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SCOR Proceedings, Volume 51
REPORT OF THE 42nd SCOR EXECUTIVE COMMITTEE MEETING

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42nd SCOR EXECUTIVE COMMITTEE MEETING

Goa, India
7-9 December 2015

1.0 OPENING

1.1 Opening Remarks and Administrative Arrangements

SCOR President Peter Burkill opened the meeting and introduced Wajih Naqvi, who formally welcomed meeting participants to the National Institute of Oceanography (NIO). SCOR was responsible, in part, for the founding of NIO 50 years ago as a result of the first International Indian Ocean Expedition. Naqvi expressed his great appreciation and gratitude to SCOR to be asked to organize the current meeting. Ed Urban thanked Naqvi and his team for hosting the meeting and helping with all the logistics.

Peter Burkill asked participants to introduce themselves very briefly. Burkill continued with memorials for six scientists who had been involved in SCOR activities and had died since the 2014 SCOR annual meeting: Luis Cappuro, Yves Collos, Katrina Edwards, S. Krishnaswami, Kon-Kee Liu, and Roland von Glasow. Burkill asked for a short period of applause to celebrate the lives of these colleagues that had passed. On the second day of the meeting, it was announced that Shizuo Tsunogai had just died.

1.2 Approval of the Agenda

Ed Urban passed around a revised annotated agenda. Two changes were requested to the agenda: (1) switching the timing of the reporting from current WGs with the discussion of the second International Indian Ocean Expedition (IIOE-II) and (2) moving the IMBER presentation to 5:30 p.m. on Tuesday afternoon to make it easier for the IMBER chair to make the presentation remotely. The proposed changes were approved.

1.3 Report of the SCOR President

Peter Burkill reviewed his activities for SCOR since the SCOR Executive Committee Meeting in September 2014 in Bremen, Germany. Burkill first listed his travel since September 2014 to represent SCOR:

<i>Year</i>	<i>Month</i>	<i>Country</i>	<i>Institution</i>	<i>Role</i>
2014	October	Qingdao, China	Ocean University of China Inst. of Oceanology, Chinese Academy of Sciences First Inst. of Oceanography, State Oceanic Administration	a) Keynote on SCOR at Symposium b) Visit Director & Staff c) Visit Director & Staff
2015	January	Goa, India	NIO	Planning for Indian Ocean

				Symposium, with SCOR Exec. Director
	March	Paris, France	ICSU, IOC	Meetings with ICSU Exec. Dir. And Science Dir., with French SCOR committee, and with IOC Exec. Sec. and staff
	April	Paris, France	IOC	IIOE-2 Interim Planning Committee Meeting
	June	Paris, France	IOC	IOC General Assembly; presentation with Exec. Sec.
	October	Hyderabad, India	INCOIS	IIOE-2 Interim Planning Committee Meeting
	November	Goa, India	NIO	Co-Chair IO50 Symposium

Burkill chaired 10 conference calls of the International Symposium Planning Committee (ISPC), from October 2014 to November 2015. His responsibilities in relation to the ISPC included working with the other two co-chairs (from India and IOC) to select the ISPC members and determine the Symposium structure (sessions, chairs, keynote speakers, oral papers, and poster presentations). The co-chairs were responsible to maintain a balance between nationalities, gender and age wherever possible. Burkill also developed links with the National and Local Organizing Committees. Burkill was one of two SCOR participants on the IIOE-2 Interim Planning Committee (with Raleigh Hood). This involved 8 conference calls and two in-person meetings. Burkill took responsibility for the Governance section of the IIOE-2 Implementation Strategy. Burkill is working with Ed Urban on the ICSU review of SCOR, which is an ongoing activity. SCOR was invited by IAPSO to participate in developing a Position Paper for the G7 on the State of Marine Environment (ongoing) and Burkill has been working with Denise Smythe-Wright from IAPSO on this.

1.4 Report of SCOR Executive Director

Ed Urban reported on his activities for SCOR since the 2014 SCOR meeting, and on the current condition of SCOR. Urban noted that the SCOR office is efficient, staffed by only 1.25 Full-Time Equivalents.

Finances: Most countries have paid their 2015 dues, although a few countries that are experiencing financial difficulties have not yet paid. SCOR maintains a healthy surplus to counteract any future shortfalls in dues income. SCOR was awarded a new three-year science grant from U.S. NSF, starting on 1 Sept. 2015, which provides funding for GEOTRACES, GlobalHAB, IMBER, IOCCP, SOLAS, and SCOR working groups.

Working Groups: Most groups continue to make progress toward fulfilling their terms of reference on time, although a few groups have postponed activities. All three working groups approved at the 2014 SCOR meeting have met for the first time.

Research Projects: SOLAS and IMBER are still in the process of approval of new science plans and transition to Future Earth. GEOTRACES is conducting mid-project synthesis activities in 2016 and beginning its 2017 Intermediate Data Product. The IQOE and IIOE-2 projects have been approved.

Outreach: SCOR is hosting a booth at Ocean Sciences 2016 and the number of Twitter followers has increased over the year.

ICSU Review: The review committee met in September, but we have heard nothing more about the review process. There are tentative plans for the review committee to visit the SCOR Secretariat in early 2016, but dates have not been discussed with us.

Urban reported that participation by female scientists has continued to increase, up to 35% in 2015. Developing country membership in SCOR activities has held constant at about 23%. Current SCOR working groups have chairs from 11 countries, which is an increase from earlier years. Full Members of current working groups are from 27 countries. Most, but not all, of these countries have ocean-going research activities. Six members are from nations that do not have national SCOR committees or pay dues to SCOR. In terms of the ages of participants in SCOR activities, Urban did a survey of participants using SurveyMonkey earlier in 2015. Of the 124 individuals who answered, the largest contingent is in the 40-49 year age bracket (about 34%), the second largest in the 50-59 year age bracket (about 25%), and the third largest in the 30-39 year age bracket (about 21%).

In terms of outreach, the number of Twitter followers continues to increase (78 followers at the time of the meeting). Urban had Tweeted 52 times by the time of the SCOR meeting. It was noted that the number of followers would probably increase if there were more Tweets, but Urban replied that he preferred to limit Tweets to the most important information. He noted that most of SCOR's Twitter followers are not currently on the SCOR email list. SCOR follows GEOTRACES, IMBER, and SOOS, so their Tweets show up in the SCOR Twitter feed. SCOR will be well represented at the Ocean Sciences 2016 in New Orleans, Louisiana, USA. SCOR will have a booth, as well as the following side meetings and Town Hall sessions:

- 19-21 February: IMBER Scientific Steering Committee Meeting
- 21 February: SCOR WG 145 meeting
- 22 February (12:45-1:45 pm): WG 145 Town Hall
- 24 February: WG 139/145 Session
- 24 February: SCOR 141 meeting
- 25 February (12:45 PM - 1:45 PM): IIOE-2 Town Hall
- 25 February (6:30 PM - 7:30 PM): GEOTRACES Town Hall
- 27 February: SCOR WG 142 meeting

Peter Burkill thanked Ed Urban for his work over the past year.

1.5 Appointment of an *ad hoc* Finance Committee

The SCOR Constitution requires that a Finance Committee be appointed at every SCOR meeting. It must consist of at least three members of SCOR who are not members of the Executive Committee. The Finance Committee reviews the administration of SCOR finances during the previous fiscal year and the current year, and will propose a budget for 2016 activities and dues for 2017. Members of the 2015 Finance Committee are Annalisa Griffa (Italy), Karen Heywood (UK), and Toshio Yamagata (Japan) The Committee will report to the meeting under agenda item 8.3.

1.6 2016 Elections for SCOR Officers

The SCOR President and all three Vice-President positions are open for nominations for the 2016 elections. The Nominations Committee is chaired and organized by SCOR Past-President Wolfgang Fennel, who presented the rules and timetable. The committee members must be nominated members of SCOR. Fennel suggested Karen Heywood (UK) and David Halpern (USA), who both agreed to serve if asked. Meeting participants suggested asking a developing country scientist to be the other member and Dileep Kumar (India) agreed to serve. The committee membership was approved by meeting participants.¹

2.0 WORKING GROUPS

2.1 Current Working Groups

Presentations were made for each group by either a member of the working group or the SCOR Executive Committee Reporter for the group.

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

P.A. Lokabharathi, a Full Member of WG 135 from India, made the presentation. The group held three meetings: in Woods Hole, Massachusetts, USA on 23-24 Nov. 2009; Hangzhou, China on 10-11 October 2011; and Vienna, Austria on 29 April 2014. At the WG 135 meeting in Vienna, group members interacted with the broader scientific community on the contribution of vent system to ocean ecosystem and carbon cycles on different scales. WG 135 published its first article this year:

German, C.R., L.L. Legendre, S.G. Sander, N. Niquil, G.W. Luther III, L. Bharati, X. Han, and N. Le Bris. 2015. Hydrothermal Fe cycling and deep ocean organic carbon scavenging: Model-based evidence for significant POC supply to seafloor sediments. *Earth and Planetary Science Letters* 419:143-153.

Highlights from this paper include the following:

- The impact of submarine venting on the global ocean carbon cycle is modeled.
- The model uses Fe as currency to predict related cycling of organic carbon.
- Diffuse flow is an important source of Fe to dispersing hydrothermal plumes.
- There is no comparable flux of dissolved organic carbon to hydrothermal plumes.
- Scavenging from plumes may be important to supply particulate organic carbon to seafloor sediments.

The group's conceptual model used the major approximation that all hydrothermal fields are similar to the basalt-based vent sites at 9°N on the East Pacific Rise. This approximation does not represent the actual situation, but the group used it because this site is where our

¹It was later determined that Dileep Kumar was no longer eligible to serve on the Nominating Committee because he was no longer a Nominated Member. The SCOR Executive Committee approved Carmen Morales (Chile) as a member of the Nominating Committee.

understanding of the distributions of both iron and organic carbon, and the processes that control them, is most complete.

A second manuscript (focused on chemosynthetic productivity) is being finalized for submission in early to mid-2016. It would be helpful to keep the group active for another year and disband it at next year's SCOR meeting, after the paper is completed. This extension was approved.

The group was commended for using SCOR travel funds to help involve early career scientists from India in group meetings.

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

Nagappa Ramaiah, a Full Member of WG 137, made the presentation on behalf of the group. WG 137 met five times, four of the meetings with SCOR support, from Oct. 2010 to Nov. 2014. The group compiled data from more than 110 sites worldwide (see <http://wg137.net/>). In addition to this dataset, the group produced a special issue of *Estuarine, Coastal and Shelf Science*:

Klais, R., J.E. Cloern and P.J. Harrison. 2015. Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems. *Estuarine, Coastal and Shelf Science* 162:1-160.
<http://www.sciencedirect.com/science/journal/02727714/162>.

The data compiled from the group will contribute to the IOC International Group for Marine Ecological Time Series (IGMETS). IGMETS is an advocate for highlighting the importance of continued sampling by (and funding of) the existing marine time series that are needed for studying and understanding marine ecosystems in our changing world (<http://igmets.net/>). IOC has an interest in forming a Group of International Group on Phytoplankton: Climate Change and Global Trends of Phytoplankton in the Oceans, which will use the data sets compiled by WG 137. The work of WG 137 should also be useful for the GOOS Biology and Ecosystems Panel. There was a question about whether SCOR is acknowledged in the papers in the special issue. It was verified that the introductory article gives full credit to SCOR and its support with NSF funds. The group was officially disbanded.

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

P. Divakar Naidu, a Full Member of WG 138, made the presentation on behalf of the group. The purpose of the group is to synthesize knowledge and identify priority research related to planktic foraminifera, and to transfer knowledge to younger researchers. The group held three full meetings from August 2011 to September 2015. WG 138's final event was a workshop held on Catalina Island, California, USA on 30 August-4 September 2015. The meeting attracted 50 participants, including a large group of students from undergraduates to finishing PhDs. The abstract volume serves as a record from the meeting:

http://www.eforams.org/img_auth.php/e/ed/SCORWG138_Catalina_2nd_circular.pdf.

The talks were videotaped and will be available later.

The group continues to work on an eBook: <http://www.eforams.org/index.php/WG138:E-book>. The book will be open for contributions from the community from January 2016 onward. The book is being hosted by Copernicus Press. It will combine new items and reprints, and there will be no cost to SCOR.

A research plan has been proposed for a cruise in autumn 2017 on RV *Meteor*. The cruise will study horizontal and vertical patchiness of forams and their diel migrations. The cruise will look for symbiont presence and photophysiology, genetic diversity, species distribution and vertical habitats, ontogenetic migration and its geochemical signature, and lunar cyclicality. The group will attempt to find opportunities to continue the network developed through the group. The next opportunity for the community to meet will be at the Bathesva de Rothschild workshop on foraminifera culturing in Eilat, Israel in September 2016.

It was noted by meeting participants that this working group has so many practical activities that publicize SCOR among younger scientists, although there still needs to be more outreach in developing countries. Naidu noted that the group had trouble finding scientists from developing countries. It was asked why there were so few submissions to the eBook so far. Naidu responded that the other manuscripts will be submitted in March 2016.

Meeting participants approved disbanding the group when its eBook is completed.

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

Parthasarathi Chakraborty, an Associate Member of WG 139, made the presentation on behalf of the group. The group has had several achievements so far:

1. Developed a model to understand metal-dissolved organic carbon interaction in marine environments—A “multi-window” model has been developed to estimate and quantify natural organic ligands and their complexation capacity with biologically important trace metals (Fe, Co, Cu and Zn). The software is available on the SCOR WG 139 Web page (<http://neon.otago.ac.nz/research/scor/links.html>).
2. Summarized published results to develop a database and a speciation model—A review paper is underway and will be completed once the database are established. Databases for metal-binding ligand measurements are being compiled by several members of the working group for four key bioactive trace elements (Co, Cu, Fe and Zn). A review paper is being prepared and will be completed once the databases are established.
3. A special issue in *Marine Chemistry* has been published.
4. A large intercalibration exercise compared the interpretation techniques routinely used for determining ligand concentrations and conditional stability constants from titration data, with 15 participants using a simulated dataset. The results of this intercalibration were published in *Marine Chemistry* as part of the special issue.²
5. In April 2015, a highly successful two-day symposium was held in Sibenik, Croatia.
6. In April 2015, a highly successful two-day symposium was held in Sibenik, Croatia. Fifty-one people attended the symposium, including 24 students and post-doctoral fellows. Twenty of the attendees also participated in a training workshop held the day before the symposium (see [04-09_17-25-01_HRT4_Zupanijska panorama Zadar-Pizeta.avi](#)). Due to the success of the *Marine Chemistry* special issue and discussions at

²Sander, S., K. Buck and M. Lohan (eds.). 2015. SCOR WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean. *Marine Chemistry* 173:1-342, <http://www.sciencedirect.com/science/journal/03044203/173>

the final symposium, another special issue was initiated, in *Frontiers Marine Biogeochemistry* and the deadline for submissions to this issue is in December 2015. A total of 24 authors have confirmed their intention to contribute to this special issue.

One participant asked whether the group's term of reference related to publishing an article in *Eos* was fulfilled. Ed Urban verified that it was.³ Each working group is recommended to publish an *Eos* article to inform the community about the group and how to get involved. Another question was whether the software would be available after the working group was disbanded. Urban replied that such working group products are maintained indefinitely on the SCOR Web site.

Meeting participants agreed to continue the group for another year without funding.

2.1.5 WG 140: Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII)

An update was presented by Sergey Shapovalov, the SCOR Executive Committee Reporter for the group. He noted that the terms of reference are very ambitious. The main outcomes so far have been contributions to a database of Australian Antarctic Data Center and some review papers that have been published. Shapovalov noted that there is still a lot of work to do.

The annual meeting of WG 140 took place after the Gordon Research Conference on Polar Marine Sciences in Lucca, Tuscany, Italy on 20 March 2015. 26 members of the BEPSII network, representing 12 countries, attended the meeting. The major activity in the coming year will be the continued submission of papers to the *Elementa* Special Feature (<https://home.elementascience.org/special-features/biogeochemical-exchange-processes-at-sea-ice-interfaces-bepsii/>). Since both mechanistic review papers and modeling applications will be published in this Feature, it is regarded as the main product of WG 140. The group is discussing mechanisms to continue its work outside SCOR

Meeting participants approved continuing the group until next year's SCOR meeting, including funding for a 2016 meeting. The chairs need to be asked about the acknowledgements of SCOR in the papers in the special issue and to add a link to the data on the Web site.

2.1.6 WG 141 on Sea-Surface Microlayers

Peter Burkill, the SCOR Executive Committee Reporter for WG 141, presented a short summary of the group's status. The group met in China in October 2014 and held a very successful workshop for 50 students. The group published its best practices manual in 2014 to fulfill its first term of reference.⁴ The group held a workshop in 2015 in Germany and are working on a paper to provide a consensus definition of sea-surface microlayers.

The Schmidt Ocean Institute has approved approximately one month of ship time (tentatively 9 October-12 November 2016) for a cruise of the R/V *Falkor* by a team representing the working group and including students. The cruise will start in Darwin, Australia and finish in Guam. The focus of the cruise will be to study the role of the sea-

³Sander, S., K. Buck and M. Lohan (eds.). 2012. SCOR WG 139: Improving Understanding of Organic Metal-Binding Ligands in the Ocean. *Eos* 93(26):244.

