ecosystems; the IMBER endorsed project INCT-TMCOcean and some announcements about the IMBER Open Science Conference and the IMBER ClimEco4 Summer School
- **Issue n°24** - August 2013, included articles about Science highlights from IMBIZO III, new endorsed project and the endorsed project POMAL

The IMBER *eNews Bulletin* is published electronically every month, providing information about IMBER and IMBER-relevant activities and events. Calls for funding proposals, job opportunities, and workshop and conference announcements are also included.

The IMBER contact database is continuously improved, with about 10,000 email contacts, and detailed information for about 1,800 marine researchers.

The IMBER IPO *YouTube* channel was opened in October 2012 to disseminate the ClimEco3 *e*-lectures, www.youtube.com/channel/UCinziRz7_TKHESn6uggCKlw and has gathered so far more than 2,500 views. Recently, an IMBER *twitter* channel, https://twitter.com/imber_ipo has been developed. The IMBER OSC plenary presentations have also been recently uploaded for further dissemination.

The IMBER GCMD metadata portal has already been mentioned earlier (see DMC section).

Finally, the IPO and RPO staff and several IMBER researchers have presented more than a dozen IMBER poster and oral presentations at many national and international meetings.

I. Support from SCOR

IMBER greatly appreciates the ongoing, key support received from SCOR, and the additional support to specific IMBER activities (especially OSC 2014 and ClimEco 4) provided by or managed through SCOR, from other funding sources. In addition, IMBER welcomes the advice, assistance and information received from the SCOR President and secretariat, especially its Executive Director, Ed Urban, and Financial Officer, Liz Gross.

J. Strategic development

IMBER is now entering the last year of its initial 10-year science plan. The IMBER science community has clearly indicated a desire for the project to continue. The enthusiasm and support shown at the recent OSC indicated that there is a strong community of researchers engaged in IMBER science. The position paper now being finalized is intended to provide guidance for the development of a new research agenda for the next phase of IMBER research.

The position paper will provide the basis for a request to SCOR for a second 10-year period of IMBER research. The grand challenges and science themes in the position paper are being derived from community inputs and strategic discussions. Thus, this is a reflection of what the IMBER community perceives to be the important research areas.

At the same time, the organizational structure for international global environmental change (GEC) research is changing. The IGBP, which co-sponsors IMBER with SCOR, will end in December 2015 and Future Earth will be operational at this time. Future Earth is intended as a 10-year initiative that is being developed around three themes, Dynamic Planet, Global Development and Transformations toward Sustainability, with a goal of addressing challenges and solutions for global sustainability. The core projects currently sponsored by the IGBP were invited in early 2013 to become core projects under Future Earth.

IMBER has a history of connecting natural and social sciences and promoting integration across disciplines and communities. IMBER is already engaged in research topics that address several of the Future Earth objectives, and many of its coordination and networking activities match the integrated approaches desired by Future Earth. As a result, IMBER is well placed to take the lead in developing marine-focused efforts under Future Earth. The transition to a Future Earth core project should not require additional modifications to IMBER science goals or implementation plan.

As with SCOR, the position paper will form the basis for a request to Future Earth to incorporate IMBER as core project. The request will include a description of what IMBER can bring to Future Earth in terms of science and as an international network of researchers. The request will also include what IMBER expects from Future Earth, such as support for SSC meetings and integrated activities, funding at the same level as provided by SCOR, and some specific assistance provided for fund raising, outreach, communication and engagement of stakeholders. It is anticipated that the formal IMBER request to Future Earth will be made in late Fall 2014.

Appendix 8
GEOTRACES
GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2013/2014
June 2014

1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

Co-Chairs

Ed Boyle, USA
Reiner Schlitzer, Germany

Other Members

Andrew Bowie, Australia
Pinghe Cai, China-Beijing
Ludmila L. Demina, Russia
Jordi Garcia-Orellana, Spain
Vanessa Hatje, Brazil
Tung-Yuan Ho, China-Taipei
Phoebe Lam, USA

Maeve Lohan, UK
Maria T (Maite) Maldonado, Canada
Olivier Marchal, USA
Katharina Pahnke, Germany
Micha Rijkenberg, Netherlands
Alakendra Roychoudhury, South Africa
Géraldine Sarthou, France
Yoshiki Sohrin, Japan
David Turner, Sweden
Angela Wagener, Brazil

The SSC membership (listed above) contains representatives of 14 different countries with diverse expertise, including: marine biogeochemistry of carbon and nutrients; trace elements and isotopes as proxies for past climate conditions; land-sea fluxes of trace elements/sediment-water interactions; trace element effects on organisms; hydrothermal fluxes of trace elements; tracers of ocean circulation; tracers of contaminant transport; controls on distribution and speciation of trace elements; and ocean modelling.

2. Progress on implementation of the project

Four years after the launch of GEOTRACES, the programme is enjoying a successful implementation. This is true in terms of implementation of the cruise field programme (with more than 50 cruises, 654 stations completed and about 1,014 data sets identified), data management and intercalibration (with the first Intermediate Data Product released in February 2014) and scientific results published (about 450 papers published).

2.1 Status of GEOTRACES field programme

The field programme is progressing very successfully, with 50 cruises already completed (654 stations sampled). At the time this report is written, two more cruises, one French and one Indian, are at sea completing sections in the Atlantic and Indian oceans, respectively.

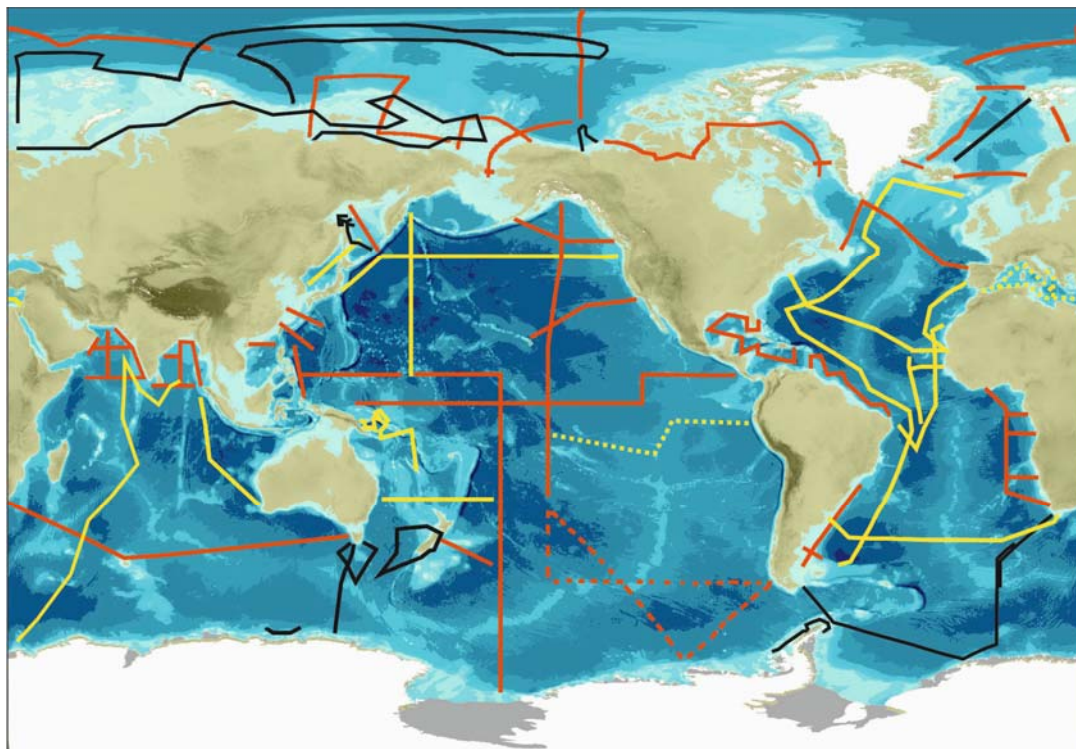


Figure 1. Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey (dotted yellow, completed during the past year). In red: Planned Sections. A frequently updated version of this map can be found on the GEOTRACES home page <<http://www.geotraces.org>>.

2.2 GEOTRACES Intermediate Data Product 2014

The GEOTRACES Intermediate Data Product (IDP2014) was released on February 25 at Ocean Sciences Meeting 2014 (Honolulu, Hawaii) during a “town hall” session attended by more than 350 individuals. Journals such as *Science* and *Nature* have featured reports describing the release of the product (see later in report).

The IDP2014, containing hydrographical and marine geochemical data acquired during the first three years of the programme, consists of two parts: the **digital data package** and the **eGEOTRACES Electronic Atlas**.

The **digital data package** (available at <http://www.bodc.ac.uk/geotraces/data/idp2014/>) contains data from 15 cruises and more than 70 hydrographic and geochemical parameters. The data product covers the Arctic, Atlantic and Indian oceans, with data density being the highest in the Atlantic Ocean. The growing body of data from the Pacific Ocean will be included in the next data product.

The **eGEOTRACES Electronic Atlas** (available at <http://www.egeotraces.org>) is based on the digital data package and provides 2-D and 3-D images of the ocean distribution of many of the parameters, as shown in the Figures 2 and 3 below. The 3-D images provide geographical context crucial for correctly assessing extent and origin of tracer plumes as well as for inferring processes acting on the tracers and shaping their distribution. The numerous links to other tracers, sections and basins found on section plots and 3-D images allow quick switching between parameters and domains to facilitate comparative studies. In addition, eGEOTRACES can help in teaching and outreach activities and can also help convey societally relevant scientific results to interested non-scientists and decision makers.

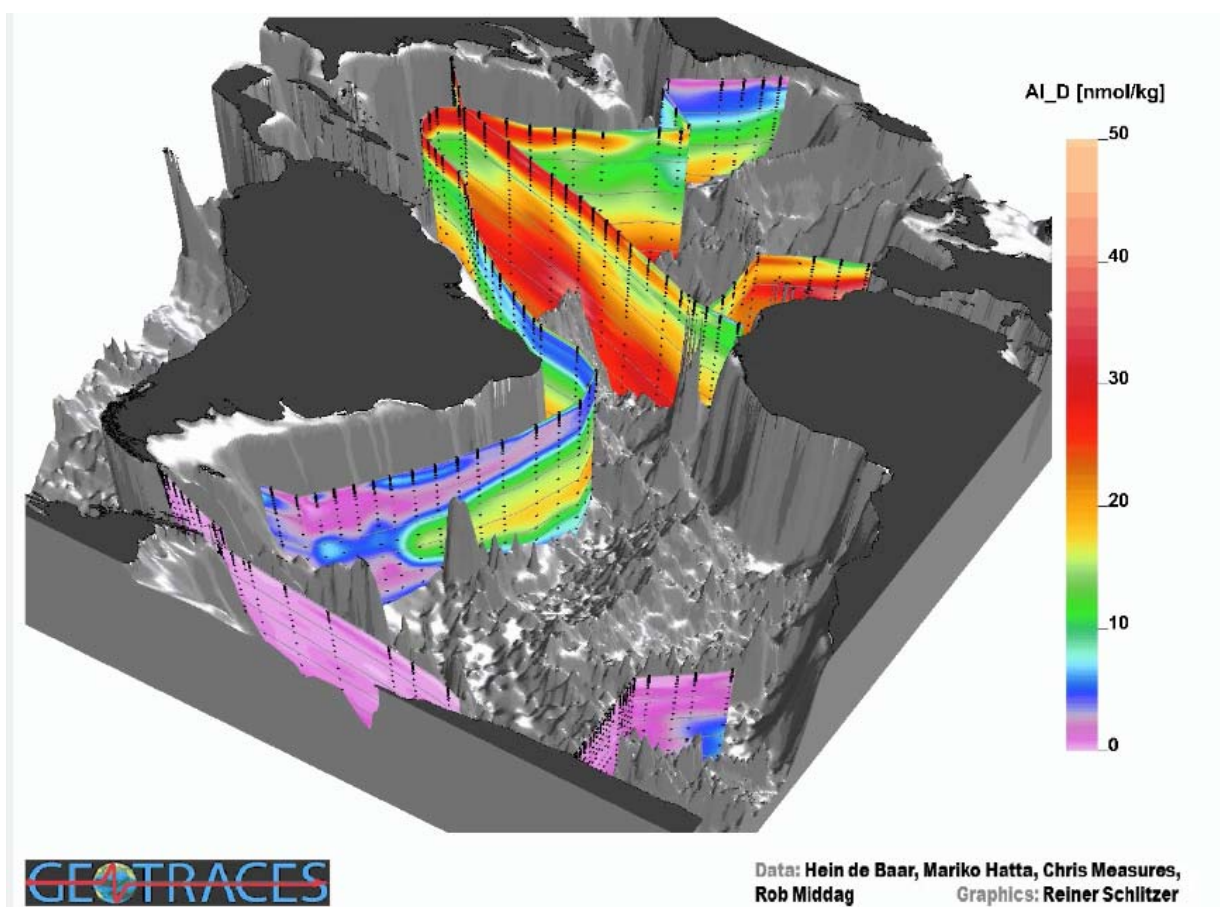
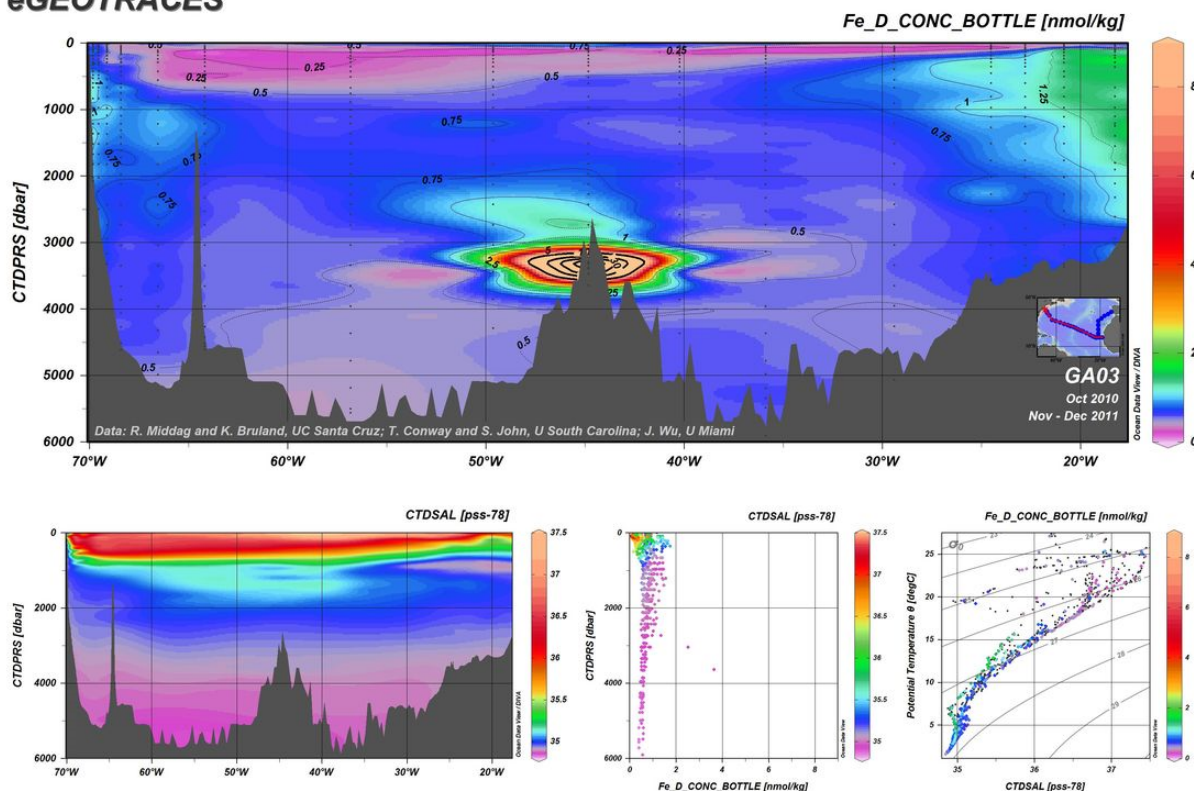


Figure 2. 3-D scene showing the distribution of dissolved aluminium (Al) in the Atlantic Ocean. Aluminium is a tracer of terrigenous inputs: in this image, high surface values are reflecting the dust inputs of Saharan origin between African and U.S. coasts, but there are also high concentrations at depth along the margins, also observed for other tracers, that might reflect Al release from the deposited sediments.

eGEOTRACES



(c) 2014 Reiner Schlitzer, Alfred Wegener Institute, Bremerhaven, Germany

Figure 3. Full-depth distribution of dissolved iron (Fe) along [GEOTRACES GA03](#) section in the Atlantic Ocean. Prominent features include the plume of hydrothermal Fe emanating from the Mid-Atlantic Ridge, and high Fe concentrations near the continental margin, especially off NW Africa, where margin sediments and Saharan dust both serve as significant sources.

The IDP2014, as well as other future GEOTRACES data products, will have a digital object identifier (DOI) assigned. Users of the data are requested to cite the data using the package DOI. Users are also asked to cite all relevant original publications from researchers that made the measurements. Details of publications that should be cited are provided point-by-point in the IDP dataset and are updated on the online database as new papers are published.

Rather than wait until the end of the programme, GEOTRACES sought instead to create and release a data product at a time when the programme is very active and actually still expanding, both in terms of the observations as well as scientific analysis of the data produced so far. By releasing and sharing the data now, GEOTRACES intends to strengthen and intensify collaboration within the oceanographic community; specifically, to attract and invite colleagues from other disciplines to join and devote their unique knowledge and skills to marine geochemical problems. At the same time, GEOTRACES is seeking feedback from the ocean research community to improve future data products.