⁴ http://scor-int.org/Publications/SCOR_GuideSeaSurface_2014.pdf

surface microlayer on air-sea interactions. The group plans to meet next in February 2016 in conjunction with the Ocean Sciences meeting in New Orleans, Louisiana (USA).

Funding was approved for a 2016 meeting of WG 141.

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

Wajih Naqvi, a Full Member of WG 142, presented a short summary of the group's status. The group met for the second time on 16-17 March 2015 in Brest, France. A major outcome of the meeting was a clear agreement among group members to prepare and publish a recommendation to the Argo community to implement an in-air measurement routine during float surfacings as an independent and reliable method to in-situ calibrate/correct oxygen optodes data from floats. Based on the evidence provided, such a quality control routine would remove any calibration biases, as well as drift issues, to an overall accuracy of approximately 1%, a tremendous improvement over the current situation. The group plans to inform the wider Argo and marine biogeochemistry community about this recommendation through an *Eos* article. WG 142 plans to meet next on 27 February 2016 in conjunction with the Ocean Sciences meeting in New Orleans, Louisiana (USA).

Meeting participants noted that the group is doing very well, but there is a focus on Argo and not on gliders, while this is in the title for this working group. It was suggested to bring the glider community into the discussion, as different issues are related to gliders. Karen Heywood offered to send information to Ed Urban to transmit to the group co-chairs.

Funding was approved for the group's 2016 meeting.

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

Herman Bange, one of the co-chairs of WG 143, made a presentation about the group's status. The group started in 2013 and held its second meeting on 4 September, at GEOMAR in Kiel, Germany. The group started with an intercalibration, and the results were rather variable. This stimulated a second intercalibration with standard gas mixtures. Thus, production of primary standard gas mixtures followed (with high and low concentrations); SCOR provided additional funding for the production of the standards. N₂O/CH₄ primary standard gas mixtures will be distributed to the labs of SCOR working group members by the beginning of 2016. All available data will be placed in the MOMENTO database.

It was agreed that additional samples should be taken from Boknis Eck (BE), as a coastal reference site. It was decided to have an intercomparison exercise for both discrete and underway measurements on 12-20 Oct. 2016. A total of 12 berths are available and ship time is already allocated. Prior to the second intercomparison, a method/best practice recommendation/guideline will be distributed to ensure that all participating labs are using the same equations, doing the same corrections, apply the same form of calibration curves, etc. A "toolbox" for dissolved N₂O/CH₄ concentration computations will be created, that can be used as a standard routine in Matlab (or other software packages), and perhaps a video showing best practice for N₂O/CH₄ sampling. The results of the intercalibration will be published in 2016.

In discussion, a question was raised about how to take care that the second intercalibration's results will not be disappointing. Bange replied that using the same gas mixtures will help reduce variation resulting from different gas mixtures. It was noted that the type of gas regulator used may cause variability. It was questioned whether microbes should be taken into account as they can be causing patchy sampling. Bange replied that samples are killed with HgCl₂, so microbes should not be a problem.

Funding was approved for WG 143's 2016 meeting.

2.1.9 WG 144 on Microbial Community Responses to Ocean Deoxygenation,

A presentation about WG 144 was made by Nagappa Ramaiah, a Full Member of the group. The working group started in 2013 and has done practical workshops in Canada (in 2014) and a meeting in Germany (in 2015) to codify best practices and compose a white paper.

The group's workshop at Saanich Inlet (Canada) in 2014 started the process of establishing a minimal core of technologies, techniques and standard operating procedures (SOPs) to enable compatible process rate and multi-molecular data collection for study of oxygen minimum zones (OMZs). These recommended techniques and SOPs should facilitate future cross-scale comparisons and time-series efforts that more accurately reflect in situ microbial community structure and functions, an important consideration for future numerical model development incorporating multi-molecular data. WG 144 held a workshop in Warnemünde, Germany on 30 August-3 September 2015, which aimed to summarize existing knowledge and to elaborate recommendations for best practices for assessing microbial communities and biogeochemical processes in OMZs.

The group is planning to meet in India in 2016 to compile an E-book in *Frontiers* or *PLoS*. In year 4, the group plans to organize a workshop in Chile to disseminate the best practices manual. The group's Web site provides information about oxygen-deficient waters (see <http://omz.microbiology.ubc.ca/>). The working group will catalyze research network formation and collaborative scientific practices over the group's four-year time frame that progressively transforms participants into a more focused and effective OMZ research community. Capacity building will be pursued through the group's meetings in India and Chile.

Funding was approved for the group's 2016 meeting.

2.1.10 WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)

Ed Urban made the presentation on behalf of WG 145, which was approved at the 2014 SCOR annual meeting. The group met for the first time in Šibenik, Croatia, on 12-13 April 2015, immediately following the closing symposium of WG 139. WG members have submitted 10 reviews of existing speciation calculation programs using a common questionnaire format focusing on the user interface. This material will be used to develop a first draft of desirable features in a "best practice" model, which will be discussed and refined at the WG's second meeting. The group is planning a variety of publications to announce its work and to encourage participation by the global ocean science community. The group is exploring possibilities for

funding to implement its Web-based tool. The group plans to meet next on 21 February 2016 in conjunction with the Ocean Sciences meeting in New Orleans, Louisiana (USA) and will hold a Town Hall session there in conjunction with WG 139.

Funding was approved for the group's 2016 meeting.

2.1.11 WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5)

Wajih Naqvi, the Executive Committee Reporter for WG 146, gave a brief presentation about the group's progress. WG 146 was approved at the 2014 SCOR annual meeting and met for the first time on 15-17 July 2015 at the Woods Hole Oceanographic Institution (USA). The group's overarching goal is to improve information available to scientists, students, and the public about radioactivity in the ocean. It will do this by enhancing existing databases and writing a peer-reviewed article to reach the scientific community, develop teaching materials and hold a training workshop to reach students, and seek funding to hold an international symposium on radionuclides in the ocean to bring together academic, nuclear industry, and national laboratory experts. The group is developing a series of e-lectures on 1) Radioactivity Basics, 2) Introduction to Radionuclides in Marine Systems, 3) Radionuclides as Tracers of Marine Processes, and 4) Impacts and Radioecology. It will hold its next meeting in Xiamen, China in conjunction with public lectures on ocean radioactivity topics on World Ocean Day (8 June 2016) and a short training course for Asian students and young scientists. The SCOR Committee on Capacity Building has approved support for developing country scientists to participate in the training course. Funding was approved for the group's 2016 meeting.

2.1.12 WG 147: Towards comparability of global oceanic nutrient data (COMPONUT)

Hema Naik, a Full Member of WG 147, made a brief presentation about the progress of WG 147. The group's first meeting took place in April 2015 in conjunction with the European Geosciences Union annual meeting. At the meeting, the terms of reference were refined and discussion took place regarding publishing nutrient data only when the measurements used reference materials. Group members checked which reference materials are available. Production of certified reference materials is underway. The group has arranged for the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) to sell nutrient certified reference materials (CRMs) at cost to get them out to the global community. WG 147 has distributed a questionnaire to determine the demand for these nutrient CRMs. The questionnaire can be found at http://www.scor-int.org/Working_Groups/Nutrient_CRM_Questionnaire.docx and the summary of the results is at http://www.scor-int.org/Working_Groups/WG_147_Questionnaire_Results.pdf. There were 67 replies to the questionnaire as of 30 October 2015. The group also plans to conduct training on best practices for nutrient measurements (including silicate) in 2017 at the Royal Netherlands Institute for Sea Research (NIOZ). The group will also rewrite the nutrient section of the GO-SHIP manual in 2016, led by Susan Becker from the Scripps Institution of Oceanography Nutrient facility to make the manual simpler and more user friendly. The results from the Global Nutrient Inter-comparison study will be published in 2016. (This study is fully open so everyone can see everyone else's results, a further incentive to improve.) Assessments for homogeneity and stability of some of the available CRMs from around the world, used in the 2015 intercomparison, are being conducted from the results from the exercise and the outcome of this will also be published. Discussions with data centers concluded that results should be submitted

without corrections, but that metadata including the CRMs results should be provided separately to allow corrections to be made later and to make it transparent. This is ongoing.

A future Global Intercomparison exercise is projected for 2016-2017, hopefully with the support of IOCCP. An at-sea intercalibration is planned for spring 2017 on board the RV *Investigator*, south of Tasmania. It is hoped that 10-12 labs with analyzers will be onboard.

The next WG 147 meeting will be held in September 2016, in Qingdao, China, in conjunction with the CLIVAR Open Science Conference, “Charting the course for climate and ocean research.”

Funding was approved for the group’s 2016 meeting.

2.2 Working Group Proposals

Peter Burkill presented the approach that would be used to determine which working group proposals would be approved. The process would balance the reviews of proposals received from national SCOR committees and others before the meeting with discussions conducted at the meeting:

- The SCOR Executive Committee member responsible for each proposal will provide a quick summary of each proposal.
- The reviews obtained from national SCOR committees and partner organizations before the meeting would be used to categorize the proposals in terms of their likelihood to be funded (those rated as “must fund” and “may fund” versus those rated as “do not fund”)
- Meeting participants will conduct a thorough evaluation of the 7 proposals in the “must fund” and “may fund” categories to determine which will be approved to start in 2016.
- Meeting participants will generate feedback on all 10 proposals. In the case of the approved proposals, the groups may be required to make some changes to the membership and/or terms of reference before the groups are approved. For the groups that were not approved, feedback will be given in case the proponents decide to resubmit their proposals in a later year.

After the quick reporting step, meeting participants agreed that three proposals would be ranked as “do not fund” and would be set aside until after the other 7 proposals had been discussed.

2.2.1 Towards a Global Comparison of Zooplankton Production: Measurement, Methodologies and Applications (ZooProd)

Ed Urban presented the proposal in place of Sun Song, who was unable to attend the meeting. A previous version of the proposal had been submitted in 2013 and was rated in the “do not fund” category. This year, the proposal was improved sufficiently to reach the “may fund” category. Most national SCOR committees acknowledge the importance of the topic, but opinions were mixed on the timeliness of the topic and its suitability for a SCOR working group. Both ICES and PICES are interested in zooplankton production, so it is not clear why they don’t handle the topic directly.

Discussion was started by Hal Batchelder from PICES. He stated that the idea for a SCOR working group on zooplankton production originated from a PICES workshop. The expertise for the group is largely outside PICES, so workshop participants thought that SCOR could handle such a group. Batchelder added that the predominance of proposed working group members from PICES and ICES nations does not match the original idea of a more geographically diverse group. New methods (indicators of activity) have been developed and it would be good to review them. The Indian SCOR committee stated that it is more important to assess for species-specific grazing rates and not bulk zooplankton production rates. The German SCOR Committee thought that there was too much focus on copepods. Hal Batchelder responded that copepods are responsible for more than 80% for secondary production in the ocean. Peter Burkill commented that protists are very important and not taken into account in this proposal. Either the project should include a broader range of zooplankton or the title should be narrowed to copepods. The Netherlands SCOR Committee placed the proposal in the “may fund” category. They found the project to be timely but not urgent. The subject is a priority for ocean sciences, but a PICES/ICES workshop may be more appropriate than a SCOR working group. The idea of a summer school as a capacity building approach was considered to be a good idea. The Italian SCOR Committee ranked the proposal in the “may fund” category, but the final goal is not focused enough. The Finnish SCOR Committee ranked the proposal in the “do not fund” category because the focus was not well enough defined and not enough detail was provided about the methods to be covered. ICES has been dealing with the zooplankton production issue for decades and has not solved it. The UK SCOR Committee liked the proposal enough to rank it in the “may fund” category, but had doubts about the breadth of the zooplankton groups that are included in the proposed work. IABO thought that the proposal was very timely and needed, but not strong enough to be funded this year. They also thought the proposal was quite disconnected with other large initiatives. The Japanese SCOR Committee thought that zooplankton productions is a very important topic, but that this proposal was not ready for approval.

Peter Burkill summarized the discussion. The proposal is very timely, but there was a general consensus that the huge diversity in taxonomy in zooplankton is missing from the proposal. The proposal was rated in the “may fund” category.

2.2.2 SEAmount Faunal vulnerability to impacts of Ocean Acidification and Mining (SEAFOAM)

Peter Burkill served as the monitor of this proposal for the SCOR Executive Committee. He stated that the review by national SCOR committees indicated that the timeliness of the proposal was acceptable, but that it was doubted that a SCOR working group would be the right approach. The proposal was rated as “do not fund” by most national SCOR committees. Because of this rating, discussion of the proposal was postponed until later in the meeting.

In the later discussion, it was noted that the proposal is not focused enough. SCOR is not the right organization to handle this topic. The International Seabed Authority would be much more appropriate. The terms of reference are too weak and the proposed membership is too much from the Northern Hemisphere. The proposal needs to connect the topics (acidification and deep sea) more clearly and justify why these two topics should be put together. The proposal is not strongly written, lacks clarity, and does not describe how the working group would advance the science.

2.2.3 BIOgeochemistry of COral REef systems (BIOCORE)

Corina Brussaard served as the monitor of this proposal for the SCOR Executive Committee. Reviews by national SCOR committees placed this proposal into the “do not fund” category. Most reviewers had doubts whether a SCOR working group would be a good way to approach the issue and wondered why the well-organized community could not conduct this work on its own. The terms of reference were too general and vague. There were few comments on membership. The capacity building activities proposed are mostly communication, with little training. Because of the “do not fund” rating, discussion of the proposal was postponed until later in the meeting.

In the later discussion, the participants concluded that a stronger case needs to be made why a SCOR working group is an appropriate mechanism to deal with this issue. Coral reefs are such an obvious topic for capacity building that a more imaginative plan should be presented. The proposed work of the group should be connected more with IOC and other organizations.

2.2.4 Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?

Patricia Miloslavich served as the monitor of this proposal for the SCOR Executive Committee, as a representative from IABO. The group would seek to improve understanding about how to move from experiments on single organisms to ecosystem and global levels. Miloslavich noted that the original version of this proposal was submitted for the 2013 SCOR meeting. The proposal was rated as a “do not fund” at that meeting. The proposal was improved and re-submitted. Most national SCOR Committees rated the proposal in the “must fund” category. It is expected to produce new standardized methods. The topic is timely and the multi-theme approach is appropriate. The group would produce a “best practices” guide to help standardize methods. The topic connects to current policy issues and the proposed membership is excellent.

Reviewers did note some weaknesses in the proposal. Some national committees thought that the work would be done anyway even without a SCOR working group and the proposed membership has too many senior scientists. The project is rather ambitious, lacks priorities, and is not totally innovative. Modeling should be included and the group may need to secure funding beyond the life of the SCOR working group.

The Brazilian SCOR Committee rated the proposal in the “must fund” category. They found the proposal to be well organized, very strong and with very focused terms of reference. A SCOR working group would be a perfect way to address the issue of multiple interacting global change impacts on marine organisms. The capacity building plans are well laid out. The Japanese SCOR Committee rated the proposal as “must fund” because understanding of ecosystem responses to multiple stressors is an important approach to an urgent issue. This topic is very relevant for developing countries and SCOR leadership could be helpful. The German SCOR Committee ranked the proposal in the “must fund” category, but had some concerns about the ambitious terms of reference, which should be prioritized according to those which are most important and most achievable within the life span of a SCOR working group. The Indian SCOR Committee noted that ecosystem responses have been observed in long-term time series, but it was not clear in the proposal if the working group would use such time series or new field work. IAPSO rated the proposal as a “may fund”, as there is a need for this kind of group, but it is not

clear if a SCOR working group is the right approach. IAPSO noted that the terms of reference seem to be more focused on research themes and only the third one is relevant for a working group. It would be better to have a session at a scientific meeting to raise awareness. The Italian SCOR Committee thought the proposal was good, but were concerned that it was too ambitious for a working group and wondered how effective a working group would be. The UK SCOR Committee agreed with the Italian SCOR Committee, that the terms of reference should be made less ambitious. The Finnish SCOR Committee rated the proposal as a “must fund” because of the timeliness and importance of this issue and the use of an interdisciplinary approach. SCOR would benefit by funding this group because of the international visibility that would be gained. The Netherlands SCOR committee believes this is a timely topic, but it discussed at length whether a SCOR working group is the right mechanism, since general awareness of the issue is already high. A product would get SCOR’s name on the product, but the group could achieve the planned work without SCOR (they have the funds, the name and the connections). The group’s tasks are ambitious and needs prioritizing. Their capacity building plans are good, but more junior members are needed for the group. PICES ranked the proposal as “may fund” because it is timely, but they agree that it is too broad and ambitious. The proposal is lacking some details, such as how they will achieve what they have proposed. The PICES rating would be increased to “must fund” if these issues can be addressed.

Peter Burkill summarized the discussion. The proposal was highly ranked, because of its timeliness and relevance. However, it is too ambitious and the proponents must prioritize and add modelling. The membership would be improved by including a few more early-career scientists and scientists from developing countries. Wajih Naqvi suggested a member from India and it was suggested that Sam Dupont should be moved from an Associate Member to Full Member, if he is interested in such a change.