SCOR Booth at Ocean Sciences 2014

In addition of the Town Hall session, the IDP2014 was also presented in the SCOR Booth at Ocean Sciences Meeting. The booth was equipped with a screen where images from the eGEOTRACES continually displayed, making it possible to make live demonstrations of the product. Interested people were also invited to navigate through eGEOTRACES. In addition, relevant scientific discoveries made in the first three years of the programme were shown in a banner.



Figure 4. Bob Anderson and Reiner Schlitzer staffing the SCOR Booth at Ocean Science 2014.

GEOTRACES also handed out USB memory sticks containing the complete *eGEOTRACES* set of images at the Town Hall event and at the booth. The advantage of the thumb-drive version is that it does not require an Internet connection, so that users can browse the atlas with no download delays.

GEOTRACES is very grateful to SCOR for the opportunity to participate in the SCOR Booth.

2.3 GEOTRACES publications and science highlights

GEOTRACES publications

Since last report, 240 peer-reviewed papers including GEOTRACES scientific results have been added to the GEOTRACES publications database; overall, about 450 GEOTRACES publications have been produced from the beginning of the project. The release of the IDP2014 has been object of broad media coverage, with reports published in printed or on-line versions of newspapers or journals (in Germany alone, reports have been published more than 111 times). Two publications about the IDP2014, one in *Science* and other in *Nature*, merit special mention:

Malakoff, D. (2014). Oceanography. Chemical atlas shows where seas are tainted--and where they can bloom. *Science* (New York, N.Y.), 343(6175), 1070. doi: [10.1126/science.343.6175.1070](https://doi.org/10.1126/science.343.6175.1070)

Morrison, J. (2014). Digital atlas shows oceans' iron levels. *Nature*, News. doi: [10.1038/nature.2014.14774](https://doi.org/10.1038/nature.2014.14774)

The official magazine of The Oceanography Society, *Oceanography*, has devoted a special issue to the topic of changing ocean chemistry. One paper of this issue is dedicated to the GEOTRACES Programme:

Anderson, R.F., Mawji, E., Cutter, G.A., Measures, C.I., & Jeandel, C. (2014). GEOTRACES: Changing the way we explore ocean chemistry. *Oceanography*, 27(1), 50–61. doi:[10.5670/oceanog.2014.07](https://doi.org/10.5670/oceanog.2014.07)

In addition, the *Limnology and Oceanography: Methods* special issue devoted to the topic of GEOTRACES intercalibration is now completed. This open access issue containing 24 papers is available on the following web site: <http://www.aslo.org/lomethods/si/intercal2012.html>.

Finally, a special issue dedicated to the results of the GEOTRACES Data-Model Synergy Workshop (14-17 November 2011, Barcelona) has been submitted to the journal *Progress in Oceanography*.

GEOTRACES science highlights

Below is a selection of recent GEOTRACES science discoveries:

Slow-spreading ridges could be major oceanic iron contributor

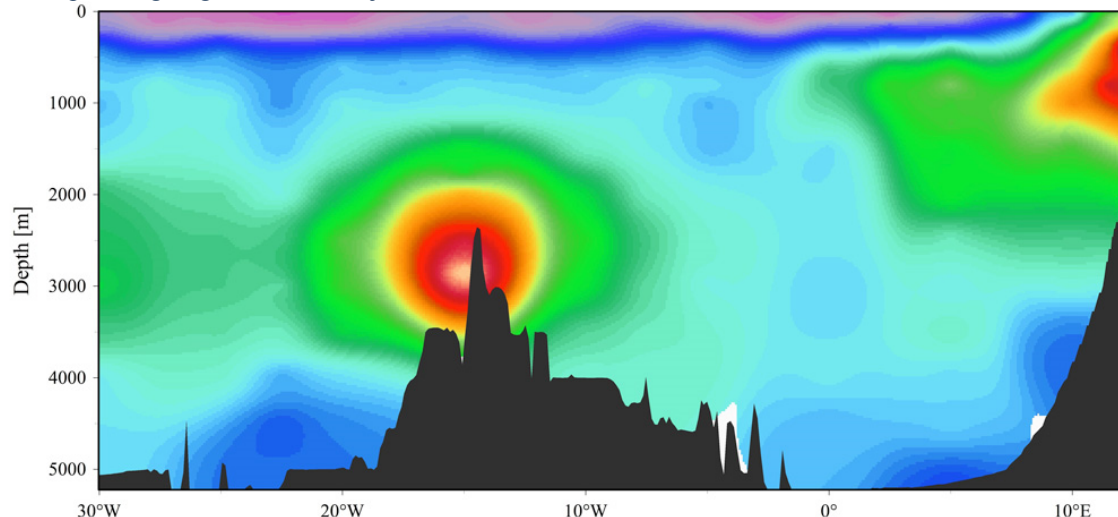


Figure 5. A zonal section of dissolved iron in the South Atlantic. The higher iron concentrations (in warm colours red, orange) reveal a large plume at ~2,900 m depth and 2 km in height.

Reference:

Saito, Mak A., Abigail E. Noble, Alessandro Tagliabue, Tyler J. Goepfert, Carl H. Lamborg, William J. Jenkins (2013) Slow-spreading submarine ridges in the South Atlantic as a significant oceanic iron source *Nature Geoscience* 6 (9), 775-770 DOI: 10.1038/ngeo1893

A large dissolved iron- and manganese-rich plume has been detected by Saito and co-authors over the slow-spreading southern Mid-Atlantic Ridge. This discovery calls into question the assumption that deep-sea hydrothermal vents along slow-spreading ridges were negligible contributors to the oceanic iron inventory. This result urges reassessment and a likely increase in estimates of the contribution of hydrothermal vents to the ocean supply of iron.

Latest discoveries in zinc concentrations and isotopes in the ocean (4 papers)

Zinc (Zn) is an essential micronutrient for phytoplankton and plays a key role in productivity of the ocean. Despite the importance of this element, the processes which govern its cycling in the ocean are poorly understood. Thanks to GEOTRACES, an unprecedentedly large volume of data has been reported, revealing fascinating results (4 papers):

Copper and zinc oceanic mass balance revisited

Little and co-workers (2014; see reference below) propose an update of the oceanic copper (Cu) and zinc (Zn) mass balance, with an original approach that takes into account the hitherto ignored constraint of their isotopes. They establish an up-to-date inventory of the input fluxes of these tracers with their isotopic signatures, discuss the internal processes that might fractionate both tracers, and evaluate one major sedimentary sink: sediments deposited beneath oxic water columns. Although the Cu oceanic mass balance appears to be roughly in balance, the Zn one is far from being constrained. Isotopes reveal that either an "isotopically light sink" or "isotopically heavy source" is missing.

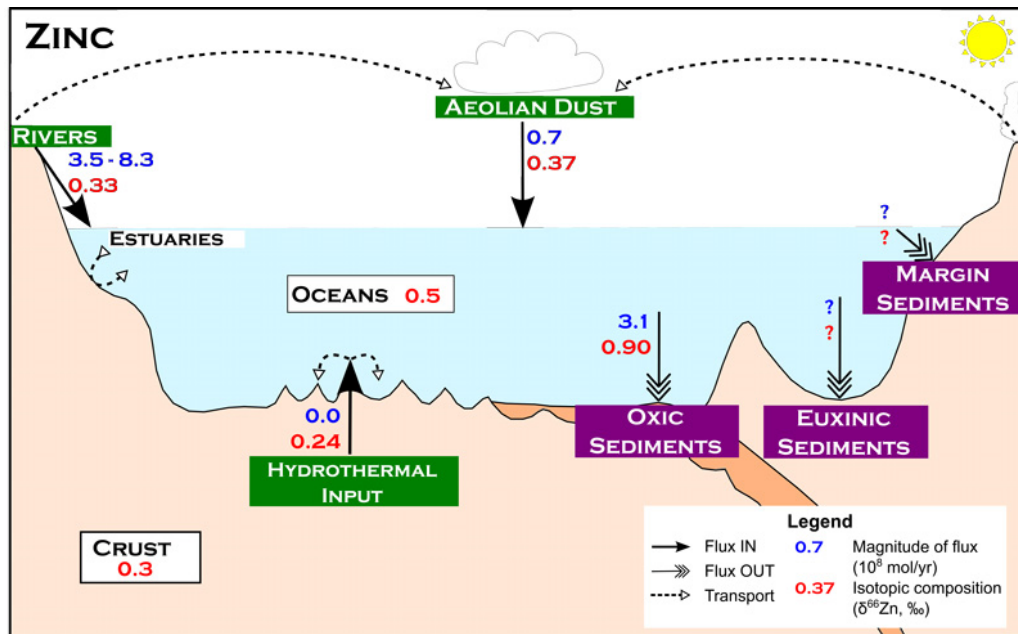


Figure 6. This figure illustrates the global ocean isotopic mass balance of Zn.
Sinking organic matter: a major driver of the oceanic zinc cycle?

A new study by John and Conway (2014), presenting the first high-resolution coupled profiles of both dissolved Zn and cadmium (Cd) concentration and isotope ratios from the GEOTRACES North Atlantic (GA03) section, suggests that scavenging of isotopically heavy Zn onto organic matter plays an important role in the surface marine cycling of Zn, and may be important for understanding why Zn, like silicon (Si), has a deeper regeneration in the ocean than nitrogen (N), phosphorus (P), and Cd. The new GEOTRACES data is supported by modelling and culture experiments, which show that while Cd and major nutrients are quickly released as phytoplankton degrade, a significant portion of the Zn is instead scavenged back onto organic matter.

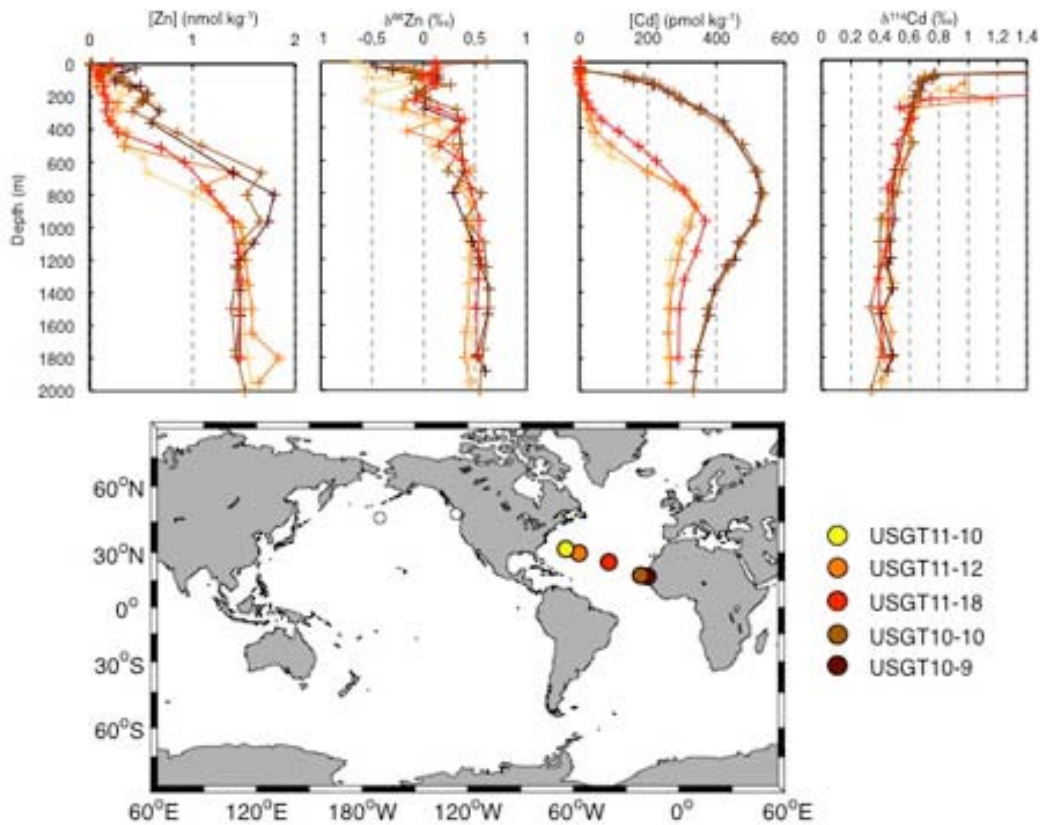


Figure 7. Zn and Cd concentration and stable isotope profiles along the North Atlantic GA03 section.

First full-depth profiles of zinc isotopes in the ocean, thanks to IPY/GEOTRACES cruise (GIPY5)

Three major and original features are deduced from the first three full-depth profiles of zinc measured by Zhao and co-workers (2014) in the Southern Ocean:

- below 1000 m, the comparison of the results with North Atlantic and Pacific ocean data reveals that the oceanic zinc (Zn) isotopic composition appears to be homogeneous ($\delta^{66}\text{Zn} = +0.53 \pm 0.14$ per mil (2SE = 0.03, $n = 21$)).
- oceanic Zn isotopic composition is more variable in the upper 1000 m ($\delta^{66}\text{Zn}$ values are more variable); these new Zn isotope data are consistent with a scenario whereby Zn removal from the surface ocean occurs via two processes: a dominant one that does not involve an isotopic fractionation (incorporation of Zn into organic matter associated with only diatom frustules) and a lesser one that preferentially removes the light isotope (metabolic uptake into the cells of all phytoplankton).
- a mass balance calculation is proposed to explain the homogeneous Zn isotopic composition of the deep ocean. The $\delta^{66}\text{Zn}$ value is slightly heavier than all the possible external sources ($\sim +0.35$ per mil). Thus, an isotopically light sink is required but not identified yet. The author's working hypothesis is that the burial of isotopically light Zn in cellular organic matter could represent the light sink from the oceanic dissolved pool.

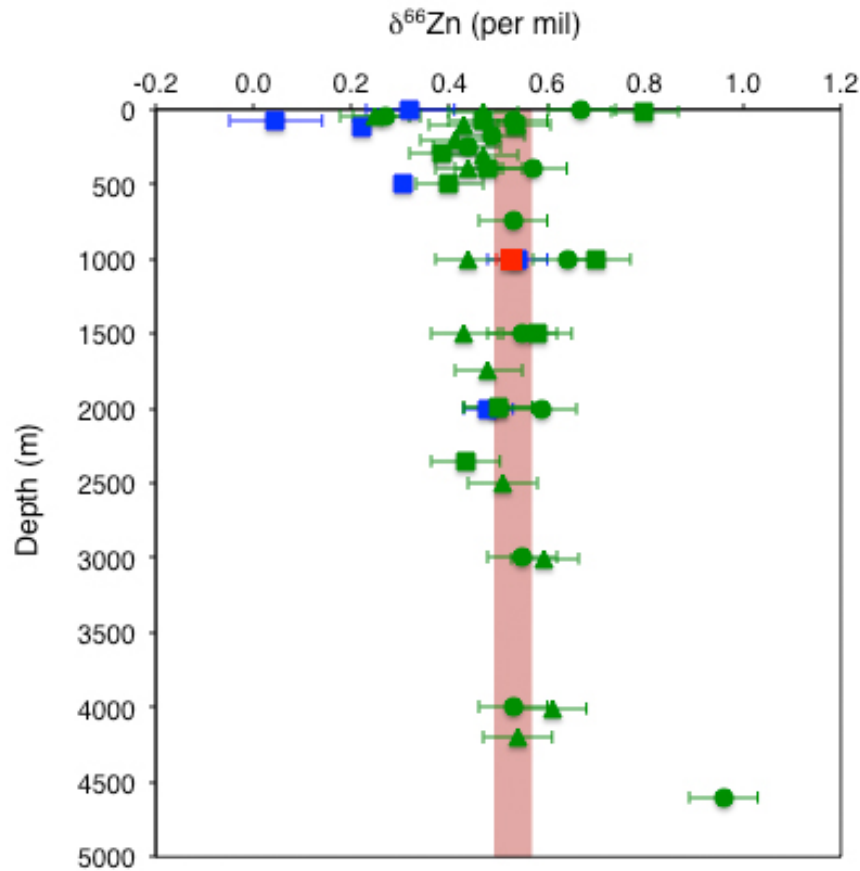


Figure 8. Zinc (Zn) isotopic data for IPY GEOTRACES samples from the Southern Ocean (green), plotted with data from the same laboratory for the GEOTRACES BATS intercalibration site in the Atlantic (blue, Boyle et al., 2012) and for the SAFE sample at 1000m in the Pacific (red). There is variability in Zn isotopes at depths shallower than about 500m, and a sample from the sediment-water interface in one depth profile at 67°S is anomalous, but in between all seawater samples yet published have a mean $\delta^{66}\text{Zn}$ of 0.53 per mil, with a spread of only 0.06 per mil (± 2 standard errors of the mean).

What does the largest data set of zinc concentration ever reported tell us?

Wyatt and colleagues (2014) measured Zn distribution at high resolution (556 discrete samples) between Cape Town and Montevideo in the South Atlantic Ocean (40°S) on board the UK GEOTRACES GA10 cruise. The surface Zn concentrations measured are among the lowest reported for the global ocean (0.015–0.39 nM). An intriguing result was the fact that Zn concentrations were very low down to depths of 500 m, which was similar to that of silicate (Si) concentrations. Using the strong relationship between Zn and Si, the authors present a new tracer Zn^* ($\text{Zn}^* = \text{Zn} - 0.065 \times \text{Si} + 0.209$), which illustrates that Zn is removed from surface waters in the Southern Ocean and remineralised deeper in the water column. This results in very low Zn concentrations in Sub-Antarctic-Mode Water (SAMW), which is the main pathway for supplying nitrate and phosphate to the thermocline waters of the South and North Atlantic oceans. These low Zn concentrations in SAMW may result in growth-limiting Zn concentrations in the surface waters of both the South and North Atlantic sub-tropical gyres.