2.2.5 A Functional Trait Perspective on the Biodiversity of Hydrothermal Vent Communities (FDvent)

Peter Burkill, the SCOR Executive Committee Monitor for the proposal, provided a quick overview of the proposal and a summary of comments from national SCOR committees. National committees varied in their opinions about the timeliness of the project, ranging from believing that the project is premature to feeling that it would answer a pressing need. The activity is critical to management, but there was mixed opinion about whether a SCOR working group would be a good mechanism. There was general agreement that the terms of reference are ambitious. The open data policy was appreciated. In terms of rankings, they were split between “may fund” and “do not fund”. The geographic and gender balance of the proposed Full Members of the working group members is good, although the proposed Associate Members are all from the Northern Hemisphere. The capacity building plan is good, but needs more specifics.

The German SCOR Committee ranked the proposal as “do not fund” because it is more of a science project than a SCOR working group and mining is not going to happen at the scale described. If SCOR did fund the group, it should include a member from China, as it is one of the only countries expected to do mining. Venu Ittekkot thought the proposal very timely, with the potential to attract small-island countries and collaborations with other organizations. IAPSO rated the proposal as “do not fund”. The Italian SCOR Committee did not rank the proposal very highly because the description the group’s tasks was not specific enough. The UK SCOR

Committee ranked the proposal as a “must fund” because it is very timely and would have high impact, but also thought there should be Chinese and Korean members. IABO rated the proposal as “may fund” because topic is very interesting, and timely in context of future exploration. There is a concern that vent knowledge is patchy and should be tied together better globally. The membership is overrepresented by developed countries. The Netherlands SCOR Committee thought that the proposal was timely and the topic needs discussion. SCOR could help raise awareness of the issue, but perhaps not through a SCOR working group. The proposal already uses a workshop model, which might be funded outside a working group structure. The Brazilian SCOR Committee rated the proposal as “do not fund” without better justification in the proposal. The Japanese SCOR Committee rated the proposal as “may fund”, also stating that the proposal needs better justification.

Peter Burkill summarized that the issues raised by the proposal are timely, because vent systems are not well known. However, the usefulness of the SCOR working group approach to handle this topic is doubtful. The proposed membership is good, but should include members from China and Korea. The proposal might be good for a different sort of activity, perhaps carried out by the SCOR Committee on Capacity Building and involving small-island states. The International Sea Bed Authority should be involved, as they need input from the scientific community on these issues. However, the consensus is that this proposal should not be funded as a SCOR working group.

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

Wolfgang Fennel, the monitor for the proposal, provided a quick summary report. He noted that this is a resubmission from two years ago. The proposal was rated as a “do not fund” at that time. The proposal was again rated in the “do not fund” category. Many national SCOR committees thought that this is a specialized topic and its importance was not clear enough. It was also not clear that a SCOR working group would be a good approach for this topic. The terms of reference are designed to produce a community, not a product.

The scientific topic is very interesting and brings together different disciplines. In detailed discussion, it was noted that science questions are not identified. The proposal lacks focus and there is a need for better terms of reference; for example, holding kick-off and finalization meetings are not appropriate terms of reference. The capacity building approaches could be improved, for example, by holding a methods workshop for young researchers, particularly those from developing countries.

2.2.7 Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)

Denise Smythe-Wright, the monitor for the proposal, provided a quick report. Most comments from national SCOR committees were very positive, noting that the topic is timely and the methods are becoming more available.

National SCOR committees generally ranked the proposal in the “must fund” category, with mostly positive comments. The activity is timely, although some of the terms of reference, particularly the first three, could be combined. Reference to other methods should be included. The Associate Membership is more orientated to the Northern Hemisphere. The proposal has a

good focus on capacity building, including a summer school, develop and public repository. The proposal describes a summer school and training courses could help in the use of new methods and instruments.

The UK SCOR Committee ranked the proposal as “do not fund” because they thought it was premature, too much like a research project, and relies too much on UK cruises, which may not be funded. (It was learned later in the meeting that the cruise has been funded.) The Italian SCOR Committee ranked the proposal as “must fund” because it is timely and important. However, the proposal could be improved by adding other equipment/expertise and improving the membership. IAPSO ranked the proposal in the “must fund” category. The German SCOR Committee ranked the proposal in the “must fund” category, with only one comment, that expertise on near-bottom sedimentation should be added. The Finnish SCOR Committee rated the proposal as a “may fund”, as the topic is important, but it was not clear whether this group would be able to expand expertise in this area, since there is a lot of expertise around and a huge data set (e.g., from the Baltic Sea) showing that high resolution is needed. At least one member should come from the Baltic Sea community. The Netherlands SCOR Committee ranked the proposal in the “may fund” category because the topic is timely and it would be good to bring together specialists and expand possibilities using optic techniques. However, the focus of the proposal could be improved. The composition and speed of the sinking particles (carbon flux) is very important to achieve a more global approach. How is this topic related to the microbial carbon pump (SCOR WG 134)? The Japanese SCOR Committee rated this proposal in the “may fund” category because it is not clear how these methods will answer the overall question. There needs to be a comparison with existing methods. More members from developing countries are needed and should be added from the start. The proposal is premature. IABO ranked the proposal as “do not fund” because it is not a high priority for ocean science or SCOR, and the membership is unbalanced. The working plan is good, but not appropriate for SCOR. The Brazilian SCOR Committee ranked the proposal as “do not fund”. The Russian SCOR Committee ranked the proposal as “must fund” because it is very timely and a high priority for SCOR.

Since many of the “must fund” rankings were provided by countries not represented at the meeting, Ed Urban summarized comments from countries not present. The Australian SCOR Committee thought the proposal was timely and that a SCOR working group would be an effective mechanism to obtain data sets. The Canadian SCOR Committee ranked the proposal as a “must fund”, but one member thought the idea was premature for a working group and that the terms of reference need work. The Korean SCOR Committee thought that the product was interesting and was overall positive about the proposal. The South African Committee thought that the activity is a priority and that a SCOR working group would help obtain key parameters. The U.S. SCOR Committee ranked the proposal in the “may fund” category.

Peter Burkill summarized that it seems that the proposal is more toward the bottom end of the “must fund” category. There were a variety of views about the timeliness of the activity, although a SCOR working group seems like a good approach. The proposed membership is good in terms of gender and age balance, but should have more developing country involvement. The terms of reference are acceptable.

2.2.8 Global Assessment of Nutrient Export Through Submarine Groundwater Discharge (NExT SGD)

Wajih Naqvi, the SCOR Executive Committee Monitor for the proposal, provided a quick summary of comments from national SCOR committees. The geographic balance of the proposed membership was considered good, as was the timeliness. Some national SCOR committees thought that the proposed activities were more of a science project than for typical SCOR working group, that it was not clear how the work done previously was different from what the group would do, and that the group's terms of reference were too ambitious. The rankings were equally divided among "must fund", "may fund", and "do not fund".

Naqvi noted that most of the national committees that supported the proposal had done a thorough review, while those national committees that rated the proposal in the "do not fund" category had not done a thorough review. The topic is important and timely, and high priority. However, the terms of reference are perhaps too ambitious and the activities more of a science project than suitable for a SCOR working group. The proposed membership is not balanced.

The German SCOR Committee rated the proposal as "may fund" because it is more of a research project than a SCOR working group, the membership needs to be improved, and the capacity building plan could be better developed. They did not think all the meetings should be held in one location, in Alabama. IAPSO rated the proposal in the "do not fund" category because they already had a Commission on Groundwater Seawater Interactions. IAPSO discussed the proposal at length, but wondered how this working group would advance the topic. The UK SCOR Committee ranked the proposal as "must fund" because the magnitude of groundwater inputs to the ocean is not well understood yet, the group is timely, and the terms of reference are clear. If approved, the working group should link to the UNESCO International Hydrological Program. The Netherlands SCOR Committee thought the proposal was very timely. Even though this is not an open-ocean topic, it would result in important knowledge for understanding marine system dynamics. SCOR working groups are a good means to enhance awareness. The terms of reference should be improved by including the scientific papers and model. It was not clear from the proposal how the database will be maintained after the group ends. The Brazilian SCOR Committee ranked the proposal in the "may fund" category. It is a good idea, but the methodology could be more developed and described more specifically in the proposal. The Italian SCOR Committee rated the proposal as "do not fund" because it seems more appropriate for science development and it is included in other projects. The Japanese SCOR Committee ranked the proposal as "may fund" because it is an important issue, but outcomes are not very clear. The database would be limited to coastal areas and thus might not be sufficient for modelling.

Peter Burkill summarized the comments from national SCOR committees. The proposal is very timely, of high priority, and with strong connection with IAPSO work. There was some feeling that the activity described is more of a research project than a SCOR working group. The first term of reference was too ambitious, but the others were OK, with the exception that modeling should be included in the terms of reference. The proposal should also specify how the database will be sustained after group has finished its work. The capacity building plan should be strengthened. The proposal is too U.S.-orientated (2 Full Members, 3 Associate Members and 3 meetings in United States).

2.2.9 International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)

John Turner provided a quick summary of comments from national SCOR committees. There was a range of comments, but most national committees thought that the proposal was timely, with a clear work plan, feasible terms of reference, and an appropriate membership proposed. A few national committees thought the proposal could be clearer and doubted whether the subject was within SCOR's realm. The group has a good plan for outreach. Most national committees rated the proposal as a "must fund".

There was some discussion about whether the project was too big for a SCOR working group and why the World Ocean Database was not undertaking such a project. Accurately reconstructing the historical database will be difficult. Other organizations should be involved.

The Japanese SCOR Committee strongly supported the proposal, rating it a "must fund", given the need for better understanding of global climate warming. They suggested focusing first on temperature alone and thereafter salinity and dissolved oxygen could be included. IAPSO ranked the proposal as a "must fund", but with strong differences within IAPSO as to whether there are other organizations who do this already. But, in the end it was decided that this would be a good topic for a SCOR working group, involving related groups if the proposal is approved. The Italian SCOR Committee also ranked the proposal as "must fund" as this is a mature scientific problem and there is a great need for standardization. The UK SCOR Committee rated the proposal as "may fund", because although it is timely, it is less exciting than other project ideas. However, this is within SCOR realm and a SCOR working group could be useful on this topic. Support of CLIVAR and IAPSO is essential. The capacity building plan is rather weak. Karen Heywood noted that temperature profiles collected by marine mammals in the Southern Ocean generate a lot of data that should be included. And the project should be funded in conjunction with other groups. The Russian SCOR Committee ranked the proposal as a "must fund", because it is important to have quality control of such large data sets. The Finnish SCOR Committee ranked the proposal as "may fund". It is timely and high priority, but in its present form is not well enough linked to the World Ocean Database. And brackish sea areas (e.g., the Baltic) should be included. How would the project relate to quality control of existing databases? The Netherlands SCOR Committee ranked the project as "may fund". It is timely and it is relevant to keep historical data. Why it is not taking place in, for example, by the World Ocean Database, should be addressed. The plan for knowledge dissemination could be improved. Co-funding the group with IAPSO would be good. The German SCOR Committee ranked the proposal as "must fund" because it is important to have historical data organized. Perhaps IOC could co-fund the group.

Peter Burkill summarized that this proposal is very timely because of the importance of establishing historical data baselines. The membership balance and capacity building plans are acceptable. No one spoke against the proposal. Temperature data collected by marine mammals should be included, if the data are high enough quality in temperature and depth to match other data. IAPSO, CLIVAR, and other organizations and projects should be involved (and hopefully even co-fund) the group.

2.2.10 The dynamic ecogeomorphic evolution of mangrove and salt marsh coastlines (DEMASCO)

Patricia Miloslavich presented a summary of the comments from national SCOR committees. In terms of the proposal's strengths, the membership is well balanced in terms of expertise, gender and age; the work is timely; and of high priority. The results of the group would be important for policymakers. On the negative side, the terms of reference and capacity building plans seem vague. The impact of the group's work on ocean science, SCOR's priority, is low. Capacity building is important for this topic as many of the mangrove coastlines in developing countries. Few countries ranked the proposal as a "must fund". South American mangrove and saltmarshes are not acknowledged in the proposal and the membership lacks biogeochemists.

The Japanese SCOR Committee ranked the proposal as "must fund" because the topic is very timely and even urgent. The proposal includes a well-designed plan and the Japanese committee would like to be involved if the proposal is approved. The Netherlands SCOR Committee agreed that topic is very timely and very urgent, but the proposal is not up to the quality needed for a SCOR working group. More focus and connection of mangroves to salt marshes would be better, for example, than the proposed connection to kelp forests. The terms of reference need improvement. The membership is not a good representation of scientists working on mangroves worldwide. The UK SCOR Committee agreed fully with these comments. The Italian SCOR Committee ranked the proposal in the "do not fund" category, despite this being an important topic. The proposal was not well developed and membership could be improved. The Brazilian SCOR Committee ranked the proposal in the "may fund" category. IAPSO thought that the proposal did not make a strong case for the importance of the topic and of SCOR funding. The German SCOR Committee ranked the proposal in the "do not fund" category because the proposal did not present a good case for funding. Membership from developing countries should be increased.

Peter Burkill summarized that this proposal dealt with a hugely important topic that is timely in having relevance to global climate change. However, the proposal did not present a global perspective and the work was not well justified from a scientific perspective. The terms of reference were not well written. The proposed members are experienced and the membership reasonably balanced in terms of gender and geography, but more developing countries should be included. The overall ranking puts the proposal at the bottom of the "may fund" category.

Meeting participants decided to approve the following three proposals:

1. Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?
2. Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)
3. International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)

3.0 LARGE-SCALE SCIENTIFIC PROGRAMS

SCOR currently sponsors six large-scale research projects; five 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. The SCOR Secretariat oversees the use of grant funds provided to the projects. SCOR uses solely grant funds for GEOHAB, IMBER, SOLAS, and GEOTRACES, but is providing SCOR support for IQOE and IIOE-2 until they are self-supporting.

3.1 IOC/SCOR Global Ecology and Oceanography of Harmful Algal Blooms and GlobalHAB Program

Ed Urban combined presentations about GEOHAB and its successor, GlobalHAB. GEOHAB was an international project designed to encourage comparative research among specific ecosystem types worldwide, including upwelling systems, eutrophied systems, stratified systems, and fjords and coastal embayments. GEOHAB identified that understanding of the oceanographic controls on benthic HABs is an important knowledge gap and developed a science plan to address this area of research. GEOHAB also advanced techniques for observing and modeling HABs. GEOHAB produced 10 science plans and other project reports, and several special issues of peer-reviewed journals. GEOHAB co-sponsored a workshop on climate change and HABs in 2014.

GEOHAB continues to complete various synthesis products, including a final special issue and a summary for policymakers. The special issue will appear in *Oceanography* magazine in 2017 (there is a backlog of special issues). An ongoing project between GEOHAB and IOCCG, on applications of remote sensing to HAB detection will result in a monograph by the end of 2016. Detection by remote sensing is rarely to the species level and this monograph will give a reality check of what is possible. GEOHAB has been co-sponsored by SCOR and IOC for 10 years since the completion of the GEOHAB Implementation Plan.

GEOHAB held an open science meeting April 2013, which developed ideas for synthesis products, but also developed an idea for a new project called GlobalHAB, which will include more human health and ecosystem service aspects. GlobalHAB will not be a research project, but will focus more on what GEOHAB called "framework activities." GlobalHAB will also have a broader scope by including brackish and fresh waters. The U.S. National Science Foundation has committed US\$90,000 for three years and IOC will provide additional support. The GlobalHAB Scientific Steering Committee has been approved by IOC and SCOR, and will meet for the first time in March 2016. GlobalHAB will establish liaisons with relevant groups (e.g. ICES, PICES, and the International Society for the Study of Harmful Algae).

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

The SCOR Executive Committee Reporter for IMBER, Peter Burkill, introduced Eileen Hofmann, the IMBER SSC Chair, who made the presentation remotely. 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 of the project. The IMBER SSC met in Santa Cruz, California in June 2015 and will meet next in New Orleans, Louisiana, USA on 19-21 February 2016, in conjunction with the Ocean Sciences 2016 meeting. Carol Robinson (UK) has been approved by SCOR and IGBP as the incoming chair of the IMBER SSC.

Hofmann showed a map of IMBER national contacts, Regional Programs, and endorsed projects. There are currently 50 projects endorsed by IMBER. Regional programs focus on the subarctic and Arctic (Ecosystem Studies of Sub-arctic Seas), the Indian Ocean (Sustained Indian Ocean Biogeochemistry and Ecosystem Research), the tropics (Climate Impacts on Top Predators), and the Southern Ocean (Integrating Climate and Ecosystem Dynamics). IMBER has working groups on carbon research, human dimensions, continental margins, data management, and capacity building, as well as a new group on upwelling systems.

The next IMBER summer school, CLIMECO5, will be held in August 2016 in Natal, Brazil. The topic will be “Towards More Resilient Oceans: Predicting and Projecting Future Changes in the Ocean and their Impacts on Human Societies.” Funding will be provided by SCOR for students and scientists from developing scientists to attend the summer school.

Some key activities of the past year include the following:

- 10th ESSAS Annual Science Meeting on 15-17 June 2015 in Seattle, Washington, USA
- 3rd CLIOTOP Symposium on 14-18 September 2015 in San Sebastian, Spain
- 4th IMBER Imbizo open science meeting on 26-30 October 2015 in Trieste, Italy (see <http://www.imber.info/index.php/Meetings/IMBIZO/IMBIZO-IV>).

The Imbizo featured four concurrent workshops, focused on the following topics:

1. Marine ecosystem-based governance: Fill gaps between traditional science advice for hierarchical management and more bottom-up, user group-produced knowledge
2. Upwelling ecosystems as models for interdisciplinary global change studies: Identify key scientific gaps, how to fill these, and their link to societal needs
3. Integrated modelling to support marine socio-ecological systems under global change: Role of marine social-ecological models in a time of rapid change and development of conceptual integrative frameworks
4. Regime shifts – evaluating socio-ecological implications: Social-ecological system approach to enable applied outcomes

The groups are planning high-level synthesis papers. The overall result of Imbizo IV was the development of understanding and approaches to integrate diverse knowledge/research outcomes of marine systems to mobilize governance agencies and society towards sustainability.

The IMBER Human Dimensions Working Group published a paper in the journal *Fish & Fisheries* on a decision support tool for changes in marine systems. IMBER contributed a paper to the IGBP legacy special issue in the journal *Anthropocene*. IMBER sessions at the fall 2015 AGU Meeting will contribute to the IGBP celebration there.

The new IMBER Science Plan and Implementation Strategy 2016-2025 was submitted to SCOR and Future Earth in November 2015 for joint review. IMBER's new vision is "Ocean sustainability under global change for the benefit of society". IMBER's new research goal is "To understand, quantify and compare historic and present structure and functioning of linked ocean and human systems to predict and project changes including developing scenarios and options for securing or transitioning towards ocean sustainability." The IMBER Science Plan and Implementation Strategy includes three Grand Challenges:

- Grand Challenge 1: Understanding and quantifying marine ecosystems
- Grand Challenge 2: Developing scenarios and projections of future marine and human systems at multiple scales
- Grand Challenge 3: Improving and integrating human-ocean-human interactions

and four Innovation Challenges

- Innovation Challenge 1: Understanding the role of genetic and evolutionary processes
- Innovation Challenge 2: Contributions to a global ocean ecosystem observational, modelling and data management network
- Innovation Challenge 3: Understanding of ecological feedbacks in the Earth System
- Innovation Challenge 4: Using social science data for ocean management, decision making and policy development

IMBER expects recognition of the need for basic ocean research and support for regional programs, working groups and other activities. IMBER's next steps include the following:

- Joint SCOR-Future Earth review of the IMBER Science Plan and Implementation Strategy
- Request to SCOR for a 10-year continuation
- Request to become a core project of Future Earth (submitted November 2015)
- Carol Robinson (UEA) takes over as IMBER Chair in January 2016

A meeting participant asked if anything had been dropped from the old IMBER. Eileen Hofmann answered that nothing will be eliminated, but some aspects will be added.

3.3 GEOTRACES

Wajih Naqvi, the Executive Committee Reporter for GEOTRACES, introduced Sunil Singh, the leader of the Indian GEOTRACES program. Singh provided a brief overview of 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. The GEOTRACES SSC is co-chaired by Ed Boyle (USA) and Reiner Schlitzer (Germany). Scientists from approximately 35 nations have been involved in the program, which is designed to study all major ocean basins over the next decade. The first GEOTRACES Intermediate Data Product (IDP2014) was released in February 2014 at Ocean Sciences Meeting 2014 in Honolulu, Hawaii. The IDP2014 has received a digital object identifier (DOI) through a publication that appeared in *Marine Chemistry*.⁵ IDP2014 consists of two parts: (1) a Digital Data Package (available at www.bodc.ac.uk/geotraces/data/idp2014/) and (2) the eGEOTRACES Electronic Atlas (available at www.egeotraces.org). GEOTRACES has released a timeline for data submission and quality control for the 2017 GEOTRACES Intermediate Data Product (<http://www.geotraces.org/dp/intermediate-data-product-2017>), which will be released at the Goldschmidt Conference in Paris, France on 13-18 August 2017.

So far, 29 GEOTRACES cruises, 30 GEOTRACES process studies, and 11 cruises as part of the International Polar Year have been completed. (GEOTRACES process studies investigate a particular process relevant to the cycling of trace metal and isotopes and usually do not measure the full suite of elements required for a GEOTRACES section cruise.) Canada, Germany, and the United States ran cruises in the Arctic Ocean this summer. Germany also carried out a section cruise in the Atlantic Ocean and Australia, Germany, Japan, Netherlands, and United Kingdom are carrying out GEOTRACES process studies in various basins in the coming year.

GEOTRACES activities have resulted in 576 peer-reviewed papers so far, including the following five published in the *Nature* journals in the past year, for which Singh presented scientific highlights:

- Field Data Constrain Ocean Mercury Budget: Lamborg, C.H., Hammerschmidt, C.R., Bowman, K.L., Swarr, G.J., Munson, K.M., Ohnemus, D.C., Lam P.J., Heimbürger L-E., Rijkenberg, M., and Saito, M.A. 2014. A global ocean inventory of anthropogenic mercury based on water column measurements. *Nature* 512(7512):65–68. doi:10.1038/nature13563
- Seasonal Iron Supply in the Southern Ocean is Dominated by Winter Mixing: Tagliabue, A., Sallée, J.-B., Bowie, A.R., Lévy, M., Swart, S., and Boyd, P.W. 2014. Surface-water iron supplies in the Southern Ocean sustained by deep winter mixing. *Nature Geoscience* 7(4):314–320. doi:10.1038/ngeo2101
- What Controls the Copper Isotopic Composition in Oceanic Waters?: Takano, S., Tanimizu, M., Hirata, T., and Sohrin, Y. 2014. Isotopic constraints on biogeochemical cycling of copper in the ocean. *Nature Communications* 5:5663. doi:10.1038/ncomms6663
- Coupling Rare Earth Elements Concentrations, Neodymium And Radium Isotopes: A Powerful Tool to Decode Environmental Processes: Rousseau, T.C.C., Sonke, J.E., Chmeleff, J., Beek, P. van, Souhaut, M., Boaventura, G., Seyler, P., and Jeandel, C. 2015. Rapid neodymium release to marine waters from lithogenic sediments in the Amazon estuary. *Nature Communications* 6:7592. doi:10.1038/ncomms8592.

⁵Mawji, E. et al., 2015. The GEOTRACES Intermediate Data Product 2014, *Marine Chemistry* 177:1-8; <http://dx.doi.org/10.1016/j.marchem.2015.04.005>.

- Unexpected Magnitude of the Hydrothermal Iron Inputs in the Deep Pacific: Resing, J.A., Sedwick, P.N., German, C.R., Jenkins, W.J., Moffett, J.W., Sohst, B.M., and Tagliabue, A. 2015. Basin-scale transport of hydrothermal dissolved metals across the South Pacific Ocean. *Nature* 523(7559):200–203. doi:10.1038/nature14577

In addition to these publications, GEOTRACES has produced several special issues of peer-reviewed journals.

GEOTRACES is beginning mid-term project synthesis activities with an open meeting at the Royal Society in London (<https://royalsociety.org/events/2015/12/ocean-chemistry/>) on 7-8 Dec. 2015 and a smaller meeting following at Chicheley Hall (<https://royalsociety.org/events/2015/12/trace-metal-cycling/>) on 9-10 Dec. 2015. A second synthesis activity will be the joint GEOTRACES-Ocean Carbon and Biogeochemistry (OCB) program Workshop in August 2016. Finally, GEOTRACES is exploring partnership with the Past Global Changes project (PAGES) for a joint workshop in 2017.

GEOTRACES has pursued a variety of outreach activities, including cruise blogs, YouTube videos, podcasts, press releases, cartoons, a GEOTRACES eNewsletter, teachers at sea, educational initiatives, posters, brochures, and Webinars. All of these outreach products are available on a dedicated outreach Web site (<http://www.geotraces.org/outreach>).

Sunil Singh presented an update of the Indian GEOTRACES program, both its technological investments and the results from some cruises.

The question was raised about the lack of mention of SCOR in GEOTRACES publications. It was noted that SCOR does not acknowledge its parent, the International Council on Science, in most SCOR publications either. SCOR is particularly concerned that SCOR is mentioned in GEOTRACES publications that result from SCOR funding, not in publications resulting from national funding.

3.4 SCOR/Future Earth/WCRP/iCACGP Surface Ocean – Lower Atmosphere Study (SOLAS)

John Turner, the SCOR Executive Committee Reporter for SOLAS, introduced V.V.S.S. Sarma, a member of the SOLAS Scientific Steering Committee to provide an update about SOLAS. SOLAS is nearing the end of its first 10 years as a research project. SOLAS had a paper in the special issue of the journal *Anthropocene* on IGBP. The paper outlines a brief history of SOLAS, reports on five selected major achievements of the project and its contribution toward Earth System science, and presents the future plans of SOLAS.

After two years of planning and multiple consultations, a complete draft of the Science Plan for SOLAS 2015-2025 was finalized and submitted to the SOLAS scientific sponsors in December 2014. A draft is available on the SOLAS Web site. Eight reviews were received in June 2015 and are currently being addressed. The reviews were very positive. A revised version is scheduled to be submitted to sponsors in December 2015. Phase II of SOLAS will include five core 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 marine ecosystems
5. Ocean biogeochemical controls on atmospheric chemistry

The future SOLAS program will include integrated topics among the five core themes, activities on SOLAS science and society, and SOLAS research into environment impacts of geoengineering.

SOLAS is continuing the process of adding Future Earth as a co-sponsor. SOLAS sent its “transition statement” to Future Earth in Nov. 2014, reviews were received in April 2015, and a revised version was sent back to Future Earth in May 2015. In Sept. 2015, SOLAS and Future Earth signed a Memorandum of Understanding. SOLAS is engaging with Future Earth via various routes (monthly webinars, contributing to consultations, shaping the Knowledge Action Network- Oceans, organizing sessions at the SOLAS OSC15 on SOLAS science and society, preparing a workshop on 2-3 topics for 2016, etc.).

In terms of communications, a SOLAS 2015-2025 flyer was produced and released at the SOLAS Open Science Conference in Sept. 2015. The annual SOLAS Newsletter and bimonthly ebulletins are circulated to a mailing list of more than 2,200 individuals. The SOLAS Web site has been designed to be smart phone-friendly.

SOLAS held an Open Science Conference (OSC) on 7-11 Sept. 2015 in Kiel, Germany. The OSC attracted 270 participants from 35 nations. There were three side events and a workshop for early-career scientists. Eleven participants from developing countries were partially supported by SCOR travel funding. The OSC program was available through a smartphone app. The OSC featured 31 plenary talks (including 16 from early-career scientists), 11 discussion sessions, and 200 posters.

The SOLAS International Project Office will be hosted until Dec. 2020 at GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany. GEOMAR is supporting the salary of the SOLAS Executive Officer. However, no funding has been secured yet to maintain the second staff person of the IPO. As of February 2016, the IPO will lose 50% of its staff, which will reduce the ability of the IPO to support SOLAS Open Science Conferences and Summer Schools.

3.5 SCOR/POGO International Quiet Ocean Experiment (IQOE)

Ed Urban reported that the IQOE Science Plan has been printed and released by SCOR and Partnership for Observation of the Global Oceans (POGO). The document is available in printed and electronic formats.

[Tyack, P., G. Frisk, I. Boyd, E. Urban, and S. Seeyave \(eds.\). 2015. International Quiet Ocean Experiment Science Plan.](#)

Editors and sponsors met in July in Woods Hole, Massachusetts (USA) to discuss implementation steps and formation of a Steering Committee for the project. An important initial task for the project will be to locate datasets on ambient sound in the ocean and determine how the data can be used to help meet project goals. Potential members of the IQOE Science Committee are being approached now and a nomination memo is being prepared for approval by the SCOR and POGO Executive Committees.

There has not previously been international coordination of research on ocean acoustics or the effects of ocean noise on marine organisms. Low-frequency sound can travel great distances and the increase in this noise may cause chronic effects on marine organisms. Many national regulations have been formed based on little information, so the regulations have purposely been made precautionary. IQOE resulted from an exploratory workshop and open science meeting funded by the Alfred P. Sloan Foundation. A science plan was written, based on output from the open science meeting. The project will raise funding for international planning and coordination, but participating scientists will have to find funding nationally for their research. The project includes four fundamental questions:

- (1) How have human activities contributed to global ocean soundscapes over time?
- (2) What are current levels, timing and distribution of human-made sound in the oceans?
- (3) What are the trends in human-made sound levels across global oceans?
- (4) What are the current and potential effects of anthropogenic sound on important marine animal populations' viability?

The project will start by doing some data rescue (e.g., navy data) to establish historic sound levels, will seek to get passive acoustics included in ocean observing systems, perform standardization activities, set up management for project data, develop the area of soundscape modelling, conduct regional experiments, estimate economic consequences of sound in the ocean, and engage with industries and the public.

Financial support was approved for SCOR's contribution to IQOE in 2016.

3.6 SCOR/IOC/IOGOOS Second International Indian Ocean Expedition (IIOE-2)

Peter Burkill began the report on IIOE-2. The Science Plan for the Second International Indian Ocean Expedition (IIOE-2) has been approved by SCOR and accepted by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The plan is being formatted for printing and will be available at the SCOR meeting. The IOC Interim Planning Committee is developing the IIOE-2 Implementation Plan. SCOR President Peter Burkill and Raleigh Hood (chair of the Science Plan Development Committee) are members of the Interim Planning Committee. The Implementation Plan will be completed by the launch of the IIOE-2 on 4 December 2015. The launch will include a formal ceremony in Goa, India, including the departure of the first IIOE-2 cruise, from Goa to Mauritius.

Raleigh Hood chaired the SCOR-sponsored Science Plan Development Committee and made a presentation about how the IIOE-2 Science Plan was developed and about its contents. "The overarching goal of IIOE-2 is to advance our understanding of interactions among geologic,

oceanic and atmospheric processes that give rise to the complex physical dynamics of the Indian Ocean region, and determine how those dynamics affect climate, extreme events, marine biogeochemical cycles, ecosystems and human populations.” The Science Plan includes 6 themes:

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

Nick D’Adamo reported on IOC interests and activities related to IIOE-2 and about the IIOE-2 Implementation Plan. He requested that SCOR national committees help identify IIOE-2 national representatives (individuals or committees). Participation by early-career scientists in IIOE-2 would be great and it would be good to accommodate the initiative of the brainstorming workshop for young scientists during the Goa symposium. The early-career scientist workshop at the Goa Symposium revealed strong interest and excitement about IIOE-2. A summary document on early-career scientist research priorities will be forthcoming. We need to support and promote these young scientists, which is consistent with the IIOE-2 capacity development goals. Would SCOR consider sponsoring an effort to turn their document into a supplement to the IIOE-2 Science Plan?

A workshop for early-career scientists was held on 2 December at the Goa Symposium to synthesize the research interests of early-career scientists in the region, with the aim of disseminating the information in a published article. Eric Raes and Marie-Alexandrine Sicre convened the session and Raes reported on it at the SCOR meeting. About 70 people attended the workshop and they compiled a list of priority research topics, ideas for future organization and infrastructure. The participants would like to launch a network like early-career polar scientists have done with the Association of Polar Early Career Scientists (APECS: <http://www.apecs.is/>). A Facebook page has been developed for early-career Indian Ocean scientists at <https://www.facebook.com/IOearlycareer>.

Financial support was approved for SCOR’s contribution to IIOE-2 in 2016.

4.0 INFRASTRUCTURAL ACTIVITIES

4.1 SCOR/IOC International Ocean Carbon Coordination Project

Wolfgang Fennel, Executive Committee reporter for IOCCP presented PowerPoint slides prepared by the IOCCP office. IOCCP helps to coordinate activities to develop globally acceptable strategies, methodologies, practices and standards, to integrate ocean biogeochemistry observations into the multidisciplinary global ocean observing system.

Projects and major activities of IOCCP include the following:

- **First International IOCCP Sensors Summer Course:** The IOCCP has completed its First International Summer Course on Best Practices for Selected Biogeochemical Sensors (oxygen, pH, pCO₂, nitrate) in summer 2015 at the Sven Lovén Center for Marine Sciences in Kristineberg, Sweden.
- **Surface Ocean CO₂ Atlas (SOCAT) Project:** IOCCP's coordination of the Surface Ocean CO₂ Atlas (SOCAT) continues. SOCAT aims to improve access to surface water CO₂ data by regular releases of quality-controlled synthesis and data products for the global oceans and coastal seas. SOCAT version 3 was released in September 2015 at the SOLAS Open Science Conference, including 14.5 million surface water fCO₂ observations from 3,630 data sets between 1957 and 2014.
- **The Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP)** decadal survey cruises are designed to quantify changes in ocean carbon inventory; estimate anthropogenic CO₂ empirically; characterize large-scale water mass ventilation rates; constrain horizontal heat, freshwater, carbon, nitrogen, and oxygen transports; and provide a basis for model evaluation. Updated GO-SHIP cruise plans are available at <http://www.go-ship.org/CruisePlans.html>.
- **Pilot project for evaluation of biogeochemical sensors on drifting buoys:** OceanObs'09 called for biogeochemical observations, and the resulting Framework for Ocean Observing asked IOCCP to lead the effort to enhance the collaboration between the existing observing networks and the marine biogeochemistry community. In cooperation with the WMO-IOC Data Buoy Cooperation Panel, oxygen and pH will be the first two parameters to be implemented.
- **Biogeochemical Observations in Global Climate Observing System (GCOS) Status Report 2015 and Implementation Plan 2016:** During the past 12 months, IOCCP significantly contributed to the Status Report on the Global Observing System for Climate (draft version is available at <http://www.wmo.int/gcos>).
- **Optimizing and Enhancing the Integrated Atlantic Ocean Observing System – AtlantOS:** IOCCP is partner in a proposal within the EU Horizon-2020 call BG-8-2014: *Developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources*. The proposal was successful. IOCCP is one of the 62 project beneficiaries from 18 countries.
- **Nutrients Inter-comparison Experiment:** In 2014, IOCCP and JAMSTEC co-organized an inter-laboratory comparison study of nutrients in seawater using certified reference materials prepared by KANSO, Japan; National Metrology Institute of Japan; and reference material from the Korean Institute of Standards (KIOST), and the silicate stock solution provided by the Royal Netherlands Institute for Sea Research (NIOZ). Detailed results will be made available by the end of 2015.