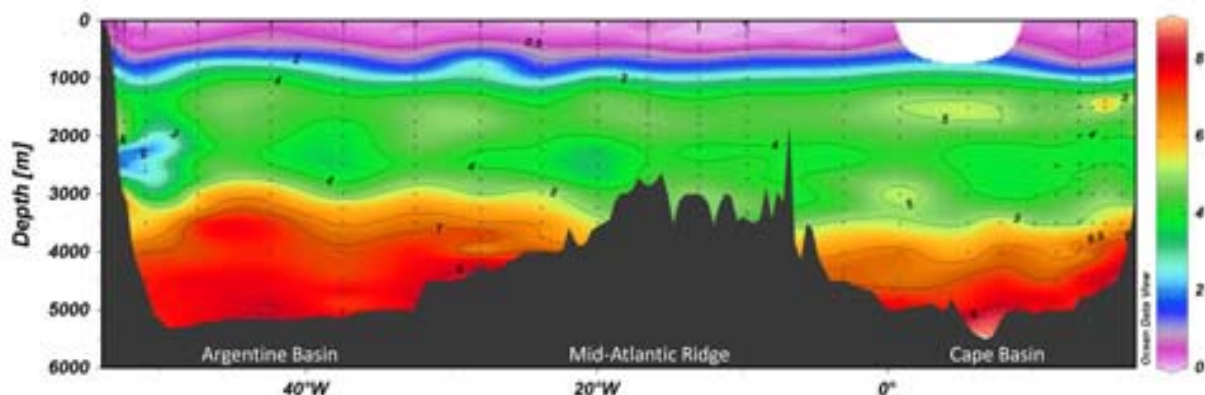


Figure 9. Concentrations of Zn along GA10 section (~40°S). Warm colours indicate high concentrations.

References:

- Boyle, E. A., John, S., Abouchami, W., Adkins, J. F., Echegoyen-Sanz, Y., Ellwood, M., Flegal, A. R., Fornace, K., Gallon, C., Galer, S. (2012). GEOTRACES IC1 (BATS) contamination-prone trace element isotopes Cd, Fe, Pb, Zn, Cu, and Mo intercalibration. *Limnology and Oceanography: Methods*, 10, 653–665. doi:10.4319/lom.2012.10.653
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- Zhao, Y., Vance, D., Abouchami, W., & de Baar, H. J. W. (2014). Biogeochemical cycling of zinc and its isotopes in the Southern Ocean. *Geochimica et Cosmochimica Acta*, 125, 653–672. doi:10.1016/j.gca.2013.07.045.

[Determining simultaneously iron, zinc and cadmium isotopes in small volumes of seawater is possible now.](#)

The first simultaneous method for the determination of these three isotope systems in seawater has been published. This method is designed for use on only a single liter of seawater, representing a 1–20 fold reduction in sample size and a 4–130 decrease in blank compared to previously reported methods. The procedure yields data with high precision for all three elements, allowing estimation of natural variability in the ocean, which spans 1–3‰ for all three isotope systems. Simultaneous extraction and purification of three metals makes this method ideal for high-resolution, large-scale endeavours such as the GEOTRACES program.

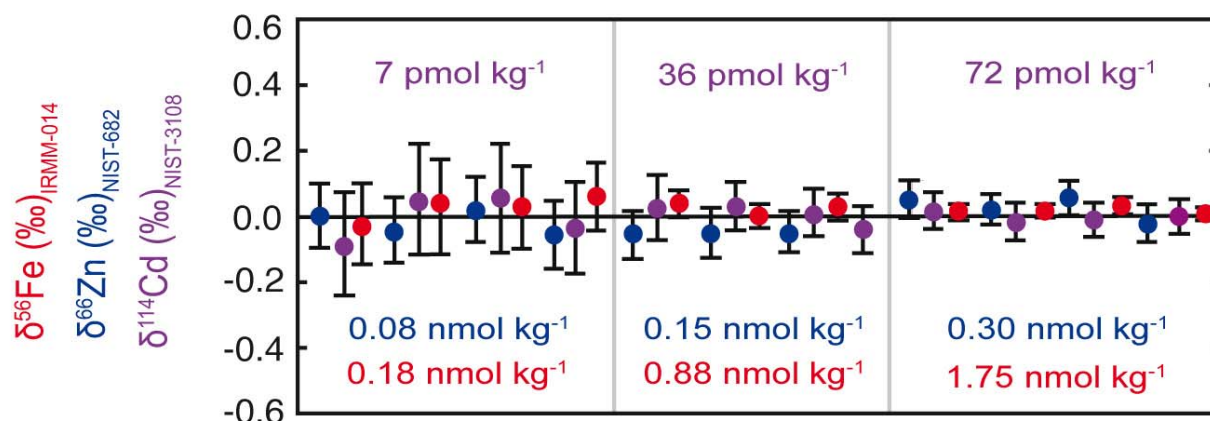


Figure 10. 'Metal-free' seawater doped with varying concentrations of 'zero' isotope standards, processed through the simultaneous method, and then analysed by double spike MC-ICPMS for Fe, Zn and Cd isotope ratios. All values were determined within 2 sigma error (error bars shown) of zero.

Reference: Tim M. Conway, Angela D. Rosenberg, Jess F. Adkins, Seth G. John (2013), A new method for precise determination of iron, zinc and cadmium stable isotope ratios in seawater by double-spike mass spectrometry, *Analytica Chimica Acta*, Volume 793, Pages 44-52, DOI: [10.1016/j.aca.2013.07.025](https://doi.org/10.1016/j.aca.2013.07.025).

New data on oceanic rare earth elements concentrations and neodymium isotopic compositions (3 papers)

Early 2014 was favourable to the publication of new data of rare earth element (REE) concentrations and neodymium (Nd) isotopic compositions in extreme areas of the ocean: the southern Atlantic Ocean, the northeast corner of the Pacific Ocean, and the remote South Pacific Ocean. Three different groups (Garcia-Solsona et al.; Haley et al.; Molina-Kescher et al.; see references below) published in *Geochimica Cosmochimica Acta* on REE distributions.

These three works confirm the conservative behaviour of Nd isotopic composition far from main biogeochemical disturbances, such as lithogenic inputs or significant biological activity. But more importantly, they reveal features in the behaviours of the REE that might need to be considered more closely. These features rely on particle/dissolved exchanges that are not understood yet, but they also yield unexpected decoupling along the REE array.

In January 2014 (Vol. 125), Garcia-Solsona and co-workers (Toulouse, France) described the distribution of dissolved and particulate REE and seawater Nd isotopic composition in samples from the IPY/GEOTRACES Bonus Good Hope (BGH) cruise between South Africa and the Southern Ocean (57°S). This work

- demonstrates the role of the South African submarine margins as sources of neodymium; shows that at open-ocean stations, dissolved and particulate REEs have acquired a marine signature (particles present negative cerium anomalies) as a result of dissolved/particulate exchange likely driven by the biological activity;
- reports positive Lanthanum (La) anomalies, observed in both particulate and dissolved phases, that could be linked to the oceanic barium cycle and the partial dissolution of barite crystals; and
- finds that Nd isotopic composition behaves conservatively in the Antarctic Circumpolar Current (ACC), supporting the use of ϵ_{Nd} as a water mass mixing tracer in BGH deep waters.

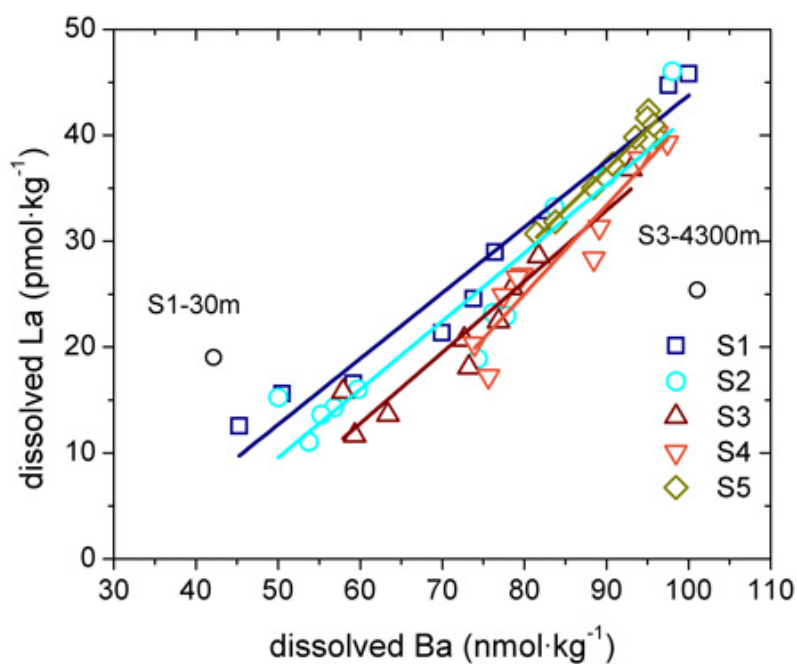


Figure 12. This figure shows linear correlations between dissolved La and Ba concentrations.

Two weeks later (Vol 126) Haley and co-workers (Corvallis, USA) presented the first combined distributions of dissolved REEs and Nd isotopes in the Gulf of Alaska. They reveal for the first time that

- ϵNd signatures allow tracing eddies that carry shelf waters to open gyre regions;
- two pools of REEs could be distinguished in this productive area using a statistical approach: one pool complexed to carbonate ion and largely behaving "quasi-conservatively", the second pool "bioreactive" and complexed by organic molecules as siderophores and only significant in the near-surface ocean; and
- the conservative fraction of the REE and its Nd isotopic composition is consistent with the hypothesis that a pool of seawater older than 1000 years is maintained in this far northeast Pacific Ocean, as already indicated by ^{14}C ages.

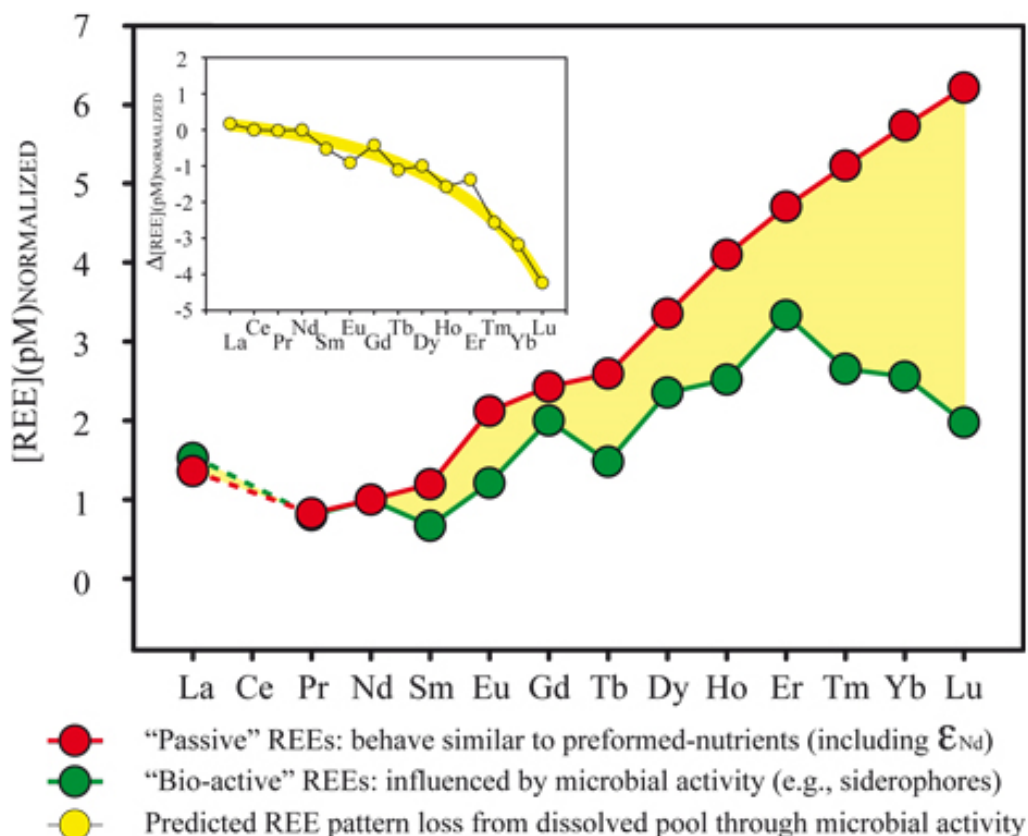


Figure 13. REE patterns.

In early February 2014 (vol 127), Molina-Kescher and co-workers (Kiel, Germany) proposed the first detailed analysis of dissolved Nd isotopes and REEs in intermediate and deep waters along a zonal transect between South America and New Zealand ($\sim 40^\circ\text{S}$). These authors

- confirm the reliability of ϵNd as water mass tracer in this area;
- propose the tagging of South Pacific water masses never done before. Among others, they identify the influence of residual North Atlantic Deep Water (NADW) in the westernmost South Pacific, characterised by the most negative ϵNd ; and
- demonstrate that biogeochemical cycling and scavenging processes in the Eastern Equatorial Pacific and release of LREEs from the sediment in the southeast Pacific Ocean influence the distribution of the dissolved REE concentrations.

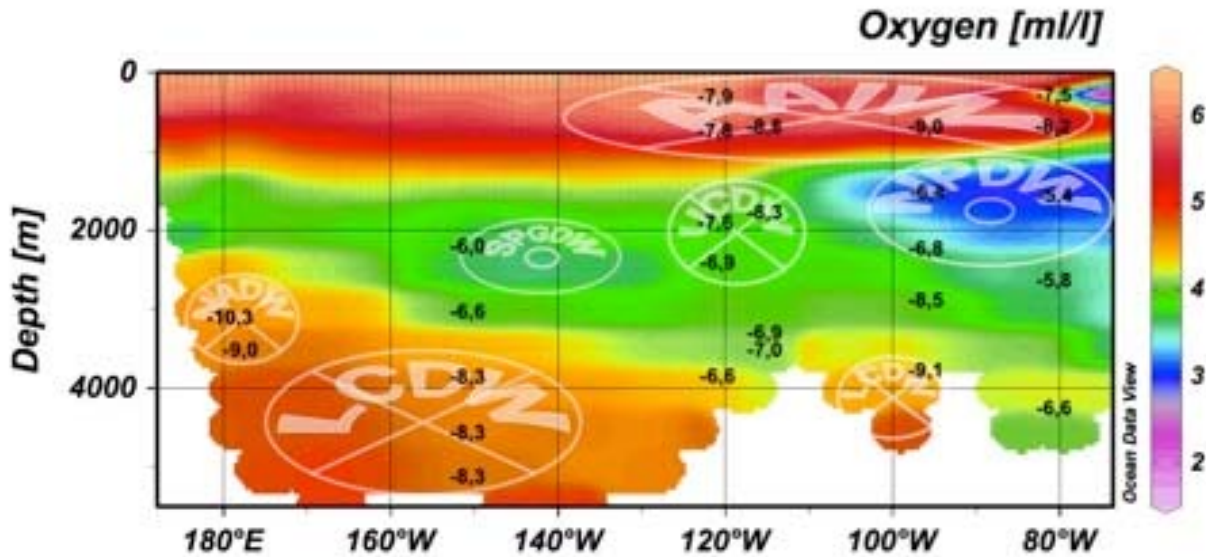


Figure 14. Zonal cross section along the South Pacific at ~40°S showing oxygen concentrations (ml/l), represented by the colour gradient, and measured ϵ Nd signatures (black values) at their corresponding depths. The flow direction of the water masses are also shown by transparent circles, where crosses represent the sense of movement into the picture and centred dots represent movement out of the picture. Water mass abbreviations: LCDW (Lower Circumpolar Deep Water), NADW (North Atlantic Deep Water), AAIW (Antarctic Intermediate Water), SPGDW (South Pacific Gyre derived Deep Water) and NPDW (North Pacific Deep Water). Oxygen concentrations are from the database of the World Ocean Atlas 09.

References:

- Garcia-Solsona, E., Jeandel, C., Labatut, M., Lacan, F., Vance, D., Chavagnac, V., & Pradoux, C. (2014). Rare earth elements and Nd isotopes tracing water mass mixing and particle-seawater interactions in the SE Atlantic. *Geochimica et Cosmochimica Acta*, 125, 351–372. doi:[10.1016/j.gca.2013.10.009](https://doi.org/10.1016/j.gca.2013.10.009).
- Haley, B. A., Frank, M., Hathorne, E., & Pisias, N. (2014). Biogeochemical implications from dissolved rare earth element and Nd isotope distributions in the Gulf of Alaska. *Geochimica et Cosmochimica Acta*, 126, 455–474. doi:[10.1016/j.gca.2013.11.012](https://doi.org/10.1016/j.gca.2013.11.012).
- Molina-Kescher, M., Frank, M., & Hathorne, E. (2014). South Pacific dissolved Nd isotope compositions and rare earth element distributions: Water mass mixing versus biogeochemical cycling. *Geochimica et Cosmochimica Acta*, 127, 171–189. doi:[10.1016/j.gca.2013.11.038](https://doi.org/10.1016/j.gca.2013.11.038).