Efforts related to the Global Ocean Acidification Observing Network (GOA-ON) are the main IOCCP contribution to understanding of this multidisciplinary, multi-scale, global phenomenon. Two major GOA-ON activities developed with IOCCP leadership over the past 12 months are (i) Ocean Acidification Data Portal and (ii) Ocean Acidification Data Synthesis Products.

The 2015 IOCCP Scientific Steering Group (SSG) meeting was held on 14-16 April 2015, parallel with the Ocean Observations Panel for Climate (OOPC) at Tohoku University, Sendai, Japan. The 2016 SSG meeting will be held in conjunction with Ocean Sciences 2016. The IOCCP office now has funding from NSF (through SCOR) and EU AtlantOS. Activity funding is more diverse, with main support by NSF, the Swedish Academy of Science, and the U.S. OCB, plus four other sponsors.

4.2 SCAR/SCOR Southern Ocean Observing System (SOOS)

Ilana Wainer, the SCOR Executive Committee Reporter for SOOS, presented PowerPoint slides provided by the SOOS office. The SOOS Scientific Steering Committee met in Hobart, Australia in June 2015. The group is working on its Implementation Plan and 5-year strategic plan, and continues to plan and conduct workshops related to SOOS science. SOOS published its 3-Year Progress Report at <http://soos.aq/resources/reports?view=product&pid=29> and has begun to issue reports as part of a Zenodo collection (see <https://zenodo.org/collection/user-southern-ocean-observing-system?ln=en>). This is for publications that would not be appropriate as peer-reviewed publications, but which are still useful to the community, should be widely available, and are accomplishments of the project.

SOOS has continued to increase its sponsorship from organizations active in the Southern Ocean. Australia and the United States submitted a joint working paper to the Committee for Environmental Protection (CEP) at the 2015 Antarctic Treaty meeting. Entitled “Shared science priorities and cooperation: systematic observations and modelling in the Southern Ocean”, this report highlighted the importance of international contributions to SOOS. CEP nations agreed unanimously on the importance of SOOS and supported all recommendations from the paper. SOOS has developed new objectives: design and implement a regional comprehensive and multidisciplinary observing system for the Southern Ocean; develop new observation technologies; and standardize, unify and enhance existing observations, long-term observations, and data management. The funding for the SOOS Executive Officer runs only through 2016 and SOOS is trying to find new funding. The SSC will be reduced in the coming years.

SCOR approved funding for the 2016 SOOS Scientific Steering Committee meeting, which will be matched by funding from SCAR.

4.3 IAPWS/SCOR/IAPSO Joint Committee on Seawater

Denise Smythe-Wright, the SCOR Executive Committee Reporter for the Joint Committee on Seawater (JCS), presented a report on the group’s status and progress. The JCS is an IAPWS/SCOR/IAPSO joint committee that is responsible for maintaining and improving the recent seawater standard (TEOS-10), and for developing cooperation with the Bureau International des Poids et Mesures (BIPM) and the World Meteorological Organisation (WMO). TEOS-10 equations of state were developed by WG 127. TEOS-10 was adopted by the Intergovernmental Oceanographic Commission at its 25th Assembly in June 2009. TEOS-10 replaces EOS-80 as the official description of seawater and ice properties in marine science. In particular, TEOS-10 involved the development of new definitions and measurement procedures

for seawater salinity, seawater pH and relative humidity of air, traceable to the International System of Units (Système International d'Unités: SI).

There are four TEOS-10 documents currently available:

1. A detailed explanation of the TEOS-10 thermodynamic description of seawater can be found in the [TEOS-10 Manual](#) which has been published by IOC, SCOR and IAPSO.
2. [What every oceanographer needs to know about TEOS-10](#) (the "TEOS-Primer" for short) is a concise summary of the salient theoretical concepts which underpin TEOS-10.
3. [Getting started with the GSW Oceanographic Toolbox of TEOS-10](#) guides the user through the steps required to process and publish physical oceanographic data using TEOS-10.
4. A pdf version of TEOS-10 Lecture Slides (see <http://www.teos-10.org/>)

The JCS is managed by an Executive Committee of three people and includes another 17 members divided into task groups on salinity/density, pH, and moist air, and expert subgroups on thermodynamics, numerical modelling and applications, software, and industry. 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. The JCS continues to work to update TEOS-10 software updates and implement TEOS-10 in large climate models. The TEOS-10 Web site and resources available there are often accessed.

Peter Burkill commented that the group does excellent fundamental scientific work. Denise Smythe-Wright encouraged meeting participants to spread the word to their communities to use absolute salinity for publication and practical salinity for database deposits. Ed Urban added that this group does not cost SCOR much, just occasional travel support for members to attend meetings of the International Association for the Properties of Water and Steam and the BIPM.

SCOR budgeted funding for the 2016 activities of the Joint Committee on Seawater.

4.4 Workshop on Seafloor Ecosystem Functions and their Role in Global Processes

Ed Urban reported that SCOR supported a workshop convened by several seafloor ecologists (Paul Snelgrove, Simon Thrush, and Alf Norkko) to consider seabed ecosystem functioning on a global scale. The workshop brought together the interdisciplinary expertise necessary to address this issue and identify priority research topics. Twelve experts in seabed biology, chemistry, and geology from North America, Europe, Asia and New Zealand met for 2.5 days in September 2015, at the Stazione Zoologica in Naples, Italy. A detailed outline has been developed for the group's paper and a rough draft is being planned by the end of 2015. SCOR does not fund a lot of top-down activities, but occasionally a topic is identified that needs attention. We will decide on further action after the group's publication is completed.

5.0 CAPACITY-BUILDING ACTIVITIES

5.1 SCOR Committee on Capacity Building

Venu Ittekkot, chair of the SCOR Committee on Capacity Building, presented an update of the committee's activities. The committee 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 has been working remotely in 2015 and is not planning a meeting this year, to free up funding for capacity building activities related to International Symposium on the Indian Ocean. 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 SCOR Committee on Capacity Building has not rotated recently and Ittekkot suggested that it was probably time to change some members, keeping in mind IIOE-2 activities. The Executive Committee will look into this issue in the future.

Regional Graduate Networks of Oceanography is a concept that SCOR has been working on for some time. Meetings have been focused on Middle Eastern and North African nations, and on southern Africa. The committee may plan a meeting in the Indian Ocean region to benefit IIOE-2. Participation of scientists from developing countries and countries with economies in transition in the SCOR-sponsored research projects and working groups is an important capacity-building approach. SCOR-sponsored scientific research projects (GEOHAB, GEOTRACES, IMBER, IQOE, SOLAS) include scientists from Argentina, Brazil, China, India, Malaysia, Peru, Russia, and South Africa. SCOR working groups include scientists from Brazil, China, India, Malaysia, Namibia, Russia, South Africa, and Ukraine.

However, as noted by the South African SCOR Committee, the current set of proposals generally lack serious and creative ideas for capacity building. Working group proposals need well-developed plans. It was suggested to change the text in the instructions for working group proposals to add more on capacity building, including on SCOR's history in capacity building, examples of capacity-building activities of previous working groups, link to capacity-building pages of the SCOR Web site, two references on capacity building from SCOR activities, and encouragement to take advantage of existing SCOR mechanisms.

It was suggested that the review of proposals at annual SCOR meetings focus on science and that the SCOR Committee on Capacity Building help improve the capacity-building plans of approved groups. Another suggestion was to include a representative of East African countries on the

Committee on Capacity Building. It was suggested that SCOR do a performance review of SCOR CB-related activities. Ed Urban responded that that this was a good suggestion and he is working with POGO on a questionnaire to send out to all former POGO-SCOR fellowships recipients to try assess this specific initiative. It is hard to do a quantitative assessment of some capacity-building activities, but it is important to try. The capacity-building accomplishments of SCOR working groups should be reviewed each year. It was suggested to check opportunities offered by the British Council.

Peter Burkill thanked the Committee on Capacity Building and others involved. Extra funding was added to the SCOR capacity building budget.

SCOR will divert focus some of its existing capacity-building activities in the Indian Ocean region to benefit the second International Indian Ocean Expedition (IIOE-2) and as a contribution to the IIOE-2 capacity-building program. Ed Urban is working on ideas to attract U.S. ocean scientists to apply to serve as Fulbright Scholars in the Indian Ocean region.

5.2 SCOR Visiting Scholars

SCOR has sent 18 Visiting Scholars to 13 different countries in the first 7 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. Another excellent example is a course on biological oceanography at the University of Dhaka in Bangladesh taught by Nagappa Ramaiah on 8-22 September 8-22 and back on 17-25 December, including a field course on sampling of biota. How is this initiative a catalyst for science in Bangladesh? In relation to this fellowship and an earlier SCOR Visiting Scholar (Prasanna Kumar), an MoU was developed between NIO and Bangladesh, including hosting Bangladeshi students at NIO. Nagappa Ramaiah, Tony Koslow, and Bill Burnett served as SCOR Visiting Scholars in 2015, approved from a pool of 15 applications. Kunio Takahashi was approved as a Visiting Scholar, but will make his visit in 2016.

A question was raised about how long the SCOR Visiting Scholars are onsite. Ed Urban responded that minimum allowed is two weeks and the longest so far has been 6 weeks. SCOR provides US\$2,500 travel and some local expenses; the local host is expected to provide lodging. The funding is from a NSF grant to SCOR for travel of developing countries scientists to attend meetings: NSF allows SCOR to devote 10% of the grant to the SCOR Visiting Scholar program.

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. A SurveyMonkey questionnaire has been developed to assess the long-term impacts of this program. Four fellowships were approved in 2015, which was decreased from previous years since POGO funding dropped from previous levels.

5.4 NSF Travel Support for Developing Country Scientists

Ed Urban reported that the current SCOR grant from the National Science Foundation for travel of developing country scientists to scientific meetings runs until 30 June 2017. 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 has approved several batches of requests since the 2014 SCOR meeting. Meeting organizers request support and the Committee on Capacity Building decides on whether to fund and, if so, how much to provide. This grant helps SCOR provide support for SCOR-related meetings, meetings of strategic partner organizations, meetings related to topics in which SCOR have been involved in the past, and other events that are important for ocean science. This program is not highly advertised in order to avoid a flood of funding requests.

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1 Intergovernmental Oceanographic Commission (IOC)

Peter Burkill, the SCOR Executive Committee Reporter for IOC, made a presentation about IOC and SCOR's relationship to IOC. Burkill noted that IOC is the only intergovernmental body in the UN system that specializes in ocean sciences, services, observations, data exchange, and capacity building. The current science focus of IOC include carbon, ocean acidification, microplastics, biodiversity, "blue carbon", harmful algal blooms, oxygen minimum zones, and time series. SCOR continues to co-sponsor several activities with IOC, including IOCCP (see item 4.1), the finishing GEOHAB project (see item 3.1), the soon-to-start GlobalHAB project (see item 4.4), and the Second International Indian Ocean Expedition (see item 3.6).

IOC has three pillars of action after 2015: (1) Sustainable Development Goals (SDGs) including the SDG on the Ocean (#14: Conserve and Sustainably Use Oceans, Seas and Marine Resources for Sustainable Development), (2) Post-2015 Disaster Risk Reduction Framework, and (3) Blue Growth/Blue Economy.

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

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. GESAMP has approved continued work of WG 38 and SCOR may again be requested to support this work through new funding from NSF.

6.3 North Pacific Marine Science Organization (PICES)

Hal Batchelder, the Deputy Executive Secretary of PICES, gave an update about PICES activities and interactions with SCOR. Six countries comprise PICES. PICES supports six main committees under the PICES Science Board:

1. Biological oceanography
2. Fisheries
3. Physical oceanography and climate
4. Monitoring
5. Data exchange
6. Environmental quality

PICES sponsors sections (with no end date) that are connected to at least one main committee. One example is a section on harmful algal blooms. PICES also supports study groups, which are exploratory activities that may grow into working groups.

PICES contributes to large-scale ocean research projects sponsored by SCOR, such as SOLAS, IMBER and GEOHAB, by convening project-related sessions at PICES annual meetings, organizing joint summer schools, assisting the projects with events in the North Pacific region in terms of logistic, and supporting the participation of early-career scientists from the North Pacific region in project-related meetings. Examples of PICES contributions to SCOR-related activities include the following:

- PICES and IMBER convened joint topic sessions at every PICES Annual Meeting from 2008 to 2014.
- IMBER co-sponsored the 3rd PICES/ICES/IOC Symposium on “Effects of climate change on the world’s oceans” (March 21-27, 2015, Santos City, Brazil). One of the symposium workshops, "Upwelling systems under future changing climate", was a CLIVAR/IMBER/SOLAS collaboration.
- PICES was a contributing sponsor of the 3rd CLIOTOP symposium, titled “Future of oceanic animals in a changing ocean”, held September 14-18, 2015 in San Sebastian, Spain.
- PICES and SOLAS convened a joint workshop at PICES-2014 (Yeosu, 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”.
- PICES partnered with GEOHAB, ICES and NOAA in organizing and funding the workshop on “Harmful algal blooms in a changing world” (March 18–22, 2013, Friday Harbor, Washington, USA) to assess the state of knowledge on HABs and climate change, and to identify the most critical research needs over the next 5–10 years.

Support for travel of developing country scientists is available from the PICES Trust Fund for participants from specific countries, so support from SCOR and other organizations broadens the range of countries whose scientists can be supported. PICES can also support travel of scientists from outside the North Pacific region from annual dues to PICES.

PICES will support an Associate Member for the new SCOR Working Group: Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?

7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

7.1 International Council for Science (ICSU)

Peter Burkill made some brief comments about ICSU. Burkill and Ed Urban met with the new ICSU Executive Director and Science Director in June 2015 when they were in Paris for the IOC General Assembly. SCOR does not receive funding from ICSU, but ICSU is SCOR's parent organization and SCOR's participation in ICSU is important for continued funding from national SCOR committees. ICSU is reviewing SCOR and we await their review.

7.1.1 International Geosphere-Biosphere Program (IGBP)

Peter Burkill also reported on IGBP. SCOR did not send a representative to the final IGBP Science Committee meeting in 2015. 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. IGBP is planning a Landmark Synthesis Event at the American Geophysical Union (AGU) Fall Meeting, 14-18 December 2015, in San Francisco. IGBP will end and future global change activities that will be conducted by Future Earth. The IGBP Website will become static (will not be updated), but will be available until 2026. The site has a lot of good content, so that it will be available for an extended period.

7.1.2 World Climate Research Programme (WCRP)

Wolfgang Fennel gave an overview of WCRP. The mission of WCRP is to facilitate analysis and prediction of Earth system variability and change for use in practical applications of relevance, benefit, and value to society. WCRP has two overarching objectives:

1. to determine the predictability of climate; and
2. to determine the effect of human activities on climate.

WCRP is organized as a network of core and co-sponsored projects, working groups, modelling and cross-cutting initiatives (see <http://wcrp-climate.org/about-wcrp/aboutimplementation>).

WCRP is sponsored by the World Meteorological Organization (WMO), the International Council for Science (ICSU) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

WCRP has five Grand Challenges:

1. Clouds, Circulation & Climate Sensitivity
2. Melting Ice & Global Consequences
3. Climate Extremes
4. Regional Sea-level Change & Coastal Impacts
5. Water Availability

A sixth Grand Challenge on Decadal Climate Variability in the planning stages.

Most relevant to SCOR is the Grand Challenge on Regional Sea-Level Change and Coastal Impacts, which represents an integrated interdisciplinary program on sea level research from

global to local scales to

- Establish a quantitative understanding of the natural and anthropogenic mechanisms of regional to local sea level variability;
- Promote advances in observing systems required for an integrated sea level monitoring; and
- Foster the development of sea level predictions and projections that are of increasing benefit for coastal zone management.

WCRP has four Core Projects:

1. CLIVAR (oceans and climate - www.clivar.org),
2. CliC (cryosphere and climate - www.climate-cryosphere.org),
3. GEWEX (water and climate www.gewex.org), and
4. SPARC (upper atmosphere and climate - <http://www.sparc-climate.org>).

Both CLIVAR and CliC are official endorsers of the SCOR/SCAR Southern Ocean Observing System (SOOS).

The CLIVAR Project is of particular relevance to SCOR. CLIVAR's overarching goal is to improve understanding and prediction of the ocean-atmosphere system. CLIVAR's structure has evolved to meet the changing nature of the science and the community it serves. CLIVAR works through a set of Global Panels and regional ocean basin panels. The global panels are on Ocean Model Development, Global Synthesis and Observations, Climate Dynamics, and a joint CLIVAR-GEWEX Monsoons Panel. The regional ocean basin panels (Atlantic, Pacific, Indian and Southern oceans) promote and provide advice on the implementation of multi-national observational systems and process studies in support of research on climate and ocean variability and predictability.

WCRP co-sponsors the SOLAS project. SCOR is co-sponsoring and providing funding for the WCRP Polar Challenge (see <http://www.wcrp-climate.org/index.php/polarchallenge>).

There was a question about the duration of WCRP. Fennel replied that WCRP has already been around for about 30 years, without a "sunset" date imposed by ICSU or by WCRP itself. WCRP's longevity is probably due to support of powerful international organizations (e.g., WMO), the importance of the climate change issue, and the high level of activity of WCRP.

7.1.3 Scientific Committee on Antarctic Research (SCAR)

Corina Brussaard, the SCOR Executive Committee Reporter for SCAR, provided an update about 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. John Turner added that SCAR likes to do more interdisciplinary research. It produces a publication each year to advise the Antarctic Treaty Committee. Turner is responsible for this publication (3-5 pages) and asked that SCOR let him know if there is anything SCOR thinks should be mentioned in this publication.

The action listed on the agenda in relation to SCAR was to discuss whether SCOR should offer to help with other SCAR activities. John Turner mentioned that SCAR is a rather small group and recently upgraded its processes with defined themes and workshops with set life times. Peter Burkill suggested that it would be good to have a workshop by SCAR and SCOR on the topic of the Southern Ocean and Indian Ocean boundary. Brussaard replied that this is exactly what several Dutch scientists are discussing as the focus for new research. Burkill suggested that Brussaard be the SCOR contact point for discussions with SCAR on this topic. Ed Urban suggested that any new SCOR-SCAR initiatives should avoid overlap with SOOS activities. There will be a SOOS SSC meeting in spring and Ed (and potentially Ilana Wainer) will be attending. Burkill commented that it would be good to have SCOR representation at the next SCAR meeting (19-31 August 2016, Kuala Lumpur, Malaysia) and John Turner agreed.

7.1.4 Future Earth Initiative

Peter Burkill provided an update about the status of the Future Earth initiative. Future Earth continues development, 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 and Future Earth signed a letter of agreement and SCOR is working with Future Earth to develop a mutually acceptable working arrangement in relation to SOLAS and IMBER. SCOR also helped plan and conduct a workshop among marine projects in Kiel, Germany in March 2015, to help them plan cooperative activities and discuss how to give ocean science a higher profile in Future Earth. We are waiting to see how Future Earth develops and how SCOR could work with this effort. SCOR is concerned with fundamental science and Future Earth focusses on policy makers and societal science-interphase, but there may be some areas of mutual interest. Ed Urban had a conversation with the Executive Director of Future Earth about the fundamental importance of healthy research projects to help Future Earth achieve its goals.

7.2 Affiliated Organizations

7.2.1 International Association for Biological Oceanography (IABO)

Patricia Miloslavich represented IABO at the meeting. IABO has continued its work to coordinate the field of marine biodiversity research internationally, particularly through the series of World Conferences on Marine Biodiversity. SCOR provided support for developing country scientists to attend the third conference in the series, held in China in 2014. The topic discussed included deep-sea diversity, biodiversity in the West Pacific, jellyfish blooms, a reef life survey program, and others. The next World Conference on Marine Biodiversity will be held in May 2018 in Montreal, Canada.

Mark Costello and others published a paper on coordination within the marine biodiversity community in 2015. IABO has a mailing list with 1,000 subscribers and invites SCOR participants to subscribe.

The GOOS Biology and Ecology Panel is establishing accurate descriptions of the present state of the ocean to be used for forecasting global climate state. Biological variables added two years ago include chlorophyll a, harmful algal blooms, zooplankton, mangroves and seagrass area,

coral cover, salt marsh area, and movement and abundance of large marine vertebrates, which were suggested by scientists. However, essential ocean variables should also include societal pressures and states of the ecosystems. To define the drivers and pressures, the panel is reviewing international organizations and conventions that mention these factors. For example, biodiversity, knowledge, and conservation can be considered drivers, and loss of resources, pollution, climate change, and invasive species can be considered to be pressures. To assess the state, the panel compiled observations and data integration projects, etc. (driver, method, area, spatial scale, temporal coverage, habitat, taxonomic group, etc.). The survey is completed and now will be tested. This will allow a determination of the readiness of the ocean observations.

In relation to future cooperation of IABO and SCOR, funding for developing country students to attend meetings is great and IABO would like to see this continue. IABO will try to stimulate interest within its community for writing of SCOR working proposals.

7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS)

John Turner, the President of the International Association for Meteorology and Atmospheric Sciences (IAMAS), presented a summary of current IAMAS activities. IAMAS was established in 1919 and renamed in 1995. It receives funding of US\$35,000 per year from the International Union of Geodesy and Geophysics (IUGG). IAMAS sponsors ten commissions:

1. International Ozone Commission: their meeting every four years is the big event in this field.
2. International Commission on the Middle Atmosphere
3. International Radiation Commission: they conduct major modeling activities
4. International Commission on Clouds and Precipitation
5. International Commission on Climate
6. International Commission on Dynamical Meteorology
7. International Commission on Atmospheric Electricity
8. Commission on Atmospheric Chemistry and Global Pollution: co-sponsor of SOLAS
9. International Commission on Polar Meteorology
10. Commission on Planetary Atmospheres and their Evolution

IAMAS holds meetings with other IUGG bodies every two years and with the IUGG Assembly every four years. The next meetings will be the IAPSO-IAMAS-IAGA meeting in Cape Town, South Africa on 27 August-1 September 2017 and the IUGG meeting in Montreal, Canada on 8-19 July 2019.

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

Denise Smythe-Wright, the IAPSO President, provided an update about IAPSO activities. IAPSO is also part of IUGG. IAPSO covers the topics of physics, chemistry, and mathematics, but now also more biogeochemistry. They encourage young scientists to come to the meetings, particularly from developing countries. The IAPSO budget is relatively small, but is partly used for travel grants. The new Secretary General is Stefania Sparnocchia (Italy); she is responsible for the day-to-day activities of the organization. Smythe-Wright was elected as IAPSO President this year, and there were some additional changes in the composition of the IAPSO Executive

Committee. Smythe-Wright mentioned the meeting with IAMAS (and IAGA) in Cape Town in 2017.

IAPSO awards two medals on a regular basis:

1. Prince Albert I Medal: IAPSO and the Monaco Royal Family established the Prince Albert I Medal for excellence in physical and/or chemical oceanography some years ago. The winner is selected every two years and the ceremony is held during the Assemblies. Toshio Yamagata was awarded the medal in 2015 for “his ground-breaking work and exceptional contribution to our understanding of the El Niño/Southern Oscillation and the newly discovered Indian Ocean Dipole”. IAPSO welcomes nominations for the next medal, particularly for chemists, biogeochemists, and female scientists.
2. Eugene LaFond Medal: Eugene LaFond was a former Secretary General of IAPSO, and this award is given in his honor to a scientist from a developing country for an oral or poster presented at an IAPSO Assembly. IAPSO forms a special commission to select the winner. In 2015, the medal was awarded to Sana Ben Ismail from Tunisia for her oral presentation "Surface circulation features along the Tunisian coast (central Mediterranean Sea): the Atlantic Tunisian current.”

IAPSO has five standing activities:

1. Commission on Mean Sea Level and Tides (CMSLT), President: Gary T. Mitchum. Web site: www.psmsl.org/
2. Tsunami Commission (Joint with IASPEI and IVACEI). Chair: Vasily V. Titov. Web site: www.iaspei.org/commissions/JCT.html
3. GeoRisk Commission (Joint with IAMAS, IAHS, IASPEI and IAVCEI). Web site: www.iugg-georisk.org/
4. Permanent Service for Mean Sea Level, hosted by Proudman Oceanographic Laboratory, UK. Contact: Lesley Rickards. Web site: www.psmsl.org/
5. IAPSO Standard Seawater Service, hosted by OSIL, Havant, Hampshire, UK. Director: Paul, Ridout; Website Web site: www.osil.co.uk/

SCOR and IAPSO have co-sponsored many working groups in the past, and are discussing IAPSO co-sponsorship of new SCOR working groups. The two organizations currently co-sponsor the Joint Subcommittee on Seawater (see item 4.3).

7.3 Affiliated Programs

7.3.1 InterRidge - International, Interdisciplinary Ridge Studies

Colin Devey, a former chair of InterRidge, gave an informal presentation. 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..

InterRidge held a Theoretical Institute on Magmatic and Tectonic Processes in September 2015 in China, followed by a one-day symposium on marine mining. InterRidge operates on a

subscription basis to support its IPO and recently reformed the subscription system. The InterRidge Office moves every three years and will be moving from China to France in 2016. Three student poster awards (US\$1000 each) were given. An active InterRidge community exists and evolves as new InterRidge questions arise. The current InterRidge working groups include the following:

1. Ecological Connectivity and Resilience
2. Island Arc and Backarc
3. Circum-Antarctic Ridges
4. Hydrothermal Energy and Ocean Carbon Cycles (with SCOR)
5. Oceanic Detachment Faults

A question was raised about whether InterRidge is part of some other organization. It is not, as it developed from the bottom up interests of the global scientific community in the 1990s, but InterRidge is affiliated to SCOR. Ed Urban noted that it could be useful for SCOR and InterRidge to interact in relation to IIOE-2. Ed will contact Jerome Dymont in the InterRidge Office about this connection.

7.3.2 International Ocean Colour Coordinating Group (IOCCG)

Ed Urban presented PowerPoint slides prepared by Venetia Stuart, IOCCG Project Coordinator. IOCCG was established in 1996 to promote application of ocean-color data and became affiliated to SCOR in 1997. The IOCCG steering committee is formed by representatives from space agencies and research scientists, with 28 members from 15 different countries. SCOR co-sponsors various IOCCG activities through support from the U.S. National Aeronautics and Space Administration. IOCCG's mandate is

- To provide a common voice for the user community: International Ocean Colour Science (IOCS) meetings.
- To advocate the importance of ocean-colour data: IOCCG Report series, news bulletins, Web site (www.ioccg.org)
- To foster expertise in using ocean-colour data: introductory and advanced training courses (Summer Lecture Series).
- To ensure continuity and quality of the ocean-colour data stream: liaison with space agencies, participate in CEOS OCR-VC, CEOS WGCV, etc.

IOCCG working groups are formed around specific topics and the groups work over several years, then produce a monograph. SCOR has suggested that IOCCG do more outreach beyond the ocean color community. Current IOCCG working groups include the following:

- Harmful Algal Blooms (IOCCG/SCOR GEOHAB WG – Chair: Stewart Bernard, South Africa) – several chapters have been completed. Report should be published in 2016.
- Uncertainties in Ocean Colour Radiometry (Co-chairs: Roland Doerffer, Germany, Fred Melin, Italy)
- Atmospheric Correction Algorithms over Optically-Complex Waters (Chair: Cédric Jamet, France)

- Earth Observations in Support of Global Water Quality Monitoring (Co-chairs: Arnold Dekker, Australia; Paul DiGiacomo, NOAA & Steve Greb, U. Wisconsin)
- Ocean Colour Applications for Biogeochemical, Ecosystem and Climate Modelling (Chair: Stephanie Dutkiewicz, MIT, USA). WG will meet for first time in February 2016.

In the past year, IOCCG established a new working group on Ocean Colour Applications for Biogeochemical, Ecosystem, and Climate Modeling. The most recent working group report is on polar seas and can be downloaded from the IOCCG Web site). SCOR recently provided support for developing country scientists to participate in the 2015 International Ocean Color Science (IOCS) Meeting. The next IOCS meeting will be held in Portugal in 2017. SCOR also provided support for the IOCCG Summer Lecture Series. These series include courses on introductory and advanced levels, and videos of the lectures are available on the IOCCG Web site. The next course will be held in July 2016.

7.3.3 Global Alliance of CPR Surveys (GACS)

Peter Burkill presented an update on the Global Alliance of CPR Surveys (GACS). GACS is SCOR's newest affiliated program. It was started in 2012 to set up a global database of existing surveys (North Atlantic, North Pacific, Southern Ocean, coastal Australia, around South Africa, eastern Mediterranean Sea). Motivation of the Mediterranean Sea initiative was from the oligotrophic nature of the eastern portion of the sea, with the occasional input of dust; as well as the introduction of species via the Suez Channel. Data are held centrally and standardized. 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. GACS will issue its next Global Status Report in 2016. Status reports are highly used; the next one will focus on essential ocean variables. GACS has been significantly involved in capacity building related to CPR survey techniques, with occasional support from SCOR. GACS was recently included under the GOOS Biology and Ecosystem Panel.

7.4 Other Organizations

7.4.1 Partnership for Observation of the Global Oceans (POGO)

Sergey Shapovalov provided an update about POGO. POGO was established in 1999 by a group of directors of marine research institutions who met to discuss ways in which they could work together more effectively in support of global oceanography. The objective of POGO is to make a major contribution to the attainment of sustained in situ observations of the global ocean. Since 2011, POGO has taken a leadership role with the Group on Earth Observations (GEO) in the formulation of an oceans task, "Oceans and Society: Blue Planet".

POGO funds jointly with SCOR a fellowship program that enables young scientists from developing countries to study for up to three months in a major oceanographic institution chosen by the candidate. The program is managed by POGO. Candidates are selected by a committee in which both POGO and SCOR are represented. SCOR also runs a Visiting Professorship modelled on the POGO one, and on several occasions the two programs have complemented one another. POGO and SCOR also collaborate in assessing capacity building at the world level in

marine science and coordinate their respective capacity-building programs. Together with partner organizations (IOC/IODE, SCOR and POGO) POGO has created a Web site advertising summer schools and other training opportunities in ocean sciences (www.oceansummerschools.org). In 2015, SCOR and POGO Secretariats have been working on an impact evaluation questionnaire to send to all past trainees of their respective and joint training programs.

SCOR has established jointly with POGO a new research initiative, the International Quiet Ocean Experiment (IQOE). POGO has started providing funding for Working Group on Implementation of IQOE Science Recommendations on Marine Noise Exposure and Broad-Scale Acoustic Monitoring. POGO contributed to the establishment, and continues to support the development, of the SCOR-SCAR Southern Ocean Observing System (SOOS). Both POGO and SCOR support the Global Alliance of Continuous Plankton Recorder Surveys (GACS). POGO has an interest in contributing to the activities planned under the International Indian Ocean Expedition 50th anniversary (IIOE-2), an initiative of SCOR and IOC.

At the most recent POGO Annual Meeting (POGO-15) held in Tenerife, Spain, in January 2015, four workshops were held on the following themes that were identified as priority areas for POGO:

- Deep-ocean observations (Leaders: Uwe Send/ Pedro Velez/Alicia Lavin)
- Ocean observations and Marine Protected Areas (Leaders: Stefan Hain/Margaret Leinen)
- Enhancing visibility of and access to long-term data (Leaders: Karen Wiltshire/Alex Kraberg)
- Engaging with industry: lessons learned, successes and failures (Leader: Susan Avery)

8.0 ORGANIZATION AND FINANCE

8.1 Membership

8.1.1 National Committees, p. 8-1

Some national SCOR Committees changed Nominated Members since the 2014 SCOR annual meeting, including Australia, Canada, Italy, Japan, Korea, Pakistan, Sweden, and the United States. Each national SCOR committee is allowed three Nominated Members, although some have fewer than this. Nominated members serve as liaisons between international SCOR and national ocean science communities.

8.2 Publications Arising from SCOR Activities

SCOR projects and working groups have produced many publications in the past year. Several SCOR working groups have special issues or significant papers under development, which will appear in the next year.

8.3 Finances

The SCOR Executive Committee approved an ad hoc Finance Committee consisting of Annalisa Griffo (Italy), Karen Heywood (UK), and Toshiro Yamagata (Japan). This committee conducted its work during the SCOR meeting and was responsible to report on (1) findings related to the 2014 Audit report, (2) recommendations related for revisions to the 2015 SCOR budget, (3) recommendations for the 2016 SCOR budget, and (4) recommendations for dues levels in 2017.

Karen Heywood chaired the *ad hoc* SCOR Finance Committee and presented its results. She thanked Ed Urban for the materials he prepared for the committee's work.

2014 Audit Report—Membership dues collected were US\$339,208, to which was added \$103,182 from NSF and other organizations for discretionary spending. Working group expenses were \$86,861, other science expenses were \$60,358 and administrative expenses were \$270,779. This resulted in a net income of \$24,392, increasing the cash balance from \$212k at the end of 2013 to \$236k at the end of 2014. SCOR requires an ending cash balance of at least \$100,000. The auditor found no accounting discrepancies and found SCOR a low-risk auditee. The Finance Committee recommended that the 2014 audit report and corresponding 2014 SCOR financial report be approved and meeting participants approved these documents.

2015 Revised Budget—At the 2014 SCOR annual meeting, discretionary income of US\$449,209 was budgeted. It was proposed at the 2015 annual meeting to increase the discretionary income to \$466,867. As in previous years, it was projected that SCOR working groups would underspend their budgets in 2015. The total discretionary expenses for 2015 were originally budgeted at \$536,087, which would have resulted in a planned net loss of \$86,878. Instead, total discretionary expenses for 2015 were expected to be \$476,537, resulting in a net loss of \$9,670.

What the Finance Committee said at the 2014 SCOR annual meeting: “The cash balance is estimated to come down at the end of 2015 from projected \$180k at end 2014 to US\$ 93k. This is slightly below the set minimum cash balance of US\$ 100,000. We believe it is unrealistic to expect this decrease to occur fully and hence recommended the 3 WG solution.”