New revelations on boundary scavenging in the North Pacific

Thorium (Th) and protactinium (Pa) are very efficient tracers of particle dynamics in the ocean. More particularly, their relative distributions inform on the intensity of "scavenging", in other words, the processes that remove dissolved elements from seawater by their precipitation or adsorption on particles. Thanks to 12 new profiles in the North Pacific, Hayes and co-authors observe a much larger relative difference in scavenging intensity between the Subtropical gyre and Subarctic Pacific gyre than within each of these regions. This effect is greater for Pa than for Th, likely reflecting the fact that biogenic silica, a phase produced by diatoms which has a strong affinity for Pa, is much more prevalent in the north. While highlighting the role of biogeography, the study also finds that in the deep ocean, manganese oxides, an inorganic phase, may play an additional role in Pa scavenging.

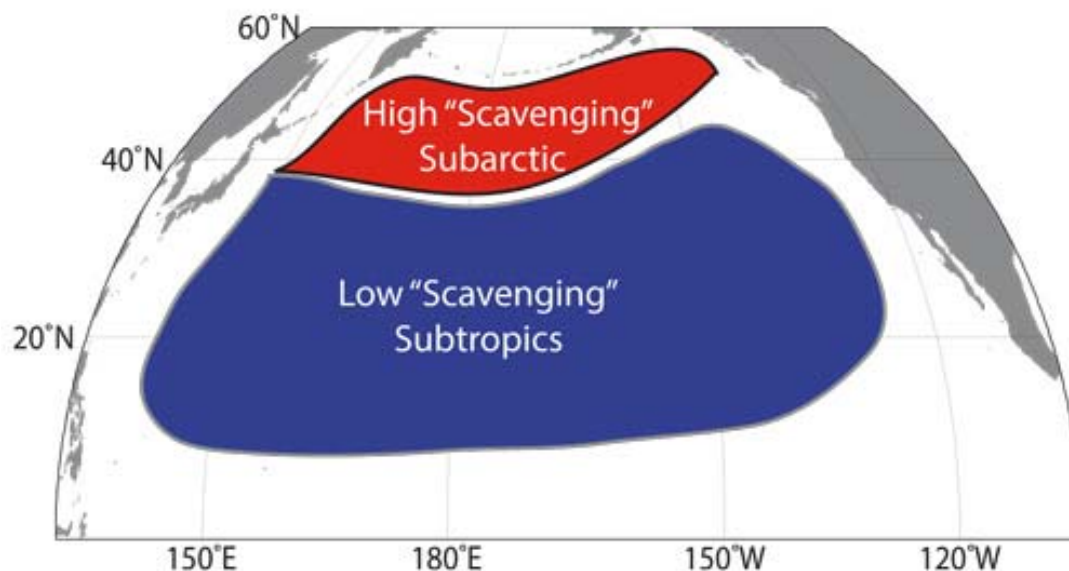


Figure 11. Simplified figure showing scavenging intensity in the Pacific Ocean.

Reference:

Hayes, C. T., Anderson, R. F., Jaccard, S. L., François, R., Fleisher, M. Q., Soon, M., & Gersonde, R. (2013). A new perspective on boundary scavenging in the North Pacific Ocean. *Earth and Planetary Science Letters*, 369-370, 86–97. doi: 10.1016/j.epsl.2013.03.008.

3. Activities

3.1 GEOTRACES Intercalibration Activities

During the 2012-2013 period, three major Standards and Intercalibration (S&I) Committee meetings were held, in order to review data that would eventually be incorporated into the 2014 Intermediate Data Product. Almost all of the data reviewed were from the GEOTRACES Crossover Stations where two section cruises occupied the same station during their transects. The S&I Committee members who reviewed these data were Gregory Cutter (Chair; Old Dominion University, USA), Per Andersson (Swedish Natural History Museum), Louis Codispoti (University of Maryland, USA), Peter Croot (National University of Ireland, Galway), Roger Francois (University of British Columbia, Canada), Maeve Lohan (University of Plymouth, UK), Hajime Obata (University of Tokyo, Japan), and Michiel van der Loeff (Alfred Wegner Institute, Germany).

The first meeting to review TEI data was hosted by Maeve Lohan at the University of Plymouth in March 2012. Data and metadata from 6 Crossover Stations in the Atlantic Ocean were examined, totalling approximately 3,600 data points reviewed and discussed during the 3-day meeting. Although little radionuclide or particulate results were available for this review, much was learned about how to conduct the reviews for the 2013 meetings when more data would be available. One of the major problems encountered was that most of these data had not been submitted to the GEOTRACES International Data Assembly Centre, so the committee had to contact investigators to obtain the data. Moreover, metadata were either missing or poorly presented, making the Committee's tasks much more difficult. These and other lessons learned were then applied to the 2013 meetings and in particular, there was a December 2012 deadline to submit data to GDAC for review by the S&I Committee and eventual incorporation into the 2014 IDP.

The second data review meeting occurred in May 2013 at the Swedish Museum of Natural History in Stockholm and was hosted by Per Andersson. All the data and metadata were compiled at GDAC, making the process of evaluations much easier. The major focus was examining the Atlantic Crossover Stations and all of these

comparisons were completed where sufficient TEI results were available. All data originators were sent the committee evaluations (meets individual TEI criteria; doesn't meet criteria, but with more information may be acceptable; doesn't meet criteria for multiple reasons and likely cannot be accepted), and they were asked to submit their revised data and metadata, and explanations for any discrepancies, by the end of August 2013 for the committee's meeting in September 2013. The reviewed data represented the bulk of hydrographic and TEI results that would be placed in the 2014 IDP, so this meeting was a major step towards compiling the first four years of GEOTRACES field data.

The third S&I Committee meeting during the 2012-2013 period was held in conjunction with the Data Management Committee just prior to the International SSC Meeting in Bremerhaven, Germany at the Alfred Wegner Institute in September 2013. The S&I Committee reviewed revised data that were based on recommendations from the May meeting, and additionally examined data from the Japanese Indian Ocean cruise (GI04), for which there was no crossover station. In the case of GI04, the cruise followed intercalibration protocols by taking replicates samples and distributing them to various labs for TEI determinations. This was the first time the Committee had examined such data. Results indicated that the procedure worked very well. The Committee also reviewed some of the Crossover Station data from 2009 IPY cruises that had not been previously examined. The Committee then met jointly with the DMC to recommend which data sets should be placed in the 2014 IDP.

After the last 2013 meeting, two members of the S&I Committee, Lou Codispoti and Roger Francois, completed their terms on the Committee and stepped down. The SSC Chairs sent them thank you letters for their years of service to GEOTRACES. Two new members were appointed: Karen Casciotti from Stanford University, USA, and Tina van der Flierdt, UK. Both of these scientists had served as Elemental Coordinators during the first intercalibration phase of GEOTRACES and are therefore ideal as the newest members of the Committee. Another intercalibration milestone during 2012 was the completion of the special volume of *Limnology and Oceanography: Methods* on Intercalibration in Chemical Oceanography, in which much of the GEOTRACES intercalibration results from the 2008 and 2009 cruises are presented: <http://www.aslo.org/lomethods/si/intercal2012.html>. Finally, the Committee completed revisions of individual sections of the GEOTRACES Sampling Protocols by the end of 2013 for general editing, collating, and placement on the web site in 2014.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanography Data Centre (BODC), Liverpool, UK. GDAC is responsible for all GEOTRACES data activities from start to finish, including interacting with the Principal Investigators (PI) and national data centres, maintaining the data website, updating GEOTRACES maps and BODC's address book, and liaising with the GEOTRACES Data Management and Standards and Intercalibration committees. GDAC will eventually become the central access point for all GEOTRACES data. The office is staffed by a single data specialist: Dr. Edward Mawji.

This year, GDAC would like to highlight the following tasks:

GEOTRACES Intermediate Data Project

In 2014, GEOTRACES released an intermediate data product (IDP) at the Ocean Sciences Meeting in Honolulu, Hawaii, USA. All of GDAC's efforts in 2013 and 2014 focused on preparing the IDP2014. The IDP was divided into two parts: tier 1 data and tier 2 data. Tier one data were assessed by the S&I Committee and were deemed to meet the high data quality of GEOTRACES. Tier two data had not been intercalibrated/quality controlled by the S&I Committee. To help the S&I Committee carry out its review role, GDAC spent considerable effort compiling data from Crossover Stations and supplying the supporting metadata. This process was very successful, although valuable lessons were learned that will be used when preparing the next IDP. In the future, improved communication between GDAC and the S&I Committee will be sought. The time frame allowed for the S&I Committee to quality control (QC) data was unrealistic; this unfortunately altered all other deadlines. For example, the final submission of QC data to GDAC was changed to 17 December 2013, leaving GDAC with a nearly impossible task of preparing data for the IDP2014 release in February.

GDAC's main role in preparing for the IDP2014 was to quality control metadata and load intercalibrated data from the IPY and GEOTRACES section cruises into BODC's database. Detailed data and metadata checks were carried out and XML method and quality control documents were created.

Working with the GEOTRACES International Project Office

A good working mechanism has been established between GDAC and Elena Masferrer Dodas at the IPO. Information is freely exchanged between the two sites. The IPO has helped GDAC keep up to date with new developments and upcoming cruises. This year, the IPO has been hugely important in helping GDAC prepare the GEOTRACES IDP2014 and was fundamental in distributing tier 1 and tier 2 documents and keeping track of scientists' replies in regards to having their data included in the IDP2014.

Data overview

The data management of the project is now a huge undertaking, with 50 cruises associated with GEOTRACES and 1,014 data sets identified in BODCs database (expected to rise once missing metadata forms are submitted). More than 200 scientists have taken part in GEOTRACES cruises, with 14 different nations having run a major GEOTRACES/IPY section cruise or process study.

2013/2014 has been a successful period; considerable progress has been made collecting data, especially from the IPY cruises and section cruises included in the IDP2014. A massive effort was made over the last 12 months by the GEOTRACES research community to submit data to national data centres and GDAC. U.S. (through the Biological and Chemical Oceanography Data Management Office) and Dutch scientists have really led the way and deserve a special mention.

Summary of GEOTRACES cruises

- 12 IPY cruises
- 5 compliant cruise
- 13 process studies
- 20 GEOTRACES cruises -14 sections

Six section cruises have taken place in the last 20 months; collecting data from these cruises and older section cruises will be the GDAC priority over the coming year.

In summary, GDAC policies are proving effective with clear results; PIs are following guidelines and metadata are being submitted in a timely manner.

3.3 GEOTRACES International Project Office

The GEOTRACES International Project Office (IPO) is based at the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France. The IPO is staffed by one person, the IPO Executive Officer, Elena Masferrer Dodas. She works under the scientific supervision of Catherine Jeandel (CNRS, LEGOS, France).

The IPO is responsible for assisting the Scientific Steering Committee (SSC) in implementing the GEOTRACES Science Plan and implementation plans of the programme; organising and staffing meetings of the SSC, working groups and task teams; liaising with the sponsors and other relevant organisations; seeking and managing programme finances; representing the project at international meetings; maintaining the project web site and Facebook page; maintaining the project mailing lists; preparing GEOTRACES science highlights and the bimonthly GEOTRACES eNewsletter; maintaining the GEOTRACES publications database and the GEOTRACES Scientists Analytical Expertise Database; assisting the GDAC in securing information about upcoming cruises; and interacting with GEOTRACES national committees and groups, as well as other international projects.

This has been a special year for the GEOTRACES programme and thus, the IPO, due to the release of the IDP2014. The IPO has been highly involved in the preparation of the IDP2014 and therefore, we would like to highlight the main tasks of the IPO in relation to the IDP:

- Assisted GDAC in keeping track of scientists' replies in regards to having their data included in the IDP2014. (The right of scientists to not include their data in the IDP was respected.)
- Built the IDP2014 publications on-line database and maintaining it up-to-date.

- Organised the GEOTRACES Intermediate Data Product Town Hall at Ocean Science Meeting 2014 (24 February 2014, Hawaii, USA).
- Coordinated the preparation of the eGEOTRACES thumb drives.
- Prepared materials for the release of the IDP2014 including:
 - 2 special issues of the GEOTRACES eNewsletter
 - 1 banner showing main relevant findings of the programme
 - 1 new brochure describing the IDP2014
 - Press releases about the IDP2014
- Communicated the release of the IDP2014 broadly. Special attention was given to identify and communicate it to main stakeholders in each country, as well as other scientific communities that could be interested in the product.
- Coordinated the SCOR Booth at Ocean Science and staffed it.
- Assisted in the organisation of the GEOTRACES Intermediate Data Product Town Hall that will be held at Goldschmidt 2014 (June 10, 2014, Sacramento, USA).

The number of GEOTRACES publications including scientific results is increasing progressively. The IPO is doing an important job of tracking GEOTRACES publication and preparing science highlights of main relevant findings. Since June 2013, 240 new peer-reviewed papers have been added in the database, which represents more than a doubling of the total number of publications included (currently it contains 450 publications in total) since the previous annual report to SCOR.

With 7 issues published, the bimonthly eGEOTRACES eNewsletter it is now well established. The eNewsletter is very well received by the GEOTRACES community and the IPO is receiving very positive feedback about it.

3.4 Special sessions at international conferences featuring GEOTRACES findings

The major event this year has been the release of the GEOTRACES Intermediate Data Product at the Ocean Science Meeting 2014 (February 25, Honolulu, Hawaii, USA). The Town Hall session was very successful, with more than 350 participants and a special ovation from the public when the first eGEOTRACES 3D scene was displayed.

A second town hall session to introduce the Intermediate Data Product 2014 was held at Goldschmidt 2014 (June 10, Sacramento, California, USA).

In addition, several special sessions with relevance to GEOTRACES were featured or planned at major international conferences, including the following:

2013 Gordon Research Conference on Chemical Oceanography: Theme - Chemical Geography of the Sea, 4-9 August 2013, University of New England Biddeford, ME, United States.

For more information: <http://www.grc.org/programs.aspx?year=2013&program=chemocean>

*Overview of the U.S. GEOTRACES North Atlantic Section
Discussion Leader: Robert Anderson (Columbia University)

*Results from U.S. GEOTRACES North Atlantic Section
Discussion Leader: Laurie Juranek (Oregon State University)

*Benthic and nearshore processes
Discussion Leader: Lelia Hawkins (Harvey Mudd College)

Goldschmidt 2013, 25-30 August 2013, Florence, Italy.

For more information: <http://goldschmidt.info/2013/index>

*17d Isotopic and elemental tracers of marine biogeochemistry and circulation
Convenors: Seth John, Julie Granger, Katharine Pahnke and Gregory F. de Souza

*17g Metal-biota interactions in seawater
Convenors: Jay Cullen, Maeve Lohan and Martha Gledhill

*17b. Constraining rates of ocean processes
Convenors: Laura Robinson and Matt Charette

11th International Conference on Paleoceanography, 1-6 September 2013, Sitges, Spain.

For more information: <http://www.icp2013.cat>

*Invited plenary "Perspectives Lecture" publicising the forthcoming Intermediate Data Product: "New insights into geochemical proxies from GEOTRACES" by Bob Anderson.

Ocean Science Meeting 2014, 23-28 February 2014, Honolulu, HI, United States.

For more information: <http://www.sgmeet.com/osm2014/default.asp>

*018 - Advancing the frontiers of the Si cycle in terrestrial, coastal, and open ocean ecosystems
Organisers: Paul Treguer, European Institute for Marine Studies; Joanna Carey, U.S. Environmental Protection Agency; Mark Brzezinski, Marine Science Institute, University of California; Christina De La Rocha, European Institute for Marine Studies; Robinson Fulweiler, Boston University; Manuel Maldonado, Centro de Estudios Avanzados de Blanes.

*037 - Dynamics of Coupled Processes in the Ocean: A tribute to the career of Dr. James Murray
Organisers: Laurie Balistrieri, USGS/UW Oceanography; Kathryn Kuivila, USGS; Hans Jannasch, MBARI

*080 - Biogeochemistry of Trace Elements and their Isotopes
Organisers: Rob Middag, University of Otago; Alessandro Tagliabue, University of Liverpool; Peter Sedwick, Old Dominion University; Claudine Stirling, University of Otago; Andrew Bowie, University of Tasmania; Jingfeng Wu, University of Miami.

*092 - From VERTEX to GEOTRACES: honoring Ken Bruland's contributions to marine biogeochemical cycles
Organisers: Gregory Cutter, Old Dominion University; Ana Aguilar-Islas, University of Alaska; Kristen Buck, Bermuda Institute of Ocean Sciences; William Landing, Florida State University; Maeve Lohan, Plymouth University.

*114 - Application of natural and anthropogenic radionuclides to the study of ocean processes
Organisers: Matt Charette, WHOI; Marcus Christl, ETH Zurich; Nuria Casacuberta, ETH Zurich; Ken Buesseler, WHOI.

*116 - Advances in approaches to assess metal-binding organic ligands and perspectives on the impacts of ligands on metal-biota interactions in the oceans
Organisers: Maeve Lohan, University of Plymouth; Kristen Buck, Bermuda Institute of Ocean Sciences; Sylvia Sander, University of Otago.

*146 - Marine micronutrient trace element cycling in oxygen minimum zones
Organisers: David Janssen, University of Victoria; Maija Heller, University of Southern California; Christina Schallenberg, University of Victoria.

*060 - Submarine Groundwater Discharge - from Ridge to Reef: Groundwater Evolution, Climate, Land-Use, Coastal Hydrology and Marine Biogeochemical Impacts
Organisers: Steven Colbert, University of Hawaii Hilo; Henrieta Dulaiova, University of Hawaii; Craig R. Glenn, University of Hawaii; Jason Adolf, University of Hawaii

Forthcoming:

International Conference on Atmospheric Dust, 1-6 June 2014, Castellaneta Marina, Italy.

For further information: <http://www.dust2014.org>

*Dust in the Sea -- Impact on Biogeochemistry and Climate

Organisers: Christel S. Hassler, Université de Genève and Véronique Schoemann, Université Libre de Bruxelles.