What actually happened:

- We ended the year with about \$180k
- SCOR's “risky approach” to fund 3 WGs last year and invest in other activities to stimulate science was proved right.

The Finance Committee recommended that SCOR accept revisions to the 2015 budget and the revised budget was accepted.

2016 Proposed SCOR Budget—The proposed 2016 SCOR budget included discretionary income of \$454,018, and proposed discretionary expenses of \$524,006, including approval of three new working groups. This would result in a net loss of -\$69,988, bringing the unrestricted net assets down to \$117,084 at the end of 2016, above the minimum \$100,000 level. The Finance Committee recommended approval of this budget and meeting participants approved.

In summary, the Finance Committee found that the cash situation for 2015 allows the planned establishment of 3 new working groups in 2015, and we can expect to be able to fund at least two new working groups in 2016. The underspending by working groups still continues, but is manageable. SCOR has taken measures (new initiatives, 3 groups approved again in 2015) to seize this opportunity to support more science activities. The Finance Committee saw no need in 2017 to diverge from the incremental dues increase (3%) practiced in recent years. Corina Brussaard suggesting increasing the capacity building budget by \$5,000, which was approved. Peter Burkill suggested that this could be used to help support a regional workshop for early-career scientists involved in IIOE-2.

Peter asked whether there are any other initiatives that should be considered, such as was done for the benthic workshop this year. Patricia Miloslavich asked whether a call for workshop proposals should be made. Ed Urban replied that this idea was discussed briefly in the Executive Committee meeting. Urban was concerned that a call for workshop proposals could result in an overwhelming response. Brussaard responded that if a call were issued, it should specify a clear format and an expectation that there would not be a call more than once every three years, because of the time involved in dealing with proposal review. Colin Devey asked whether SCOR could do more to make more data from SCOR activities available.

9.0 SCOR-RELATED MEETINGS

9.1 SCOR Annual Meetings

9.1.1 2015 Executive Committee Meeting: Goa, India

Peter Burkill and Ed Urban thanked Wajih Naqvi and his staff for their excellent hosting of the SCOR meeting and the Indian Ocean symposium that preceded the SCOR meeting. Gifts were presented to Wajih Naqvi, Dileep Kumar, and V. Purnachandra Rao.

9.1.2 2016 General Meeting: Sopot, Poland

The dates for the 2016 SCOR General Meeting have been set as 5-7 September 2016. A meeting room at the Institute of Oceanology of the Polish Academy of Sciences has been reserved, as has been a block of hotel rooms within walking distance of the institute. All the planning seems to be going smoothly.

9.1.3 2017 Executive Committee Meeting

Denise Smythe-Wright suggested that South Africa might be considered as host for the 2017 SCOR annual meeting in combination with the IAPSO-IAMAS-IAGS Assembly. Isabelle Ansorge, a Nominated Member from SCOR South Africa and Vice President of IAPSO had extended this invitation.

Peter Burkill thanked all meeting participants and closed the meeting.

APPENDICES

APPENDIX 1

Agenda

42nd SCOR EXECUTIVE COMMITTEE MEETING

Goa, India
7-9 December 2015

ANNOTATED AGENDA

1.0 OPENING

- | | | |
|-----|---|------------------------------|
| 1.1 | Opening Remarks and Administrative Arrangements | <i>Naqvi, Burkill, Urban</i> |
| 1.2 | Approval of the Agenda | <i>Burkill</i> |
| 1.3 | Report of the President of SCOR | <i>Burkill</i> |
| 1.4 | Report of SCOR Executive Director | <i>Urban</i> |
| 1.5 | Appointment of an <i>ad hoc</i> Finance Committee | <i>Burkill</i> |
| 1.6 | 2016 Elections for SCOR Officers | <i>Fennell</i> |

2.0 WORKING GROUPS

- | | | |
|--------|---|--------------------------|
| 2.1 | Current Working Groups | |
| 2.1.1 | SCOR/InterRidge WG 135 on Hydrothermal energy transfer and its impact on the ocean carbon cycles | <i>Bharathi</i> |
| 2.1.2 | WG 137: Patterns of Phytoplankton Dynamics in Ecosystems: Comparative Analysis of Time Series Observation | <i>Ramaiah, Sun Song</i> |
| 2.1.3 | SCOR/IGBP WG 138: Modern Planktic Foraminifera and Ocean Changes | <i>Naidu, Brussaard</i> |
| 2.1.4 | WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry In the Ocean | <i>Naqvi</i> |
| 2.1.5 | WG 140: Biogeochemical Exchange Processes at the Sea-Ice Interfaces | <i>Shapovalov</i> |
| 2.1.6 | WG 141 on Sea-Surface Microlayers | <i>Burkill</i> |
| 2.1.7 | WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders | <i>Naqvi, Burkill</i> |
| 2.1.8 | 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 | <i>Bange, Turner</i> |
| 2.1.9 | WG 144 on Microbial Community Responses to Ocean Deoxygenation | <i>Ramaiah</i> |
| 2.1.10 | WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC) | <i>Urban</i> |
| 2.1.11 | WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5) | <i>Naqvi</i> |
| 2.1.12 | WG 147: Towards comparability of global oceanic nutrient data (COMPONUT) | <i>Naik</i> |
| 2.2 | Working Group Proposals | |
| 2.2.1 | Towards a Global Comparison of Zooplankton Production: Measurement, Methodologies and Applications (ZooProd) | <i>Sun Song</i> |
| 2.2.2 | SEAmount Faunal vulnerability to impacts of Ocean Acidification and Mining (SEAFOAM) | <i>Burkill</i> |
| 2.2.3 | BIOgeochemistry of CORal REef systems (BIOCORE) | <i>Brussaard</i> |
| 2.2.4 | Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean? | <i>Miloslavich</i> |

2.2.5	A Functional Trait Perspective on the Biodiversity of Hydrothermal Vent Communities (FDvent)	<i>Burkill</i>
2.2.6	Rheology, nano/micro-Fluidics and bioFouling in the Oceans (RheFFO)	<i>Fennel</i>
2.2.7	Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)	<i>Smythe-Wright</i>
2.2.8	Global Assessment of Nutrient Export Through Submarine Groundwater Discharge (NExT SGD)	<i>Naqvi</i>
2.2.9	International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)	<i>Turner</i>
2.2.10	The dynamic ecogeomorphic evolution of mangrove and salt marsh coastlines (DEMASCO)	<i>Miloslavich</i>

3.0 LARGE-SCALE SCIENTIFIC PROGRAMS

3.1	IOC/SCOR Global Ecology and Oceanography of Harmful Algal Blooms Program	<i>Urban, Sun Song</i>
3.2	SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research	<i>Burkill</i>
3.3	GEOTRACES	<i>Naqvi</i>
3.4	Surface Ocean – Lower Atmosphere Study (SOLAS)	<i>Sarma, Turner</i>
3.5	International Quiet Ocean Experiment (IQOE)	<i>Urban, Shapovalov</i>
3.6	Second International Indian Ocean Expedition (IIOE-2)	<i>Burkill</i>

4.0 INFRASTRUCTURAL ACTIVITIES

4.1	IOC/SCOR International Ocean Carbon Coordination Project	<i>Fennel</i>
4.2	SCAR/SCOR Southern Ocean Observing System (SOOS)	<i>Wainer</i>
4.3	IAPWS/SCOR/IAPSO Joint Committee on Seawater	<i>Smythe-Wright</i>
4.4	GlobalHAB	<i>Urban, Sun Song</i>
4.5	Workshop on Seafloor Ecosystem Functions and their Role in Global Processes	<i>Urban</i>

5.0 CAPACITY-BUILDING ACTIVITIES

5.1	SCOR Committee on Capacity Building	<i>Ittekkot</i>
5.2	SCOR Visiting Scholars	<i>Ittekkot</i>
5.3	POGO-SCOR Visiting Fellowships for Oceanographic Observations	<i>Urban</i>
5.4	NSF Travel Support for Developing Country Scientists, p. 5-14	<i>Urban</i>

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1	Intergovernmental Oceanographic Commission (IOC)	<i>Enevoldsen, Burkill</i>
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|-----|--|-----------------------------|
| 6.2 | Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) | <i>Urban</i> |
| 6.3 | North Pacific Marine Science Organization (PICES) | <i>Batchelder, Sun Song</i> |

7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

- | | | |
|-----|--|----------------------|
| 7.1 | International Council for Science | <i>Burkill</i> |
| | 7.1.1 International Geosphere-Biosphere Program (IGBP) | <i>Burkill</i> |
| | 7.1.2 World Climate Research Programme (WCRP) | <i>Fennel</i> |
| | 7.1.3 Scientific Committee on Antarctic Research (SCAR) | <i>Brussaard</i> |
| | 7.1.4 Future Earth Initiative | <i>Burkill</i> |
| 7.2 | Affiliated Organizations | |
| | 7.2.1 International Association for Biological Oceanography (IABO) | <i>Miloslavich</i> |
| | 7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS) | <i>Turner</i> |
| | 7.2.3 International Association for the Physical Sciences of the Oceans (IAPSO) | <i>Smythe-Wright</i> |
| 7.3 | Affiliated Programs | |
| | 7.3.1 InterRidge - International, Interdisciplinary Ridge Studies | <i>Urban</i> |
| | 7.3.2 International Ocean Colour Coordinating Group (IOCCG) | <i>Sun Song</i> |
| | 7.3.3 Global Alliance of CPR Surveys (GACS) | <i>Burkill</i> |
| 7.4 | Other Organizations | |
| | 7.4.1 Partnership for Observation of the Global Oceans (POGO) | <i>Shapovalov</i> |

8.0 ORGANIZATION AND FINANCE

- | | | |
|-----|---|---------------------------------|
| 8.1 | Membership | <i>Urban</i> |
| | 8.1.1 National Committees | |
| 8.2 | Publications Arising from SCOR Activities | <i>Urban</i> |
| 8.3 | Finances | <i>Finance Committee, Urban</i> |

9.0 SCOR-RELATED MEETINGS

- | | | |
|-----|--|----------------|
| 9.1 | SCOR Annual Meetings | |
| | 9.1.1 2015 Executive Committee Meeting: Goa, India | <i>Naqvi</i> |
| | 9.1.2 2016 General Meeting: Sopot, Poland | <i>Burkill</i> |
| | 9.1.3 2017 Executive Committee Meeting | <i>Burkill</i> |
| 9.2 | Locations of Past SCOR Annual Meetings | |
| 9.3 | SCOR-Related Meetings Since the 2014 SCOR Executive Committee Meeting and Planned for the Future | |

APPENDIX 2

Participants

42nd SCOR EXECUTIVE COMMITTEE MEETING

Goa, India
7-9 December 2015

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APPENDIX 3

Proposal for a Working Group on Changing Ocean Biological Systems (COBS): How will biota respond to a changing ocean?

Title

Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?

Acronym: COBS

Abstract

Climate models all project concurrent alterations to multiple oceanic properties, due to the effects of anthropogenic climate change. These projections are supported by a growing body of ocean observatory evidence demonstrating simultaneous shifts in life-sustaining properties such as temperature, CO₂, O₂, and nutrients. Hence, a major challenge for marine sciences is to determine the cumulative effects of such interactive and widespread alterations of oceanic conditions on organisms, communities and ecosystems. This challenge is multi-faceted, and research must advance in parallel to tackle three major themes: effects of multiple environmental drivers on the performance of individual organisms; community and foodweb responses to complex ocean change; and timescales of biological responses to climate change.

Consequently, we urgently need to develop a new generation of studies based on methodology that will allow us to progress from:

- ***Single to multiple environmental drivers***
- ***Organismal to community and ecosystem level responses***
- ***Transient acclimation physiology to long-term adaptation and evolution.***

This proposed SCOR working group will build strong transdisciplinary linkages to facilitate the design and development of a framework of experiments, observations, and conceptual/mathematical models to evolve each of these themes. This multi-thematic approach will provide a platform for the next generation of scientists to conduct rigorous inter-related research and to further refine this approach as new technologies emerge. The working group will also target how to develop powerful tools to convey the major research findings of this complex topic as directly and simply as possible for decision-makers in the marine realm.

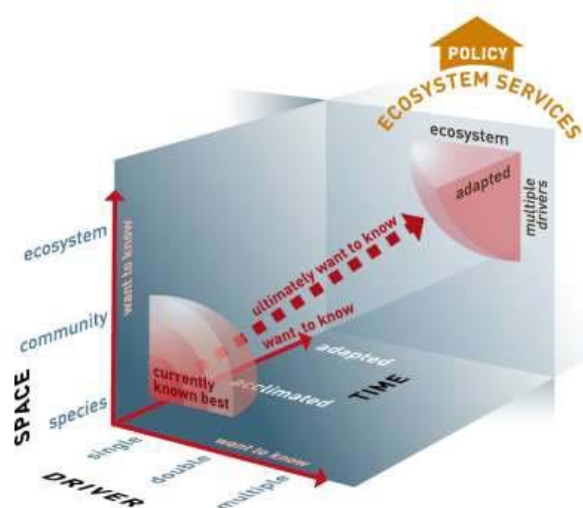


Figure 1 Present state of knowledge on Changing Ocean Biological Systems: most information on the impacts of ocean change presently available is on acclimated single species/strains under the influence of a single driver (lower left corner). Red arrows indicate the direction where we must expand our understanding. Assessment of impacts on ecosystem services, leading up to science-based policy advice, requires information on adapted responses to multiple drivers at the ecosystem level (upper right corner). From Riebesell and Gattuso (2015).

Background and Rationale

Theme 1: From single to multiple drivers

Experiments manipulating climate-related variables have provided valuable insights into the wide range of biological responses to projected alteration of oceanic conditions, for example ocean acidification (Gattuso and Hansson, 2011; Hutchins et al. 2013) or warming (Boyd et al., 2013). The design and interpretation of these single-driver manipulation experiments, in which a range of altered conditions – such as 550, 750 or 1000 μatm pCO_2 – are compared and contrasted with a control treatment (present day 400 μatm CO_2) – have been relatively straightforward. Since 2010, increased awareness across the marine science community of the complexity of the many concurrent changes to future ocean conditions (Doney, 2010) has resulted in more studies manipulating several environmental drivers concurrently. For example, one third of the 225 papers at the 2012 SCOR-sponsored symposium on “The Ocean in a High- CO_2 World” which reported on the biological response to Ocean Acidification (OA) also manipulated at least one other property (Cooley, 2012). Cooley reported a wide range of permutations of multi-driver perturbation experiments, for example pH and temperature, or CO_2 and nutrient manipulations. Figure 2 provides estimates of the number of studies which looked at multiple drivers (acidification plus at least another one) and how this trend has developed with time.

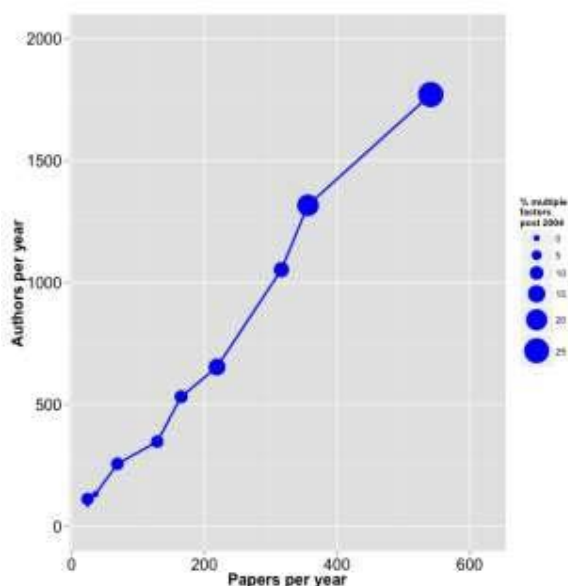


Figure 2 Increase in the number of papers focusing on both ocean acidification and other environmental drivers. Data courtesy of Jean-Pierre Gattuso, from a bibliographic database arranged with the Ocean Acidification International Co-ordination Centre (OA-ICC).

There has been a growing realisation that the experimental outcomes of such multi-driver experiments may not simply be additive and some are therefore highly non-linear, so their interpretation is exponentially more challenging than for single driver experiments (Figure 3).

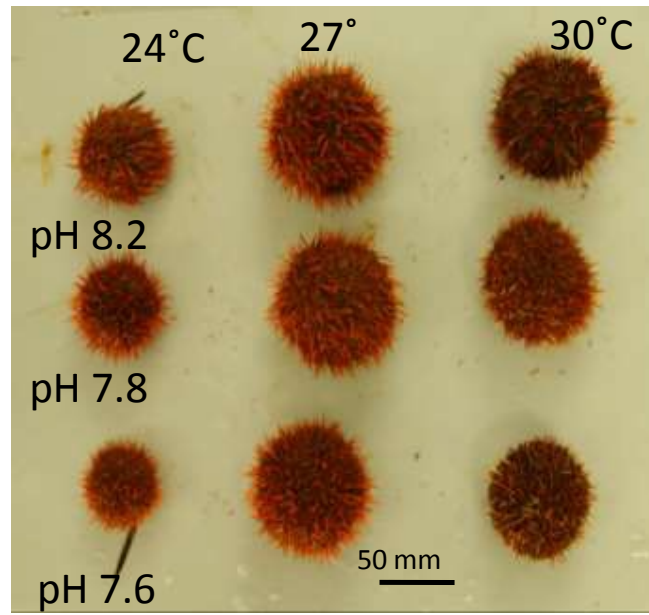


Figure 3 An example of the complex interplay of multiple environmental drivers on marine life. Temperature and pH both had a significant effect on growth of this sea urchin. Acidification reduced body size and warming mitigated this effect. Image - courtesy of Maria Byrne (University of Sydney, Australia).

Moreover, the results of the warming and acidification manipulation study on the sea urchin presented in Figure 3 highlight several important issues that have both direct scientific and wider policy ramifications. First, the effects of multiple drivers can offset or magnify one another, and so provide a different outcome than could be predicted from the results of a single-driver experiment. Second, the outcome of a multiple-driver experiment depends heavily on the selection and magnitude of the individual drivers being combined. Third, accurate communication and predictions of the collective effects of multiple drivers on marine life to policy makers requires consensus (in experimental trends) across a representative number of multiple-driver experiments.

Hence, to provide more reliable estimates of how marine biota will respond to the cumulative effects of multiple drivers requires that *we develop comprehensive approaches/studies that progress from single to multiple environmental drivers.*

Theme 2: From organisms to ecosystems

The findings from even sophisticated multiple-driver experiments on organisms, such as phytoplankton, that occupy a single trophic level in a foodweb cannot be used to predict how entire ecosystems will respond to complex ocean change (Boyd et al., 2010; Caron and Hutchins, 2013). The components within a foodweb, such as predators and their prey, may respond in very different ways to the same changing ocean conditions. For example, the physiology of microzooplankton (grazers) is more responsive than that of their prey (phytoplankton) to warming (Rose et al., 2009). Hence, as is evident for the previous theme, there has also been progress in the last five years in transitioning from an organismal to an ecosystem-level view of how marine life responds to global change (Brose et al., 2012).

There has been increased use of mesocosms (large volume, 1000 L or more, enclosures, Figure 4) to examine marine pelagic ecosystems in coastal and most recently oceanic waters, which has provided valuable information on the responses of the organisms that occupy trophic levels across foodwebs (Calbet et al., 2014). These mesocosm studies provide unprecedented detail on how ecological and biogeochemical processes will be altered by ocean change. This approach has also opened the door for implementing experimental evolutionary biology approaches in natural systems (Scheinin et al. 2015). Other ecosystems, such as those in benthic nearshore waters (from the tropics to the polar oceans) have also been examined via mid-term (months) deployments of innovative large volume (1000 L) experimental chambers such as Free Ocean CO₂ Enrichments (FOCE) (Gattuso et al., 2014). Both mesocosms and FOCE enable multiple large-scale multi-disciplinary marine manipulation experiments that detail both ecological and biogeochemical responses to environmental change (Figure 1).



Figure 4 Large volume mesocosms of 20 m depth deployed in the Raunefjord, Norway to investigate the impacts of ocean acidification on pelagic communities (photo: Solvin Zankl, GEOMAR, 2015)

Although these large volume holistic approaches are advancing this theme, they do have limitations, such as the logistical challenges presented in manipulating more than a single driver (Figure 4). This illustrates the need to build strong cross-links with theme 1 which can more readily tackle the effects of multiple drivers. Thus, an approach such as modelling that facilitates integration of *organism to community and ecosystem levels responses* is urgently needed.

Theme 3: From Acclimation to Adaptation

Virtually all manipulation experiments, whether based on single- or multiple-driver experiments with organisms, communities, or ecosystems, have not considered the potential for adaptation to influence the outcome of the study (Schaum et al., 2014). In order to detect a measurable response to environmental manipulation, such experiments are primarily conducted using climate change projections for the year 2100, and thus represent a quasi-instantaneous alteration of environmental conditions, for example, increasing pCO₂ from present day (400 µatm) to 750 µatm (projected in some climate change IPCC scenarios for year 2100) on a timescale of hours to days. Such an experimental design cannot take into account the abilities of the study organisms to acclimate (days to weeks) or adapt (longer timescales) to alterations of oceanic conditions that occur incrementally over years or decades. Adaptation via micro-evolution for rapidly reproducing organisms such as microbes has been shown to occur on shorter timescales (<1000 generations, years) than previously thought (Lohbeck et al., 2013, Hutchins et al. in press), revealing the ability and indeed the need to consider evolutionary responses in global change experimental design (see Figure 1).

Hence, failure to more accurately mimic the ability of organisms to respond to environmental change in manipulation experiments may give a series of misleading experimental outcomes which could skew predictions of how organisms, communities and/or ecosystems will respond to changing oceanic conditions. Thus, this third theme must be interwoven into themes 1 and 2, such that a subset of experiments considers *adaptation* in their design.

Terms of Reference (TOR)

- 1) Assess the current status of emerging research themes 1-3 by reviewing the literature to assess the dominant research foci, their relative coverage, and identify any major gaps and/or limitations. Publish this review in an open-access peer-reviewed journal.
- 2) Raise awareness across different scientific communities (evolutionary experimental biologists, ecologists,

- physiologists, chemists, modelers) to initiate better alignment and integration of research efforts.
- 3) Co-ordinate thematic transdisciplinary sessions to attract and assemble experts from other fields such as paleoceanography and marine ecotoxicology to learn from the successful approaches their fields have developed to address multiple drivers.
 - 4) Develop a multi-driver Best-Practice Guide (BPG, or other tools) as one potentially valuable way to help this research field move forward in a cohesive manner.
 - 5) Mentor early career scientists in the design process for complex multiple driver manipulation experiments, familiarize them with BPG, and teach them practical methodologies for the analysis of their experimental findings.
 - 6) Build an interactive website on 'multiple drivers and marine biota' to ensure the long-term future and inter-connectedness of this international research community, and to provide educational information at a variety of levels.
 - 7) Publish a series of short articles in both the scientific media and with scientific journalists to disseminate the challenges and opportunities surrounding multiple drivers and ecosystems.
 - 8) Engage with policy-makers and science communication experts to produce a glossary of terms and an implementation guide for policy-makers to better understand the role of multiple drivers in altering marine living resources and ecosystem services.

Working plan

The TOR will each be fulfilled as action items between and/or during WG meetings. We will run each meeting alongside conferences that will be well attended by WG members including *Oceans in a High CO₂ World* (May 2016), the *Ocean Global Change Biology Gordon Research Conference* (GRC, July 2016, 2018), and other venues – AGU/EGU meetings to minimise travel costs.

Year 1: The proposed WG will focus on TOR 1/2 to develop the point of departure for this WG (i.e. assessment of the status of emerging research themes), and to build a research community (better alignment and integration of research themes).

Specifically we will use the IPCC AR5 2014 marine chapters as a platform to assemble this Review (TOR 1). To 'kick-start' this WG, the Chair will initiate this Review so that a draft can be circulated to stimulate discussion at our inaugural meeting.

Efforts to initiate better alignment and integration of research efforts will commence early in year 1 by surveying different research communities (outlined in Figure 1) through customized questionnaires such as SurveyMonkey (<https://www.surveymonkey.com/>) that have been used previously by Boyd/Hutchins. Surveys will enable the WG to identify which meetings different researchers attend (e.g., experimental evolutionary biologists), that will help to assess the suitability of conferences (GRC, EGU, AGU) to bring together many different marine scientists.

At our first WG meeting, the design of customized questionnaires (akin to those used for the IPCC ocean acidification special report, Gattuso et al., 2013) will be discussed so they can be circulated (via the Web) at the end of year 1 to identify experts from other fields (e.g. marine ecotoxicology) to learn from their approaches to multiple drivers (TOR 2/3).

Year 2: We will build on our initial activities, in particular to co-ordinate thematic transdisciplinary sessions (TOR 3) and to develop a Best-Practice Guide (BPG, and/or other tools) for COBS. These discussions will commence at the 2nd WG meeting (end of year 1). We will target transdisciplinary workshops such as GRC/GRS (Gordon Research Symposia for early career researchers) which regularly attract a diverse range of speakers from paleoceanography to ecotoxicology (TOR2).

Based on the experiences of Riebesell/Gattuso in preparing and updating the Ocean Acidification BPG (Riebesell et al., 2010), this WG proposes to proceed in a more innovative and flexible way – via wiki books (<http://www.gms-books.de>). This approach can involve many contributors, leading to a better product that could be launched initially with a few chapters and expanded later. Furthermore, updates would be relatively straightforward to implement.

The synthesis of these findings will help guide us as to the timeline for developing BGP wiki books that will commence towards the end of year 2.

Year 3: The main goals (in addition to adding further value to earlier TORs that will be fulfilled, partially or wholly in years 1/2) will be to run a ‘hands-on’ training workshop that targets primarily early career scientists (TOR 5) and to build the interactive website (TOR 6). This will be done in conjunction with the capacity building activity of the Ocean Acidification International Coordination Center which organizes several training courses worldwide annually.

The workshop will train researchers, and in particular early career researchers (ECRs), in the design of complex multiple driver manipulation experiments. It will also familiarize them with BPG, and assist with development of skills needed for analysis of their experimental findings. The WG will bring together a diverse range of skillsets (physiology, -omics, bio- statistics, evolution, food webs, ecosystems, mesocosm ‘engineering’, chemistry, remote-sensing and modellers) to build a workshop programme. To make the most of the assembled interdisciplinary talents, the WG will seek co-funding from national and foundation science funding agencies to expand the scope of this workshop and maximise the participation of ECRs. We will align this workshop with a WG meeting to further enhance the interactions between the WG, other experts and the workshop participants. Our ability to raise additional funding will also determine whether we run this workshop once or twice during the WG’s four-year tenure.

The interactive website (TOR 6) will ensure the long-term future and inter-connectedness of this international research community, and provide educational information from school-leavers to postgraduate. It will also provide live links to prior TOR’s such as 1 (the state-of-the-art review) by updating bibliographies of new research, emerging policy documentation, and be a repository for topical popular articles.

In addition, the website will list international contacts and national programmes that are aligned with this research network, publicise up and coming events, workshops and conferences, and ensure that these activities and the capacity build during the lifetime of the WG continues to thrive beyond this WG.

Year 4 and looking beyond the lifetime of the COBS WG

The final TOR’s will be fulfilled in year 4, and together with some of the prior TOR’s will provide a range of flexible tools and approaches that up-and-coming ECRs (from TOR 5 workshops) as well as established scientists can build upon, ensuring the longevity of this research theme, that will be required for at least a decade (Riebesell and Gattuso, 2015).

We will publish articles (research and popular) in both the scientific media and with scientific journalists to disseminate the issues surrounding multiple drivers and marine ecosystems. Articles will include a thematic section in an open-access journal such as *Marine Ecology Progress Series*. Popular articles will be contributions to the media, as well as the product of discussions/advocacy with journalists at magazines including *Scientific American*. The website will integrate these approaches and make further links to a new generation of scientists and environmentalists who increasingly use social media to disseminate their research and scientific opinions.

The website will help to build strong relationships with policy-makers and science communicators to produce a glossary of terms and a practical implementation guide for policy-makers (similar to the IOC/UNESCO ocean fertilization guide) to better understand the role of multiple drivers in altering marine ecosystem services. 8 TOR will link to IPCC AR6 (due 2020) individual chapters, and assist with Executive Summaries and other IPCC products.

Deliverables

TOR 1 and 2: Communicate this state-of-the-art as a Synthesis paper to an open-access journal (end of year 1). This Review paper will contribute to IPCC AR6 cycle.

TOR 2 and 3: Co-ordinate thematic transdisciplinary sessions at international conferences to attract and assemble experts from fields such as paleoceanography and marine ecotoxicology. Produce a short popular article on this topic in an open-access journal (end of year 2)

TOR 4: Produce a BPG or equivalent tool(s) for COBS such as wiki books in conjunction with Copernicus/EGU (end of year 4)

TOR 5: Establishment of a new training course for young scientists moving into this field, with the intention of this becoming an annual or semi-annual event for the foreseeable future (years 3, 4, and beyond).

TOR 6: Build and maintain an interactive website focused on new approaches to multiple- driver research themes for document and methods collation, open forum discourse, and communication and outreach activities. Actively seek web co-ordinators and a host institution beyond the life of this WG.

TOR 7: Publish a transdisciplinary thematic series in an open-access journal such as MEPS. Publish a range of articles in both the popular scientific media and with scientific journalists to disseminate the challenges and opportunities surrounding multiple drivers and marine ecosystems.

TOR 8: Policy outreach via the production and dissemination of a clearly written, non- technical guide for marine resource managers and policy managers that includes a glossary of terms and a practical set of recommendations for predictive management of marine multi- driver impacts.

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

Given the need for long-term (i.e., well beyond the lifetime of a 4 year WG) and sustained international research into how biota will respond to a changing ocean, we have in part detailed some of our longer term aspirations in our working plan under the section “Year 4 and looking beyond the lifetime of the COBS WG”.

The combination of training workshops for early career scientists (TOR 5), online publication of a COBS BPG as wiki books (TOR 4), and of succession planning (TOR 6) beyond the lifetime of the proposed COBS WG will ensure the following:

- a) A new generation of scientists, from a wide range of countries, with comprehensive skillsets to further evolve the field of COB, and to meet the challenges that lie ahead in better understanding how ocean biota will respond to changing ocean conditions.
- b) A series of interactive guidelines (wiki books on a multiple drivers BPG) that can be readily updated and accessed on line by the emerging international community of both established and emerging early career researchers.
- c) An interactive website that will continue to act as a repository for new information and emerging initiatives that the international community can focus on.

The wide range of products from this WG from popular articles (TOR 7) to tools for policy analysts (TOR 8) will raise awareness on this issue from schools through to Governments. Such enhanced awareness will provide a platform for further engagement with a new generation of scientists, and the publications from the COBS WG will act as benchmarks that will be updated and improved over the coming decade.

The provision of synthesis products (TOR 1 and 2) will feed into landmark widely-read publications such as IPCC AR6 (due in 2020) and beyond 2020 provide a “point of departure” for other IPCC cycles. The outreach fostered by this WG will also provide important links into emerging and multi-faceted organisations such as Future Earth.

Working Group composition

Full Members

Name	Gender	Place of work	Expertise relevant to proposal
1 Philip Boyd (<u>chair</u>)	Male	Institute for Marine and Antarctic Studies, Australia	Phytoplankton and multiple drivers
2 David Hutchins	Male	University of S. California, USA	Global change and ocean biogeochemical cycles
3 Jean-Pierre Gattuso	Male	University of Paris, France	Foodweb responses to ocean acidification and warming
4 Ulf Riebesell	Male	IFM-GEOMAR at University of Kiel, Germany	Pelagic foodwebs and mesocosm enclosures
5 Christina McGraw	Female	University of New England, Australia	Chemical engineering and experimental design
6 Sinead Collins	Female	University of Edinburgh, UK	Experimental evolutionary biology
7 Aurea Ciotti	Female	Centro de Biologia Marinha (CEBIMAR), Universidade de São Paulo, Brazil	Detection of phytoplankton functional types from Space
8 Marion Gehlen	Female	CNRS-LSCE-IPSL-CEA, France	Biogeochemical modeler, co-chair e Marine Ecosystem and Prediction Task Team
9 Jorge Navarro	Male	Marine Science Institute, Austral University of Chile, Chile	Climate change and marine bivalves
10 Kunshan Gao	Male	Xiamen University, China	Multiple drivers and their interactive effects on ocean biota

Associate members

Name	Gender	Place of work	Expertise relevant to proposal
1 Hans-Otto Pörtner	Male	Alfred Wegener Institute, Germany	Animal physiology and multiple drivers, IPCC AR5 Co-ordinating lead author
2 Graham Bell	Male	McGill University, Canada	Evolutionary rescue and climate change
3 Gorann Nilsson	Male	Biosciences, Univ. of Oslo, Norway	Fish dynamics and climate change
4 Marcello Vichi	Male	Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy	Climate change modelling
5 Uta Passow	Female	Univ. California Santa Barbara, USA	Climate change and the oceans biological pump
6 Katharina Fabricius	Female	Australian Institute of Marine Sciences, Australia	Natural laboratories to study multiple drivers (vent systems)
7 John Havenhand	Male	University of Gothenburg, Sweden	Biostatistics and experimental design
8 Haruko Kurihara	Male	University of the Ryukyus, Okinawa, Japan	Impact of ocean change on marine invertebrates
9 Sam Dupont	Male	University of Gothenburg, Sweden	Coastal communities and multiple drivers

Working Group contributions

Together, the full members bring a wide range of expertise that ranges from multiple driver lab and field manipulation studies, evidence of biological responses to a changing ocean (from satellites), environmental sensor design, experimental evolutionary biology, and mathematical modelling.

Philip Boyd (Australia, Chair). Boyd is a Professor in Marine Biogeochemistry whose research focusses on the influence of multiple drivers on pelagic ecosystems. He was a lead author on the Ocean systems chapter of the IPCC AR5 report and will chair the 2016 Gordon Research Conference on Ocean Global Change Biology.

David Hutchins (USA). Prof. Hutchins has expertise in how global change affects marine biology and carbon, nutrient and trace metal biogeochemistry. His most recent work has examined evolutionary responses of phytoplankton to ocean acidification and warming, and he served as chair of the first Ocean Global Change Biology Gordon Conference in 2014.

Jean-Pierre Gattuso (France). Is a field leader in the study of multiple drivers and their effects on coastal marine communities using innovative experimental systems. He led the seminal European Project on Ocean Acidification (EPOCA) for four years.

Ulf