Goldschmidt 2014, 8-13 June 2014, Sacramento, California, United States.

For further information: <http://goldschmidt.info/2014/index>

*17e: Trace Elements, Microbes, and Biogeochemical Cycles in the Ocean Environment

Co-convenors: Kathy Barbeau, Maite Maldonado, Benjamin Twining

*16g: Sources, sinks and stores: integrating isotope and geochemical proxies for past and present surface processes, from elementary reactions to global change

Co-convenors: Tim Conway, Penelope Lancaster, Damien Lemarchand

3.5 Capacity building

At-Sea Training GEOTRACES gratefully acknowledges support from SCOR to enable one scientist per year from a developing nation to participate in a GEOTRACES cruise. These opportunities are vital to the development of technical expertise in sampling and sample handling for contamination-prone elements aboard “dirty” ships.

Sampling Systems It is a goal of GEOTRACES that every nation carrying out oceanographic research should have access to a trace metal-clean sampling system. GEOTRACES offers guidance based on past experience in the design and construction of sampling systems as well as advice in operating these systems as shared facilities. A complementary goal is to establish a program whereby scientists who have accrued experience in operating these systems can share that knowledge with scientists from nations that are in the process of acquiring clean sampling systems.

An updated status of trace metal-clean sampling systems to support GEOTRACES research is provided in the table below. Scientists interested in developing one of these systems for their own use are encouraged to contact the GEOTRACES IPO or any member of the SSC, who will arrange for contact with an appropriate person to provide technical information about the design, construction, and cost of a system.

Nation	Status	System/ Carousel	Bottles	Depth
Australia	Complete	Powder coated aluminium, autonomous General Oceanics 1018 intelligent rosette system	12 x 10-L Teflon-lined Niskin-1010X	6000 m; 6 mm Dynex rope
Australia	2nd system (in progress)	Polyurethane powder-coated aluminium Seabird rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	12 x 10-L Teflon-lined OTE external-spring Niskin-style bottles	6000 m 24mm Dyneema rope
Brazil	Complete	GEOTRACES WATER SAMPLER - 24-bottle sampler for use with moderm equipped 911plus CTD	24 X 12-L GO-Flo	3000 m; Kevlar cable

Canada	Complete	Powder coated aluminium with titanium CTD housing, Seabird Rosette	24 X 12-L GO-Flo	2300 m; conducting Vectran soon to be upgraded with 5000 m conducting Vectran 06/2013
China - Beijing	Complete	Towed fish	NA	Surface
China – Taipei	Complete	Teflon coated rosette	Multi- size GO-Flo	3000 m; Kevlar line
France	Complete	Powder coated aluminium with titanium pressure housing for CTD	24 X 12-L GO-Flo	8000 m; conducting Kevlar
Germany	CTD and bottles purchased, winch planned	Powder coated aluminium with titanium pressure housings and fittings	27 x 12-L OTE GO-Flo	8000 m; conducting Kevlar
India	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L Niskin-X	8000 m; conducting Kevlar
Italy	Complete	Go-Flo bottles on Kevlar line	5 x 20-L Go-Flos	Kevlar
Japan	Complete	Powder coated aluminium	12-L Niskin-X	10000 m; titanium armored cable
Netherlands	Complete	Titanium frame	24 X 12-liter GO-Flo	10000 m; conducting Kevlar
Netherlands	Complete	Titanium frame	24 X 27-liter ultraclean PVDF	10000 m; conducting Kevlar
New Zealand	Complete	Powder coated aluminium	5-L Teflon-lined Niskin-X	4000 m; 8 mm Kevlar line
South Africa	Complete	Powder coated aluminium, titanium housing/fittings	24 X 12-liter GO-Flo	6500 m; Kevlar cable
UK	In testing phase	Titanium frame, Ti pressure housings	24 10-L OTE	8000m conducting Kevlar
USA - CLIVAR	Complete	Powder coated aluminium	12 X 12-L GO-Flo	1500 m; conducting Kevlar
USA - GEOTRACES	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L GO-Flo	8000 m; conducting Kevlar
USA- University of Alaska Fairbanks	Complete	Seabird Rosette. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	No Kevlar line available yet.
USA- Old Dominion University	Complete	Seabird Rosette. SBE-19plusV2 CTD unit. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	2000 m 0.5-inch Kevlar wire
USA – Polar Programs	Complete	Powder coated aluminium with titanium pressure housings and fittings	12 X12-L Niskin-X	3000 m; conducting Kevlar

4. GEOTRACES Funding

GEOTRACES receives income from several nations. In the 2013-2014 period, income has been received from Dutch, French, German, Japanese, U.K., and U.S. sources. This multinational funding has been important for GEOTRACES. From the United States, the National Science Foundation is the major contributor to the work of GEOTRACES and in the reporting period, one grant ended and another one started.

5. Plans for coming year

Field programme

The main cruises in the forthcoming year will happen in the Pacific Ocean and especially in the Arctic Ocean, to implement the international GEOTRACES research Arctic programme defined during the GEOTRACES Arctic Workshop held in Vancouver, Canada, on 2-4 May 2012

(http://www.geotraces.org/images/stories/documents/workshops/Arctic/2012_Arctic_Workshop_Canada/Arctic_report_June12.pdf).

Intermediate Data Product

While working to further develop the GEOTRACES Intermediate Data Product for the next release in 2016, a review of the process of building the IDP2014 will be done in the coming months. The main objective of this review is to prepare a document about the *lessons learned* in the process of producing the IDP2014 so that the next intermediate data product can benefit from this experience. The principal persons involved in the creation of the product include the S&I Committee, Ed Mawji (GEOTRACES Data Manager), and Reiner Schlitzer (GEOTRACES SSC co-chair). In addition, feedback received by IDP2014 users, through the form available on the site when downloading the product, will also be examined and included in the report.

Workshops

Atlantic Synthesis Workshop

GEOTRACES plans to organise an Atlantic Synthesis Workshop in order to synthesise Atlantic Ocean sections across the range of trace elements and isotopes. The aim of this workshop will be to make a comprehensive examination of Atlantic data (being the core data included in the IDP2014, but other data might be also included) and interpret results from the entire basin perspective. The workshop will include, as well, some thematic focused sessions (e.g., processes such as hydrothermal plumes, boundary exchange, etc.).

Indian Ocean Planning Workshop

At the same time, GEOTRACES is planning to hold an Indian Ocean planning workshop to review the GEOTRACES action plan for this ocean basin, considering other international initiatives in this area such as the International Indian Ocean Expedition-2 (IIOE-2).

Acknowledgements

We offer our special thanks to Ed Urban, who continues to provide tremendous support and valuable advice to the implementation of the GEOTRACES programme.

Written and compiled by:

Ed Boyle (Co-Chair GEOTRACES SSC)

Reiner Schlitzer (Co-Chair GEOTRACES SSC)

Elena Masferrer Dodas (GEOTRACES IPO Executive Officer)

June 2014

Appendix 9
SCOR/Future Earth/WCRP/iCACGP Surface Ocean – Lower Atmosphere Study (SOLAS)

SOLAS Annual Report to SCOR

Reporting period: July 2013- May 2014
Version of 2 June 2014 by Dr Emilie Brévière

I. Progress on implementation of project science and implementation plans, and schedule for major project activities, including open science meetings, major data releases, synthesis activities, and project completion

I.a. SOLAS Scientific Steering Committee

Since July 2011, Eric Saltzman from the United States has served as Scientific Steering Committee (SSC) Chair; his term will end in Dec. 2016. Since May 2013, Cecile Guieu from France has been Vice-Chair. Alfonso Saiz-Lopez from Spain joined the SSC in Jan. 2014. SOLAS has an Executive Committee composed of the Chair, Vice Chair, Lisa Miller and Roland von Glasow (from May to Dec 2013) and Christoph Heinze (since Jan. 2014).

The SOLAS SSC met in Tsukuba, Japan, 27-30 May 2013 for its 13th SSC meeting and will meet on 16-18 June in Tel Aviv, Israel for its 14th SSC meeting. The current membership of the SSC is listed below (15 members including Chair):

Last name	First name	Country of employment	Gender	Scientific expertise	SOLAS expertise	Term end in 31 Dec
Dai	Min-Han	China-Beijing	M	Coastal carbon/acidification	Focus 3 - SIOA	2014
Engel	Anja	Germany	F	Microbial biogeochemistry, sea surface microlayer	MTS Marine Aerosols	2014
Gao	Huiwang	China-Beijing	M	Atmospheric deposition and ecological effect	MTS Nut Deposition - Task Team ADOES	2014
Garbe	Christoph	Germany	M	Air-sea physical interaction	Focus 2 - MTS EBUS - Liaison ESA	2016
Graco	Michelle	Peru	F	Biogeochemical cycles in upwelling systems, OMZ	MTS EBUS	2014
Guieu	Cecile	France	F	Marine ecosystems/nutrient	MTS Nut Deposition	2014
Heinze	Christoph	Norway	M	Carbon cycle modeling/paleoceanography	Focus 3 - Paleo	2015
Koren	Ilan	Israel	M	cloud physics	Focus 1 - Cloud	2015
Miller	Lisa	Canada	F	Sea-ice/CO ₂ exchanges	Focus 3 - MTS Sea Ice	2016
Nojiri	Yukihiro	Japan	M	Ocean carbon	Focus 3 - SIOA	2015
Quinn	Patricia	USA	F	Aerosols/atmos chemistry	MTS Marine Aerosols	2014
Saiz- Lopez	Alfonso	Spain	M	Atmospheric halogens/modelling	Th 5- Atmospheric Chemistry	2016

Saltzman	Eric S.	USA	M	Atmospheric chemistry	Focus 1&2	2016
Simo	Rafel	Spain	M	Ocean biogeochemistry /trace gases	MTS Marine Aerosols	2014
Ward	Brian	Ireland	M	Air-sea physical interaction	Focus 2- Liaison WCRP	2016

In December 2014:

- Minhan Dai, Cecile Guieu, Trish Quinn and Rafel Simo will rotate off the SOLAS SSC after two 3-year terms.
- Anja Engel, Huiwang Gao and Michelle Graco will end their first 3-year terms on the SOLAS SSC.

I.b. Development of the SOLAS Mid-term strategy

Since 2008, SOLAS has supported the development of its Mid-term Strategy (MTS) themes, identified as areas where progress can be accelerated significantly with the support of an international programme such as SOLAS. The themes are described in the following paper:

Law C. *et al.* (2013) Evolving Research Directions in Surface Ocean - Lower Atmosphere (SOLAS) Science. Environmental Chemistry. Available on our SOLAS website and at http://www.publish.csiro.au/view/journals/dsp_journals_pip_abstract_Scholar1.cfm?nid=188&pip=EN12159

Each theme is at a different stage in its implementation, but there is a major amount of scientific activity ongoing and planned:

• Sea-ice biogeochemistry and interactions with the atmosphere

Recent activities of the MTS on sea-ice are intrinsically linked to the BEPSII SCOR WG 140, chaired by Jacqueline Stefels and Nadja Steiner. BEPSII had its second meeting in March 2014 after the IGS International Symposium on Sea Ice in a Changing Environment in Hobart, Australia. Goals of the meeting were to evaluate the progress of the three Task Groups (TGs), to establish what is still missing and to set a timeline for the coming period.

TG1 (led by Lisa Miller and Lynn Russell) has 3 primary goals:

- 1) The methodological survey has been submitted to the e-journal *Elementa: Science of the Anthropocene- Oceans*.
- 2) For the intercomparison of methods, several potential field stations were identified and an overview of parameters that need to be intercompared, including a first approach for such a campaign, has been drafted. Not all parameters can and need to be intercompared simultaneously. Hence, it was concluded that splitting-up into different campaigns is the best way forward. Possibilities for campaigns in Japan (Saroma-ko Bay) and Finland (Tvarminne) will be further investigated and stimulated. The actual realization is beyond the scope of BEPSII.
- 3) Recommendations for best practices on biogeochemical methods will be explored in the coming period. New and existing papers will be placed on the new BEPSII website.

TG2 (led by Klaus Meiners and Martin Vancoppenolle) has 2 primary goals:

- 1) The production of new data inventories and datasets by collation of existing data has resulted in the first dataset on chlorophyll-a from Antarctica pack ice (published by Meiners et al. GRL 39, 2012, doi:10.1029/2012GL053478). In addition, five other projects are ongoing or were initiated: 1. Arctic chlorophyll-a; 2. chlorophyll-a from Antarctica fast ice; 3. Inorganic carbon parameters; 4. macro-nutrients; and 5. Iron.
- 2) A standardized protocol for meta-data collection will be derived from the ASPeCt log sheet and made available on the BEPSII website.

TG3 (led by Nadja Steiner and Clara Deal) has four primary goals:

- 1) A short paper on “recommendations from modelers to observationalists” is underway.
- 2) Within the task to produce review papers on the major biogeochemical processes, several topics were identified: an overall review paper on the ‘Role of sea ice in global biogeochemical cycles: emerging views and challenges’ has been published in *Quaternary Science* by Vancoppenolle et al. (2013). A special issue in an on-line journal that allows continuous publication will be explored. Planned reviews are on the following topics: the DIC system, Fe distribution and controls, nutrient distribution, light transfer in ice, algal release from ice, DMS(P) in ice, and ice-atmosphere exchange of halogens. A few more topics were identified for which lead authors will be sought.
- 3) The 1D-model intercomparison exercises are taking shape. Eight modeling groups will contribute. The target is to use two sites for model evaluation, one in the Arctic, and one in the Antarctic. A series of four simulations for each site has been developed, with the aim to understand the coupling between ice physics and ocean biology.
- 4) The link to regional modeling and global earth system models will be explored through activities within the AOMIP/FAMOS program.

To facilitate collaboration and scientific outreach of developments and results from the BEPSII community, a website will be built and options for future financial support will be explored.

• **Atmospheric control of nutrient cycling and production in the surface ocean**

In Dec. 2010, a COST action 735-funded workshop took place in Istanbul, Turkey on “Atmospheric versus land based controls of nutrient cycling and production in the surface ocean: from fieldwork to modelling” (coord. C. Guieu and B. Salihoglu). After a set of rejections by *Science*, *Nature Geosciences* and *PNAS*, what is now a more research-oriented paper and includes new model runs, was submitted to *Global Biogeochemical Cycles* in August 2013

Guieu C., O. Aumont, A. Paytan, L. Bopp, C.S. Law, N. Mahowald, E. P. Achterberg, E. Mara  n, B. Salihoglu, A. Crise, T. Wagener, B. Herut, K. Desboeufs, M. Kanakidou, N. Olgun, F. Peters, E. Pulido-Villena, A. Tovar-Sanchez, C. V  lker, 2013, The significance of episodicity in atmospheric deposition to Low Nutrient Low Chlorophyll regions

Following the reviewers’ suggestions, the modelling aspect has been developed and the paper now provides a representation of the spatial and temporal impacts of dust pulses in the oligotrophic ocean. The paper has been under review since March 2014. Another clear outcome of this long publishing process is the birth of a new community composed of modellers and observers.

A review paper was published in *Nature Geosciences*, the outcome of the IGBP/SCOR Fast Track Initiative ‘Upper Ocean Nutrient limitation: processes, patterns and potential for change’. Moore et al., 2013, Processes and patterns of oceanic nutrient limitation, *Nature Geoscience*, doi:10.1038/ngeo1765. This paper is also part of “*Nature Geoscience Insight*, September 2013 Volume 6, No. 9: “Marine cycles in flux” that highlights ‘some of the most intriguing advances in the microbial biogeochemistry of the oceans, a field that is very much in flux’.

Finally, this MTS theme was largely covered in chapter 4 ‘Ocean-Atmosphere interactions of particles’ of ‘Ocean-Atmosphere Interactions of Gases and Particles’, which marked the end of COST Action-735. Lead Authors: G. de Leeuw and C. Guieu. Contributing authors (alphabetical): A. Arneth, N. Bellouin, L. Bopp, P. Boyd, H. Denier van der Gon, K. Desboeufs, F. Dulac, C. Facchini, B. Langmann, N. Mahowald, E. Maranon, C. O’Dowd, N. Olgun, E. Pulido-Villena, M. Rinaldi, E. Stephanou, T. Wagener.

With regard to conferences, one hot session topic under the theme “Oceans and Atmosphere” (Fluids, solids and gases interfaces in the ocean and atmosphere) of the Goldschmidt 2014, California, USA, June 9-13 is relevant to the MTS: ‘Natural and Anthropogenic Impacts on Ocean Chemistry (Nutrients, Oxygen and the Biological Pump)’; Chairs: Cecile Guieu, Linn Hoffman, Martha Gledhill, Jay Cullen. N. Olgun, as a Keynote speaker will give a presentation: “Volcanic Nutrients and their Impacts on the Surface Ocean Biogeochemistry: A New SOLAS Perspective”. Six projects endorsed by SOLAS are related to the MTS.

To achieve further progress, small workshops on some hot topics, such as dust/ashes impacts, are envisioned. The MTS leaders will get in contact and keep the communication flow with the bioGEOTRACES activity (<http://www.geotraces.org/science/biogeotraces>, leaders Philip Boyd, Carol Robinson and Maite Maldonado), especially on the dust/ash hot topic.

• **Air-sea gas fluxes at Eastern Boundary upwelling systems**

In the context of the EUR-OCEANS Flagship, Ivonne Montes started a postdoctoral fellowship in Sept. 2011 between Toulouse, Lima and Kiel on the theme. Her fellowship ended in Feb. 2014 at GEOMAR, Kiel, as Montes was recruited as a scientist at IGP, Peru. The ESA OceanFlux ‘upwelling’ project is ending well (see later section).

A series of field studies have been carried out:

- 1) the East South Pacific Cruises *Meteor*, German SFB754, Oct. 2012 -March 2013. All cruises have been completed with great success;
- 2) German mesocosms experiments off Peru, between Feb. and Apr. 2016;
- 3) AMOP Mooring deployment carried out on Jan. 5, 2013 from R/V *Meteor* and recovered 21 Feb. 2014;
- 4) One visit to the mooring site by R/V *Olaya* in June 2013;
- 5) French AMOP Cruise is taking place (25 January-23 February 2014) with R/V *L'Atalante*.

Activities are underway to set up a meteorology and oceanographic station at Hormigas Islands (OceanSITES). The station is located close to the AMOP mooring. There is already a lighthouse there.

A plenary lecture by Andreas Oschlies (GEOMAR, Kiel, Germany) on deoxygenation took place at the EUR-OCEANS Hot topics Conference in Las Palmas, Spain, 6-8 Nov. 2013. The 46th Liège colloquium took place on 5-9 May 2014 in Liège, Belgium on "Low oxygen environments in marine, estuarine and fresh waters", Véronique Garçon was co-organizer and member of the Scientific Committee, The colloquium received support from SCOR through SOLAS.

With regard to interaction between SOLAS, CLIVAR and IMBER, some discussions happened between Véronique Garçon and Ken Drinkwater from Bergen (CLIVAR SSG member and IMBER SSC member) to join forces on this MTS. Indeed, CLIVAR and IMBER formed a group around a research opportunity on upwelling in 2012. A proposal was submitted in April 2014 by CLIVAR/IMBER/SOLAS to Future Earth for a Fast-Track Initiative or cluster activity on ‘Upwelling Systems in a Changing Climate: from Biophysics and Ecosystems to Marine Resource Management’. The applicants are Kenneth Drinkwater, Lead Scientist, Peter Brandt, Manuel Barange, Enrique Curchister, Véronique Garçon, Raleigh Hood, Shoshiro Minobe, Salvador Lluch Cota, Ryan Rykaczewski, and Lynne Shannon.

A SCOR working group on Microbial Community Responses to Ocean Deoxygenation was approved in November 2013 for 4 years, with Bess Ward is the Chair and V. Garçon is a Full Member. The WG is highly interdisciplinary, gathering biogeochemists, microbial oceanographers, modelers and physical oceanographers.

Regarding future plans, there will be 1) a session during the IMBER Open Science Conference in Bergen, Norway, 23-27 June 2014 chaired by A. Oschlies, L. Stramma and V. Garçon, 2) an EU ESF COST Action: GOOD (Global Ocean Oxygenation/Deoxygenation) proposal is to be submitted in early 2015 and 3) IOC will launch a coordinated action around the topic of Oceanic Oxygen and Climate.

• **Ship plumes: impacts on atmospheric chemistry climate and nutrient supply to the oceans**

The earlier SOLAS White Paper on Ship Plumes explored the consequences for atmospheric chemistry, which has important consequences for respiratory health impacts on humans (Corbett et al., 2007; Winebrake et al., 2009) and may affect radiative budgets important for climate change (Lauer et al., 2009). Recent publications have broadened the scope of this subject area by highlighting the potential effects of ship-based emissions on ocean chemistry (Hassellöv et al., 2013; Hunter et al., 2011; Ito, 2013), and on Arctic sea ice (Browse et al., 2013). Since international shipping is a growing transport activity with weak environmental regulation, the time is ripe for an integrated assessment of the environmental consequences of ship plumes. Initiatives to regulate ship-based emissions are both slow and controversial, due to the multinational jurisdictional complexities of governance and industry concerns about potential increased costs. Tighter regulation of ship-based emissions, therefore, cannot be achieved without a sound scientific basis quantifying impacts and potential benefits to affected ecosystem services (air

quality, ocean and coastal waters, and land terrestrial and freshwater aquatic environments). The SOLAS programme can provide an appropriate mechanism for coordinating this research effort. Existing ship plume research has been well summarised in the recent SOLAS review of evolving research directions (Law et al., 2013).

There is currently no established community working on this issue. The research capacity to address ship plumes in an integrated manner exists, but collaboration is at best extremely limited among researchers working on a) shipping and its emissions; b) atmospheric dispersion and chemistry; and c) ocean biogeochemistry. Here, SOLAS could contribute by convening a workshop to explore the potential for development of an integrated research programme.

• **Ocean-derived aerosols: production, evolution and impacts**

A workshop took place in Raleigh, North Carolina, on 4-6 June 2012 on “Status and prospects of sea spray aerosol research”. An outcome of this workshop is the following paper:

Meskhidze et al. 2013. Production mechanisms, number concentration, size distribution, chemical composition, and optical properties of sea spray aerosols. *Atmospheric Science Letters*, DOI: 10.1002/as12.441

The WACS 2012 cruise took place in August 2012 in the North Atlantic, focusing on the production and properties of nascent sea spray aerosol in different ocean biological regimes. Several papers have been published reporting results from the cruise and more are in preparation. Published papers include the following:

- 1) Frossard et al. 2014. Side-by-side comparison of four techniques explains the apparent differences in the organic composition of generated and ambient marine aerosol particles, *Aerosol Sci. Technol.*, 48, DOI:10.1080/02786826.2013.879979;
- 2) Long et al. 2014. Light-enhanced primary marine aerosol production from biologically productive seawater, *Geophys. Res. Lett.*, 41, 2661-2670, doi:10.1002/2014GL059436; and
- 3) Quinn et al. 2014. Contribution of sea surface carbon to organic matter enrichment in seaspray aerosol, *Nature Geoscience*, 7, 228-232, DOI:10.1038/NGEO2092

SCOR WG 141 on Sea-Surface Microlayers (SML), approved in 2012, will contribute to the SOLAS MTS on ocean-derived aerosols. Members of the group are currently working on a guide to best practices to study the ocean's surface. The guide is expected to be completed this summer, and will be showcased during a 4-day workshop at Ocean University of China in Qingdao. The workshop is being held in October and will include training students in SML sampling techniques and promoting SML research to the next generation of oceanographers. Members of the group will be attending the SOLAS Open Science Conference in Kiel, Germany in September 2015, and will organize a special session on the SML at a major international ocean science meeting in late 2015 or 2016.

A workshop was held at the University of Washington in March 2014 on “Clouds, Aerosols, Radiation, and the Air-Sea Interface of the Southern Ocean: Establishing Directions for Future Research”. The workshop was sponsored by DOE. The workshop initiated the planning of a proposed multi-national, multi-platform experiment SOCRATES to be conducted in 2018.

A relevant oral and poster session took place at the 2013 AGU Fall meeting (9-13 December, in San Francisco, CA) led by Volkamer, R.M. and N. Meskhidze on Marine Trace Gases and Aerosols.

A relevant oral and poster session also took place at the 2014 Ocean Sciences meeting (23-28 February 2014 in Honolulu, HI) led by W.L. Miller and D.J. Kieber, on Surface Ocean – Lower Atmosphere Study (SOLAS): Advances and Impacts of Ocean Derived Aerosols and Atmospheric Nutrient Inputs.

A series of field experiments are planned:

- 1) WACS II, Western Atlantic Climate Study II, will take place in May and June 2014, targeting the same region of the North Atlantic and production and properties of nascent sea spray aerosol. The 2014 cruise will have a larger component of surface seawater measurements of organic matter composition and ocean biology;

- 2) The PEGASO project (Plankton-derived Emission of Gases and Aerosols in the Southern Ocean) led by Rafel Simo is funded. Its core activity is an oceanographic expedition to the Southern Ocean aimed at studying plankton production of aerosols and seeking evidence for biological influence in cloud waters. The cruise will be 1 Jan.-6 Feb. 2015;
- 3) The CORMORANT project (Cumulus Ocean Radiation Measurement Over a Natural Tropical Site) proposal was submitted to US DoE. The study area is the Galapagos Islands, with field campaigns in Aug.-Sept. 2016 and March-Apr. 2017. The project scientific questions of relevance to SOLAS concern the relationship between boundary layer clouds, aerosols, air-sea fluxes and upper ocean properties around the relatively pristine region of the Galapagos. What are the effects of biological and organic sources of aerosols associated with ocean upwelling near the Galapagos on CCN and the evolution of clouds? How does the vertical structure of the boundary layer change with strong variations in the SST and air-sea fluxes about the Galapagos and what is the impact on cloud properties?

I.c. SOLAS- IMBER Carbon Group

Much of the science of SOLAS Focus 3 overlaps with IMBER and thus a joint SOLAS/IMBER Carbon Group (SIC) was formed during a meeting held in Colorado in Oct. 2005. This group is working in close collaboration with International Oceanic Carbon Coordination Project (IOCCP). The SIC group is currently subdivided into three working groups:

***WG1-Surface Ocean Systems.** Chair: Andrew Lenton (Australia)

The Surface Ocean CO₂ Atlas (SOCAT) is a largely volunteer, international activity by the marine carbon community, with more than 100 contributors to assemble surface ocean carbon dioxide (CO₂) data in a uniform, quality-controlled format. Version 1 was made public in 2011, version 2 in 2013, and the release of version 3 is planned for 2015. SOCAT version 2 provides 44 years of surface water fCO₂ (fugacity of CO₂) values from 1968 to 2011 for the global ocean and coastal seas, with 10.1 million unique data points. The SOCAT synthesis and gridded data products can be interrogated via interactive online viewers or downloaded in a variety of formats via the SOCAT website (www.socat.info). Three publications document SOCAT versions 1 and 2 (Pfeil et al., 2013; Sabine et al., 2013; Bakker et al., 2014).

About 3 million new fCO₂ values from 1957 to 2013 have been submitted to SOCAT version 3. Quality control by regional groups is about to start. The quality-control criteria have been adapted for version 3 to accommodate calibrated CO₂ data from new sensors and alternative platforms. A major thrust is to streamline data submission and data entry procedures. Testing the automation system will commence soon.

Applications of SOCAT include process studies, quantification of the ocean carbon sink, its seasonal to year-to-year variation, and ocean carbon cycle modelling. The 2013 Global Carbon Budget (www.globalcarbonproject.org/carbonbudget/) has used SOCAT for quantification of the annual ocean carbon sink. A new initiative, the Surface Ocean pCO₂ Mapping intercomparison (SOCOM), will compare surface ocean CO₂ gridded products, derived by a variety of methods, many of them based on SOCAT. To date, 25 scientific articles and 3 book chapters cite SOCAT.

A SOCAT Community Event will take place on 23 June 2014 (IMBER Open Science Conference, Bergen, Norway). Finally, Steve Hankin of NOAA/PMEL was replaced by Kevin O'Brien on the SOCAT global group. Hankin, with support from the NOAA Climate Program Office, has been instrumental in SOCAT since 2007, responsible for designing the SOCAT online quality control system, the interactive viewers and the automation system.

Further, in 2013 the Global Carbon Project continued its focus on The REgional Carbon Cycle Assessment and Processes (RECCAP). Several regional groups continued working on regional GHG budget products and major progress has been made on the Asia Chapter. Plans for RECCAP2 were discussed at ICDC9. There will be a joint session between the WG1 and 2 of SIC and IOCCP on 'the ocean carbon cycle at a time of change: Data syntheses, analyses and modelling' at the IMBER Open Science Conference Future Oceans, 23-27 June 2014, Bergen, Norway.

A side event to discuss the Southern Ocean and the detection of change in the marine biogeochemistry and the carbon cycle-Southern Ocean Observing System (SOOS) might take place at the IMBER OSC 2014 (to be confirmed). Regarding future plans, the WG1 is planning on meeting in person at the next Ocean Sciences meeting (to be confirmed).

Geoengineering is increasingly discussed by policymakers, with significant implications, analogous to volcanic eruptions, for which surface ocean feedbacks can be large. SIC WG1 may contribute to such a topic.

The WG1 plans on having a closer integration with WG3, given that many of expected changes with ocean acidification (e.g., ecosystem structure, nutrient cycling and carbon uptake) will be seen in the surface ocean.

***WG2-Interior Ocean.** Chair: Nicolas Gruber (Switzerland)- update from Feb. 2014.

WG2 did not meet in 2013, but is planning to meet at the IMBER Open Science Conference in June in Bergen. The global synthesis of repeat hydrography initiative is progressing since 2009 and has made major advances in the last year. The secondary data quality control effort of the GLODAP2 group is nearly completed and the data are planned to be released also at the IMBER OSC in June. An ad hoc steering committee to oversee the work to determine the global-scale oceanic accumulation of anthropogenic CO₂ since the 1990s was formed at a synthesis workshop in Beijing (held in conjunction with the 9th International CO₂ conference). Its members are Masao Ishii (Japan), Jeremy Mathis (USA), Toste Tanhua (Germany), and Nicolas Gruber (Switzerland). At the Beijing workshop an action plan was agreed to, with the goal to finish a high-profile paper by summer 2014. The synthesis group held a workshop at the 2014 Ocean Sciences meeting in order to discuss the first results and agree on a draft outline of the paper. The final results will be presented at the IMBER OSC, where this synthesis group is organizing a dedicated session. WG2 is also continuing to support the growing Bio-Argo program, with WG2 SC members Arne Körtzinger and Ken Johnson co-chairing a SCOR working group on sensor calibration (SCOR WG 142). This group also held its first workshop at the 2014 Ocean Sciences Meeting.

***WG3-Ocean Acidification.** Chair: Jim Orr (France)

The most recent annual meeting of the SIOA working group was in May 2014, supported financially by SOLAS and IMBER. The Chair of the SIOA working group is Jim Orr. SIOA Members are all Members of the Advisory Board of the OA-ICC (Ocean Acidification International Coordination Centre), based at the IAEA Environment Laboratories in Monaco since 2012 for 3 years. Many SIOA Members are focal points for the OA-ICC activities, and Jim Orr is the Scientific Coordinator of the project. IAEA Project Officer is Lina Hansson and Programme Manager Michel Warnau. There is an OA-ICC web site (www.iaea.org/ocean-acidification) and a news stream (www.news-oceanacidification-icc.org). A data curator, based at Xiamen University in China, is working on the OA-ICC data compilation on the biological response to ocean acidification; updated published experimental data are easily available at <http://www.iaea.org/ocean-acidification/page.php?page=2195>. The OA-ICC bibliographic database currently holds more than 2,000 references and includes citations, abstracts and keywords (<http://tinyurl.com/oaicc-biblio>).

The activities of the OA-ICC are to promote 1) the development of a global observation network; 2) use of joint platforms and facilities; 3) collaboration between natural and social sciences; 4) intercomparison exercises; 5) joint ocean acidification experiments; 6) best practices in OA research; 7) online bibliographic database; 8) data management; 9) capacity building; and 10) information sharing and communication.

The OA-ICC is also supporting intercomparisons, the first of which has resulted in a recent publication that compares publicly available software to compute carbonate chemistry, in collaboration with the International Ocean Carbon Coordination Project (IOCCP) and the EU CARBOCHANGE project.

I.d. SOLAS Metadata Portal

The SOLAS metadata portal was set up by the SOLAS project integration initiative (2007-2013) with the intention to help SOLAS scientists identify what SOLAS-related data exist, the data originators, and where the data are currently stored. The portal is hosted by NASA and the metadata files are stored on the international standard Global Change Master Directory (GCMD). The resource is freely available to the entire community.

The SOLAS metadata portal is an ongoing effort. Scientists can help support the SOLAS Metadata base by completing a simple template available at <http://tinyurl.com/328zjr5> and email it to solas@geomar.de.

I.e. Task teams

SOLAS/IGAC Task Team: Halogens in the Troposphere (HitT)

The primary objective of the SOLAS/IGAC Halogens in the Troposphere task team (HitT) is to determine and quantify the importance of reactive halogen compounds in tropospheric chemistry and climate forcing. The goal of HitT is to facilitate international collaboration between laboratory, field, and model activities regarding tropospheric halogen chemistry especially in the following domains: polar regions, salt lakes, marine boundary layer (both remote and coastal), volcanoes, free troposphere, and urban areas. The co-chairs are Roland von Glasow (University of East Anglia, UK) and Ulrich Platt (University of Heidelberg, Germany). Anyone interested by the activities of this task team can subscribe to the HitT mailing list at <http://www.hitt-task.net/>.

Activities of the past year:

- Polar session at DACA 2013, 8-12 July 2013, Davos, Switzerland http://www.daca-13.org/program/index_EN
- A poster and oral session on Halogens in the Troposphere took place at the 2014 EGU Vienna on 28 April 2014.

Task Team: Asian Dust and Ocean EcoSystems (ADOES)

The goal of ADOES is to quantitatively understand the deposition flux and bioavailability of Asian dust, and its impact on biogeochemical processes and ocean ecosystem in order to provide scientific bases for the mechanism of eolian dust-ocean ecosystem-radiative gases-climate change. The co-chairs of this task team are Huiwang Gao (Ocean University of China, China), Guangyu Shi (Chinese Academy of Sciences, China) and Mitsuo Uematsu (University of Tokyo, Japan). A poster on ADOES activities was presented at 50th Anniversary of the IOC/WESTPAC celebration, 26 June-5 July 2013. A joint session on Status, trends and effects of climate, natural disturbances and anthropogenic stressors on ocean ecosystems (by Dr. Uematsu Mitsuo, Dr. Thamasak Yeemin, Prof. Dr. Huiwang Gao) was held at the IOC-WESTPAC 9th international Scientific Symposium, 2014, 22-25 April 2014, Vietnam.

A major joint research project with Canada on “Impacts of ocean acidification on estuary and nearshore marine ecosystems and biogeochemical processes of biogenic active gases” was funded (3.3 million RMB) by the Natural Science Foundation of China (2014-2018). PI is Gui-Peng Yang from Ocean University of China and Co-PI is Maurice Levasseur, from University of Laval, Canada

The project “Atmospheric deposition and its impact on marine primary production and nitrogen cycle (2014-2018)” was funded (15 million RMB) by MOST (Ministry of Science and Technology of the People’s Republic of China). PI is Huiwang Gao from Ocean University of China.

The publication in April 2014 of the e-Book “Western Pacific Air-Sea Interaction Study (W-PASS)” as an open-access book marked the end of the Western Pacific Air-Sea Interaction Study (W-PASS) project. The book is edited by M. Uematsu, Y. Yokouchi, Y. W. Watanabe, S. Takeda. The Joint 7th ADOES Workshop with Asian SOLAS will be hosted by Ocean University of China in 2014 to promote regional exchanges.

I.f. SOLAS Open Science Conference 2015

The OSC15 will take place in Kiel, Germany at the Christian-Albrechts-Universitaet zu Kiel during the week of 7-11 September 2015.

The local organising committee (LOC) is composed of Hermann Bange (GEOMAR), Gernot Friedrich (Univ. Kiel), Christa Marandino (GEOMAR), Birgit Schneider (Univ. Kiel), Emanuel Soeding (Future Ocean Cluster of Excellence Kiel) and a young scientist (finished his PhD 6 months ago) Jonathan Durgadoo (GEOMAR).

Structurally, the SOLAS OSC15 will be taking place in conjunction with two major events 1) the SOPRAN final meeting, to take place on the Monday, 7 Sept. (a day before the start of the OSC15) and 2) the OSC15 will be part of the Future Ocean Cluster of Excellence semester theme on “Processes at Ocean Interfaces: from science to society”. The OSC15 is one of the events of this summer theme; significant funding will then be dedicated to the OSC15.

The Scientific Organising Committee is composed of the SSC and one member of the LOC.

The conference website is up and running using Conference Manager, a SCOR-provided tool (www.solas-int.org/osc2015.html). The registration will open on 1 Sept 2014. For this edition of the OSC, SOLAS is inviting 7 keynote speakers and will select about 20 other speakers from the poster abstracts pool, a significant new feature of this OSC. The conference scientific theme will be forward looking and the themes of the 8 plenary sessions will be those forming the Future SOLAS plan.

I.g. SOLAS v2.0

In the first 10 years of the lifetime of SOLAS, the community has accomplished a great deal towards the goals of the original Science Plan & Implementation Strategy (IGBP report 50, 2004) and Mid-Term Strategy (launched in 2008 and described in Law *et al.*, 2013). But there are still major challenges ahead that require coordinated international research by ocean and atmospheric scientists, as this was identified by the community at the last SOLAS Open Science Conference in 2012. With this in mind, in Spring/Summer 2013, SOLAS has begun an effort to define research themes of importance for SOLAS research over the next decade. The SOLAS Scientific Steering Committee members drafted eight short White Papers. SOLAS being a bottom-up organisation, an online community consultation was carried out in Fall 2013 to give the community the possibility to provide feedback and input on the White Papers, and to inform SOLAS if their research field is represented in the White Papers. But, respondents also were asked more openly what they think SOLAS should be like within the next decade and what they think are the main SOLAS science questions to be addressed.

In addition, on 3-5 December 2013, Tom Bell from the Plymouth Marine Laboratory (PML), UK hosted a very successful workshop to brainstorm on the scientific scope of SOLAS v2.0. Thirteen bright and highly motivated SOLAS early-career scientists from around the world, many of them SOLAS Summer School alumni, met and constructively brainstormed about the next 10 years of SOLAS. To help place Future SOLAS in the context of the Future Earth initiative, two socio-economists from PML were invited to take part to the workshop. Together, the group defined what ecosystem services mean in terms of Future SOLAS science and identified where the natural and social sciences can work together. The recommendations and outcome of this workshop are feeding into a document describing the next phase of SOLAS. (A full report of the workshop is available on the SOLAS website.)

During the next phase, with regard to scientific sponsorship, SOLAS will seek to continue its relationship with current sponsors SCOR, WCRP and iCACGP, but not from IGBP as the programme is ending at the end of 2015. SOLAS will also seek endorsement of the new ICSU initiative Future Earth: Research for Global Sustainability. A proposal describing the next phase of SOLAS and formally asking for its extension is to be submitted to the above-mentioned programmes.

To draft such a proposal based on the White Papers, taking into account feedback from the online community consultation and young scientists' workshop, another workshop took place on 9-10 January 2014 in Galway, Ireland. Brian Ward from the National University of Ireland in Galway hosted this workshop. Some of the current and former SOLAS Scientific Committee members, one of the early-career scientists from the workshop hosted in PML, and the SOLAS Executive Officer met and set up the structure and content of the proposal. The meeting participants developed a table of contents for the extension proposal:

- I. Executive Summary
- II. Introduction
- III. a) Science themes – with proposed activities?
 - Theme 1: Greenhouse gases and the oceans
 - Theme 2: Air sea interface and fluxes of mass and energy
 - Theme 3: Atmospheric deposition and ocean biogeochemistry
 - Theme 4: Aerosols, clouds and ecosystems
 - Theme 5: Atmospheric chemistry, ocean biogeochemistryb) Integrated studies
- IV. SOLAS science and society
- V. SOLAS management and organization
 - a) IPO
 - Communication, Education and Capacity Building
 - Data management
- VI. Linkages to other programs

Appendices

References

The proposal is well underway and an advanced draft is expected to be ready in summer 2014 to be submitted to the expected endorsing bodies.

Engagement with Future Earth: Research for Global Sustainability

Since the Future Earth interim Secretariat was opened, SOLAS has had regular communication with Future Earth officers on various topics. SOLAS contributed to the formulating of the Memorandum of Understanding to be signed between projects and Future Earth, to search for Future Earth Scientific Committee members and Engagement Committee members, and to develop the Future Earth Strategic Research Agenda. Cecile Guieu, SOLAS Vice Chair, gave a short presentation in September 2013 at one of the monthly webinars organised by Future Earth to inform about SOLAS. Finally, the SOLAS Executive Officer and Chairman attended and contributed to the first Future Earth Global Environmental Change projects meeting in Washington, D.C., USA, in January 2014. SOLAS envisions transitioning into Future Earth before the end of 2014.

II. Activities (including capacity building) and publications that resulted from the project's work since the previous year's report

II.a. International SOLAS Summer School 2013

The SOLAS International Summer School is a biennial, two-week program designed to immerse early-career scientists in SOLAS sciences and provide them with the skills necessary for their future scientific careers. SOLAS believes that by providing excellent training, it adequately prepares these future scientists to contribute to the understanding of global change and its significant environmental and societal challenges.

Following the previous, highly successful summer schools held in France, in 2013 the program moved east, “Far East”, and was held in Xiamen, Fujian Province, P.R. China from 23 August to 2 September 2013. It was co-chaired by Dr. Véronique Garçon of CNES/LEGOS and Dr. Minhan Dai of Xiamen University. Sixty-nine students from 24 different countries attended the summer school, along with 15 world-leading scientists.

As with previous schools, the 6th SOLAS Summer School was divided into three sections. The first week consisted primarily of plenary lectures covering a diverse range of topics. These included an introduction to SOLAS, carbon and iron cycles in the ocean, greenhouse/trace gases and their relationship to climate change, atmospheric chemistry and modeling, air-water gas exchange, ocean physics and coastal processes, remote sensing and time series observations, marine ecology, aerosols, marine genomics, macronutrients, solar radiation, and biogeochemical modeling over long time scales. In addition to these, special sessions were also arranged that covered ethics in science, scientists and the press, and the changing Earth.

Poster sessions were also held during the first 3 days of the program and 4 winners were selected by the faculty (Shlomit Sharoni, Israel; Hilary Palevsky, USA; Young-shin Kwon, South Korea; Meri Eichner, Germany). Having the poster sessions occur at the start of the school allowed the students to learn about each other's research and fostered networking during the remainder of the school.

The second section coincided with the start of the second week when the school became more interactive. Students were divided into small groups (averaging 8-10 per group) and took part in hands-on practicals that introduced them to techniques regularly employed in the field. Laboratory work focused on atmospheric and carbon cycle modeling, marine molecular ecology, and gas exchange. Students were also given the opportunity to collect, process, and analyze samples taken along the Jiulong River Estuary aboard Xiamen University's research vessel, *Ocean II*. These results were then presented before the faculty and peers, giving the students a chance to not only interpret their results, but to practice their communication skills.

Prior to their arrival in Xiamen, students were told to prepare a 5-minute oral presentation (along with a poster) on their research. After the poster sessions, each student attended a mandatory “Oral and Communications” workshop whereby faculty provided constructive criticisms and guidance on their posters and students were given the chance

to practice and refine their 5-minute presentations.

In the final section of the summer school, in addition to lectures on more advanced SOLAS science topics, each student presented their oral presentations in plenaries, drawing on the skills and lessons they learnt just a few days earlier. Faculty and students each voted for their top three during these sessions and winners were announced at the closing ceremony (Faculty selections: Eva Mayol, Spain; Natalie Freeman, USA; Neil Clark, UK; Student selections: Jana Schneider, Germany; Raissa Philibert, South Africa; Shlomit Sharoni, Israel).

Another, equally important, though less discussed, aspect of the Summer School was the varied opportunities for networking it provided, even outside of the classroom. While exploring Xiamen, its surroundings, and culture during their free time, students and faculty alike were subconsciously creating those networks and linkages that are critical to the interdisciplinary and collaborative nature of science today.

Each iteration of the Summer School has been highly successful, as evidenced by the high number of applications received. The 6th School was no different, with well over 200 applications received for the limited spots. Furthermore, the feedback from the anonymous, post-program evaluations given to faculty and students was overwhelmingly positive. Without the support of groups such as the Asia-Pacific Network for Global Change, PICES, Scientific Committee on Oceanic Research, the State Key Laboratory of Marine Environmental Science (Xiamen University), the National Natural Science Foundation of China, the Natural Environment Research Council, Xiamen University, the State Oceanic Administration of China, the Centre Nationale d'Etudes Spatiales, Ocean Carbon and Biogeochemistry and many more, this program would not have been possible.

No discussion has taken place yet with regard to the next SOLAS Summer School.

II.b. COST /SOLAS Synthesis book

The EU COST Action 735 was managed by the SOLAS IPO and its project integration sought to develop global air-sea flux datasets of gases and aerosols (2006-2011). The last and major outcome of the action is the publication in open access of a Springer textbook in 2014 entitled *Ocean-Atmosphere Interactions of Gases and Particles*. A considerable number of SOLAS scientists contributed to this major effort led by Peter Liss and Martin Johnson, the editors. The book is the first synthesis of a set of disparate topics into a coherent treatment of the exchange of matter across the sea surface. See <http://link.springer.com/book/10.1007/978-3-642-25643-1>

Book content description: The oceans and atmosphere interact through various processes, including the transfer of momentum, heat, gases and particles. In this book leading international experts come together to provide a state-of-the-art account of these exchanges and their role in the Earth-system, with particular focus on gases and particles. Chapters in the book cover: i) the ocean-atmosphere exchange of short-lived trace gases; ii) mechanisms and models of interfacial exchange (including transfer velocity parameterisations); iii) ocean-atmosphere exchange of the greenhouse gases carbon dioxide, methane and nitrous oxide; iv) ocean atmosphere exchange of particles and v) current and future data collection and synthesis efforts. The scope of the book extends to the biogeochemical responses to emitted/deposited material and interactions and feedbacks in the wider Earth-system context.

II.c. SOLAS synthesis paper in Earth's Future in prep.

SOLAS is preparing a paper to contribute to the IGBP synthesis effort, which likely will be published in the journal *Earth's Future*, Wiley in early 2015. Five major achievements have been selected to be reported in the paper. The main contributors are Bob Duce, Natalie Mahowald, Cliff Law, Philip Boyd, Hermann Bange, Eric Saltzman, Trish Quinn, and Emilie Breviere as of now. A draft is well underway.

II.d. IGBP Fast Track Initiatives

In May 2009, IGBP launched two fast-track initiatives (FTIs) proposed by SOLAS and other IGBP core projects. Both FTIs were co-endorsed by SCOR. Both FTIs came to an end in 2011. The FTI on 'Upper Ocean Nutrient Limitation: processes, patterns and potential for change' coordinated by Mark Moore (NOCS, UK) and Matt Mills (Stanford Univ., USA) had a workshop in Southampton, UK on 3-5 Nov. 2010. An outcome of this workshop is a review paper published in *Nature Geoscience*: Moore et al. (2013) Processes and patterns of oceanic nutrient limitation, *Nature Geoscience*. doi:10.1038/NGE01765

II.e. Future Earth Fast Track Initiatives and/or Clusters Activities

In February 2014, Future Earth launched a call for FTI and clusters activities. SOLAS was involved in two proposals (100kUSD for 2 years). The outcome of the proposal review will be known by the end of June 2014.

- 1) “Upwelling Systems in a Changing Climate: From Biophysics and Ecosystems to Marine Resource Management”, proposal submitted in collaboration with CLIVAR and IMBER
- 2) “International, Interdisciplinary Polar Science Network”, proposal submitted in collaboration with IGAC, OASIS/AICI, HitT, BEPSII, ASP, ArcticNET, AINA, CRAICC, PEEX, SVALI, DEFROST, NORDFROST, CliC, CLIVAR, ISAC, DBO, SEARCH

II.f. OceanFlux three projects update: collaboration between ESA and SOLAS

The OceanFlux project series aimed at reinforcing the scientific collaboration between ESA and SOLAS. The overall project objective was twofold: 1) Support the development of novel products and enhanced EO-based observations responding to the needs of the SOLAS community and 2) Advance in the integration of EO-based products, in-situ data and models in order to contribute to SOLAS major scientific gaps. Three projects have been identified and carried out (2011-2013), and the major features and accomplishments follow.

Ocean Flux GHG, <http://www.oceanflux-ghg.org>

The OceanFlux Greenhouse Gases project is now nearing completion. The project has published 4 journal papers on altimeter gas transfer velocity algorithms, Arctic air-sea CO₂ fluxes and wave breaking statistics and another 6 journal papers are in draft form.

All of this work has exploited satellite Earth observation, in situ data, and modelling approaches. The project has released a version of its global CO₂ flux climatology and the data processing system (called FluxEngine) that was used to create the climatology is available for the community to use and exploit. Further updates to the processing system and the climatology are expected over the next few months.

OceanFlux Upwelling, <http://upwelling.eu/>

OceanFlux Upwelling aimed at exploring the potential of EO technology to characterize the role of ocean upwelling processes as sinks and/or sources of greenhouse gases, with a distinctive focus on the Peru-Chile and Benguela Eastern Boundary Upwelling Systems (EBUS).

In this context, image-processing techniques have been used to extract fluxes of GHGs from EO data. Through concomitant information on gas solubility and gas transfer velocities, the partial pressure of GHG in the ocean has been extracted. A new non-linear and multi-scale processing method for complex signals has been applied to infer a higher spatial resolution and properly map the GHG fluxes. These analyses have been linked to a coupled physical bio-geochemical model (ROMS-BioBus). The project has been officially completed, but a further 6-month extension is foreseen, allowing a further refinement of the super-resolution CO₂ ocean fluxes algorithm (merging different data sources) and validating the methodology enlarging the two test areas beyond the initial upwelling zones.

OceanFlux SSA, <http://oceanflux.fmi.fi>

The Oceanflux Sea-Spray Aerosol (OSSA) project focused on the development of a new sea-spray aerosol (SSA) source function (SF) and effects of SSA on climate. Using two independent data sets, SSA fluxes and particle number concentrations, the OSSA SF has been parameterized in terms of five log-normal modes and the Reynolds number. It encapsulates effects of wave height, and accounts for the different flux relationships associated with rising and waning wind speeds and dependences on SST and salinity. The OSSA SF, together with a scheme for the organic fraction, was implemented in the aerosol-climate model ECHAM-HAMMOZ. Comparison of modeled concentrations of SSA and OM with in situ data and PARASOL-retrieved AOD suggest areas for further improvement. The simulated SSA contribution to the indirect radiative effect is positive, which is ascribed to the tendency of SSA to suppress both the in-cloud supersaturation and the formation of cloud condensation nuclei from sulphate.

The end of the OceanFlux projects coincided with topical workshops: Sea Spray aerosol workshop for the OSSA theme, 30 Sept.-1 Oct. 2013 in Galway, Ireland and ‘Air-sea Gas Flux Climatology, progress and future prospects’ for the themes on GHGs and upwelling, 24-27 Sept. 2013, Brest, France. ESA is very interested by continuing its collaboration with SOLAS, although additional funding will depend on its budget. In order to continue collaboration

and identify areas of common interest, ESA, EGU and SOLAS are organizing a topical conference on "Earth Observation for Ocean-Atmosphere Interactions Science 2014 - Responding to the new scientific challenges of SOLAS". The conference will be held in Frascati (Rome), Italy on 28-31 October 2014. This joint ESA-EGU-SOLAS Conference aims at bringing together the Earth observation and SOLAS communities, as well as scientific institutions and space agencies involved in the observation, characterisation and forecasting of ocean-atmosphere interactions and their impacts.

II.g. Collaboration with PICES

- SOLAS co-sponsored the Topic Session on "The changing carbon cycle of North Pacific continental shelves and marginal seas" at the 2013 PICES Annual Meeting in Nanaimo, Canada, Oct. 2013 by supporting the attendance of the invited speaker KK Liu. Lisa Miller represented SOLAS at the Annual Meeting.
- A half-day workshop will take place in 17-26 Oct. 2014 in Korea on "SOLAS into the future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth Program" at the PICES annual meeting 2014 "Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future". The workshop was proposed and will be run by Lisa Miller, Minhan Dai and Yukihiro Nojiri.
- Leticia Cotrim Da Cunha, SOLAS Brazil national representative and colleagues from Latin American countries submitted a proposal to run a one-day workshop on SOLAS matter at the Effects of Climate Change on the World's Ocean Meeting in 2015 in Brazil.

II.h. Swedish SOLAS events in Sweden

On 18-19 Nov. 2013, about 25 SOLAS scientists from Swedish Institutions met at the Royal Swedish Academy of Sciences in Stockholm. Three SOLAS Scientific Steering Committee Members and three representatives of Swedish funding agencies joined them to discuss how to enhance the engagement of Swedish researchers in SOLAS, in particular in the context of the Future Earth initiative. The participants successfully established a matrix mapping Swedish capacity in relation to the SOLAS scientific scope and a list of current members of the Swedish network. During this workshop, it was also identified that David Turner, an established scientist at Gothenburg University, is working with his group on ship plume emissions and their impacts on the surface ocean. David accepted to lead the 'Ship Plumes' SOLAS emerging issue, taking over from Roland von Glasow. This successful workshop was initiated, organised and supported by the Swedish Secretariat for Environmental Earth System Sciences (SSESS). This workshop revived the SOLAS network in Sweden. A 2-day Swedish symposium is planned to take place in August 27-28, 2014 in Gothenburg.

II.i. SOLAS visited the EU, Brussels

A SOLAS delegation composed of Brian Ward, Cecile Guieu, and Christoph Heinze, accompanied by Wendy Broadgate from IGBP visited the European Commission in Brussels, Belgium on 25 Nov 2013, to improve the chances for an EU call related to SOLAS activities (also for prospective funding of the IPO) under Horizon 2020.

II.j. SOLAS Symposium day in Israel

SOLAS will have a special symposium day on 19 June 2014 in the Lopatie Conference Centre at the Weizmann Institute of Science campus in Rehovot, Israel. The symposium is aimed at interdisciplinary exchange of ideas, insights, and knowledge, between scientists whose work deals with SOLAS-related processes. The symposium day will take place back to back with the 14th SOLAS Scientific Steering Committee meeting.

II.k. SOLAS France days, July, Paris

SOLAS Scientists in France are organizing a 2-day workshop, 7-8 July in Paris, France. SOLAS scientists, established and younger, from French institutes will share results and knowledge, with the ultimate goal to determine how SOLAS France can contribute to Future SOLAS v2.0.

II.l. SOLAS communication

SOLAS website <http://www.solas-int.org/>

The **SOLASNews newsletter** (NL) is emailed to about 2,200 scientists and airmailed to about 100 scientists, mainly from developing countries. Copies are held by the SOLAS IPO for distribution at SOLAS-relevant conferences and meetings. The NL is also available from the SOLAS website. The SOLASNews is printed and airmailed from China

courtesy of the State Key Laboratory of Marine Environment Science, Xiamen University. Since issue 11, SOLAS also implemented an on-screen reader pdf version. Issue 15 (summer 2013) proposed a general update of the large scope of SOLAS activities, from the SOLAS Mid-term Strategies to the SOLAS/IMBER Carbon Groups and the Focus 2. Issue 16 is well underway and expected to be published in early June 2014.

E-bulletins are sent to more than 2,200 SOLAS scientists, roughly 10 times per year and previous issues are archived on the website at <http://www.solas-int.org/archive.html>. The bulletins contain news from SOLAS, opportunities for meetings, abstract submission deadlines, recent publications, vacancies, and news from relevant partner project and collaborators.

Flyers. The IPO has created an A5 flyer, with the support of the IGBP designer Hilarie Cutler. The flyer informs on the current scientific structure of SOLAS and updates on its plans for the future. The flyer was distributed at 2014 Ocean Sciences Meeting in Hawaii and other SOLAS-relevant events.

Booth at Ocean Sciences. SCOR had a booth (#10) at the 2014 Ocean Sciences Meeting in Hawaii on 23-28 February 2014. SOLAS was invited to display project research information. The SOLAS PO and some SSC members attending the meeting and staffed the booth. This was the first time SOLAS had been represented at a booth and it was a positive experience.

II.m. SOLAS National Networks

Scientists from 29 nations are represented in the SOLAS network. Each nation has one or two representatives:

Australia: Sarah Lawson and Andrew Bowie
Belgium: Christiane Lancelot
Brazil: Leticia Cotrim Da Cunha (NEW)
Canada: Maurice Levasseur
Chile: Laura Farias
China (Beijing): Minhan Dai
China (Taipei): Gwo-Ching Gong
Denmark: Lise Lotte Soerensen and Mikael Sejr
France: Remi Losno
Germany: Hermann Bange and Ulrich Platt
India: Dileep Kumar
Ireland: Brian Ward
Italy: Chiara Santinelli
Finland: Gerrit de Leeuw
Japan: Mitsuo Uematsu

Korea: Kitack Lee
Mexico: Jose Martin Hernandez Ayon
Netherlands: Jacqueline Stefels
New Zealand: Cliff Law
Norway: Siv Lauvset (NEW)
Peru: Michelle Graco
Poland: Timo Zielinski (NEW)
Russia: Sergey Gulev
Spain: Rafel Simo
South Africa: Carl Palmer
Sweden: Katarina Abrahamsson
Turkey: Baris Saglihoglu and Mustafa Koçak
UK: Tom Bell (NEW)
USA: Bill Miller

Implemented in Jan. 2009, the national representatives of the SOLAS nations are asked to report annually about the SOLAS activities in their countries. To facilitate the reporting effort, a template form is provided. In January 2014, 19 reports were received and posted on the SOLAS website. The information contained in the reports has been/are a great source of information for the IPO to report to sponsors, but also to facilitate the coordination job and to redistribute the results and progress from some nations to the rest of the SOLAS community via the Newsletters and the website. All the reports received during the reporting period are available in an Addendum to this report.

II.n. Endorsed projects

Over the reporting period, SOLAS endorsed three projects: OASIS, NETCARE, and WDAC II. Information about support letters and endorsements are more accessible on the new website. The endorsement submission forms and update reports will be shortly available on the SOLAS website.

III. SOLAS Management

III.a. SOLAS International Project Office, Kiel

The SOLAS IPO is hosted at the GEOMAR Helmholtz-Centre for Ocean Research Kiel in Kiel, Germany. The office is currently staffed with the Executive Officer, Dr. Emilie Brévière and the Project Officer, Stefan Konradowitz. GEOMAR provides office space and has funded the Executive Officer's salary since 1 February 2011. The Project Officer's salary has been supported since 1 February 2013 by the German Ministry of Education and Research (BMBF) via the German national SOLAS project 'SOPRAN' Phase 3. The IPO has benefited since mid-March 2014 from a master's student's help with the OSC2015 (38 hours per month), funded by BMBF until mid- Sept 2014.

GEOMAR will provide office space and the salary of the executive officer, Dr. Emilie Brévière until January 2016. The salary of the project officer, Stefan Konradowitz covered by BMBF, via the SOPRAN Phase 3 funding is secured until January 2016 too.

III.b. SOLAS Funding

The Executive Officer salary, office space and in kind provided by GEOMAR until January 2016. The Project Officer salary and some travel support are provided by BMBF via SOPRAN phase 3 until January 2016. The U.S. National Science Foundation (via SCOR) provides annual funding until 1 Sept. 2015, when the current grant to SCOR ends, but SOLAS funding will be requested in the grant renewal proposal. One-third of this amount is used for the annual meeting of the SOLAS/IMBER working group on Ocean Acidification and the other two-thirds of the SCOR contribution covers the cost of the SSC meeting. IGBP provides an annual block grant, contributing to the cost of the SSC meeting. French CNRS provided funding in 2013 and 2014 for the SOLAS Vice Chair for SOLAS-related travel. Xiamen University provided support for the printing and shipping of the annual SOLASNews newsletter.

The future of the SOLAS IPO is currently unknown beyond January 2016. Various paths are being investigated.

Appendix 10

SCOR/POGO International Quiet Ocean Experiment (IQOE)

The International Quiet Ocean Experiment is a project under development by SCOR and the Partnership for Observation of the Global Oceans (POGO). Funding was initially provided by the Alfred P. Sloan Foundation, but that funding is now completed. Since the 2013 SCOR meeting, activities of the IQOE co-chairs and SCOR and POGO staff has focused on review of the report and working on responses to the review. In addition, IQOE co-funded a workshop on Predicting Sound Fields—Global Soundscape Modelling to Inform Management of Cetaceans and Anthropogenic Noise” in April 2014 in The Netherlands. This workshop relates to one of the major IQOE themes.

The timeline for the International Quiet Ocean Experiment (IQOE) has been as follows:

- 27-29 October 2010—Exploratory workshop at the University of Rhode Island
- 10-11 February 2011—Meeting at Florida Atlantic University to complete report from Rhode Island meeting and article for *Oceanography* magazine, and plan open science meeting
- 30 August-2 September 2011—Open Science Meeting at UNESCO Headquarters, Paris
- 15 June 2013—Science Plan sent to Review
- 24 January 2014—Last review received
- 1 September 2014—Response to Review sent to SCOR and POGO report monitors

It is planned to for the IQOE co-chairs to submit the response to review to SCOR and POGO around 1 September 2014. The SCOR Executive Committee will discuss the IQOE response to review in closed session and will announce the outcome of its discussions during the meeting.

Appendix 11

SCOR/IOC/IOGOOS Second International Indian Ocean Expedition (IIOE-2)

SCOR has convened a committee to develop a Research Plan for the Second International Indian Ocean Expedition (IIOE-2), chaired by Raleigh Hood. The full membership of the committee follows.

Name	Expertise	Institution	Country
Raleigh Hood, Chair	Biological oceanography	University of Maryland	USA
Hermann Bange	Chemical oceanography and air-sea interactions	Helmholtz Centre for Ocean Research	Germany
Lisa Beal	Physical oceanography	University of Miami	USA
Lynnath Beckley	Fisheries oceanography	Murdoch University	Australia
Greg Cowie	Organic Ocean chemistry	University of Edinburgh	UK
Harry Hendon	Tropical Climate and climate prediction	The Centre for Australian Weather and Climate Research	Australia
Juliet Hermes	Physical oceanography and climate, observations	South African Environmental Observation Network	South Africa
Makio Honda	Biogeochemistry	JAMSTEC	Japan
Frank Peeters	Paleoceanography	Vrije Universiteit	Netherlands
Sunil Singh	Chemical oceanography	Physical Research Laboratory	India
Weidong Yu	Physical oceanography	First Institute of Oceanography	China-Beijing
Liaison to IOC			
Nick D'Adamo	Physical oceanography	Perth Office, Australia	IOC
SCOR Staff			
Ed Urban	Marine Biology	University of Delaware	SCOR

The committee has been working remotely and will meet for the first and only time on 12-13 September 2014 in Bremen, before the SCOR meeting. The committee's term is from 1 June 2014 to 31 December 2015. Its terms of reference are the following:

1. Gather input from the international community about research interests in the Indian Ocean for 2016-2020.
2. Condense and summarize this research into international research priorities.
3. Plan IIOE-2 Workshop for 12-13 September 2014 in Bremen, Germany
4. Promote the IIOE-2 concept in national and international fora.
5. Liaise with national planning committees on IIOE-2 development.
6. Help plan launch of IIOE-2 in Goa, India in December 2015.

The committee will hand off its Research Plan to the IIOE-2 Interim Planning Committee before the IOC General Assembly in June 2015.

Appendix 12
2013 Audited SCOR Statement of Activities

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH, INC.
STATEMENT OF ACTIVITIES
YEAR ENDED DECEMBER 31, 2013

UNRESTRICTED NET ASSETS

SUPPORT AND REVENUE

Grant and contract revenue	\$792,256
Membership dues	\$330,247
Meeting registration fees and miscellaneous income	\$18,068
Interest income	<u>\$10</u>

TOTAL SUPPORT AND REVENUE	<u>\$1,140,581</u>
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EXPENSES

PROGRAM SERVICES

Scientific programs	\$723,139
Travel and subsistence programs	\$77,907
Other conferences and meetings	<u>\$18,815</u>

TOTAL PROGRAM SERVICE EXPENSES	\$819,861
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SUPPORT SERVICES

Management and general	<u>\$280,080</u>
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TOTAL EXPENSES	<u>\$1,099,941</u>
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CHANGE IN UNRESTRICTED NET ASSETS	\$40,640
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UNRESTRICTED NET ASSETS, beginning of year	\$171,422
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UNRESTRICTED NET ASSETS, end of year	<u>\$212,062</u>
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Appendix 13
SCOR-Related Meetings (2013-2015)

2013		
1 January	IMBER IMBIZO III	Goa, India
16 February	SCOR WG 139 on Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean	New Orleans, Louisiana, USA
16 March	WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces	Ventura, California, USA
11 April	WG 141 on Sea-Surface Microlayers	Vienna, Austria
22-23 April	International Ocean Carbon Coordination Project Scientific Steering Group	Norwich, UK
25-27 April	GEOHAB Open Science Meeting	Paris, France
20-24 May	SOOS Scientific Steering Committee and Asian Workshop	Shanghai, China
27-31 May	SOLAS Scientific Steering Committee	Tsukuba, Japan
17-19 June	IMBER Scientific Steering Committee	Canary Islands, Spain
19-22 June	WG 138: Two Parallel Workshops on Planktonic Foraminifera	Prague, Czech Republic
1-5 September	SCOR/IAPSO/IAPWS Joint Committee on the Properties of Seawater	London, UK
30 September-4 October	GEOTRACES Scientific Steering Committee, Data Management Committee, and Standards and Intercalibration Committee	Bremerhaven, Germany
2-4 November	WG 137 on Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation	San Diego, California, USA
25-28 November	SCOR Executive Committee Meeting	Wellington, New Zealand
3-5 December	GEOHAB Scientific Steering Committee	Barcelona, Spain
2014		
21 February	WG 143 on Dissolved N ₂ O and CH ₄ Measurements: Working Towards a Global Network of Ocean Time Series Measurements of N ₂ O and CH ₄	Honolulu, Hawaii, USA
22 February	IOCCP Scientific Steering Group	Honolulu, Hawaii
23 February	WG 139 on Organic Ligands: A Key Control on Trace Metal Biogeochemistry in the Ocean	Honolulu, Hawaii, USA
1 March	WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders	Honolulu, Hawaii, USA
16 March	WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces	Hobart, Tasmania, Australia
18-21 March	Workshop on Ecosystem Essential Ocean Variables in the Southern Ocean	New Brunswick, New Jersey, USA
29 April, 2 May	SCOR/InterRidge WG 135 on Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycle	Vienna, Austria
16-20 June	SOLAS Scientific Steering Committee Meeting	Israel
18-20 June	SOOS Scientific Steering Committee Meeting	Tromsø, Norway
23-27 June	IMBER Open Science Meeting	Bergen, Norway
26 June	Workshop on Foraminiferal Geochemistry (WG 138 on Modern Planktic	Texel, The

	Foraminifera and Ocean Changes	Netherlands
14-18 July	WG 144 on Microbial Community Responses to Ocean Deoxygenation	Vancouver and Saanich Inlet, BC, Canada
12-13 September	Open Meeting to Discuss Draft Research Plan for IIOE-2 and Coordinate National Research Plans	Bremen, Germany
14 September	SCOR Committee on Capacity Building	Bremen, Germany
15-18 September	SCOR General Meeting	Bremen, Germany
6-10 October	GEOTRACES SSC and DMC Meetings	Stellenbosch, South Africa
14-17 October	WG 141 on Sea-Surface Microlayers	Qingdao, China
3-7 November	WG 137 on Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation	Zhuhai, China
2015		
16-17 March	WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders	Brest, France
20 March	WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces	Lucca (Barga), Italy
7-11 April	WG 139 on Organic Ligands: A Key Control on Trace Metal Biogeochemistry in the Ocean	Sibenik, Croatia
12-13 April	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	Sibenik, Croatia
14-15 April	WG 147: Towards Comparability of Global Oceanic Nutrient Data (COMPONUT)	Vienna, Austria
7-10 June	SOOS Scientific Steering Committee and Associated Meetings	Hobart, Tasmania, Australia
8-10 June	IMBER Scientific Steering Committee Meeting	Santa Cruz, California, USA
13-17 July	GEOTRACES Data Management Committee and Scientific Steering Committee	Vancouver, British Columbia, Canada
15-17 July	WG 146 on Radioactivity in the Ocean, 5 Decades Later (RiO5)	Woods Hole, Massachusetts, USA
30 August - 3 September	WG 144 on Microbial Community Responses to Ocean Deoxygenation	Warnemünde, Germany
30 August-4 September	WG 138 on Planktonic foraminifera and ocean changes (with IGBP)	Catalina Island, California, USA
4 September	WG 143 on Dissolved N ₂ O and CH ₄ measurements: Working towards a global network of ocean time series measurements of N ₂ O and CH ₄	Kiel, Germany
7-11 September	SOLAS Open Science Conference	Kiel, Germany
12-13 September	SOLAS Scientific Steering Committee Meeting	Hamburg, Germany
16-18 September	Workshop on Seafloor Ecosystem Functions and their Role in Global Processes	Naples, Italy
26-30 October	IMBER IMBIZO IV	Trieste, Italy
30 November-4 December	NIO Golden Jubilee, Celebration of 50 Years of Indian Ocean Research Since Completion of IIOE, and Launch of IIOE-2	Goa, India
7-9 December	SCOR Executive Committee Meeting	Goa, India

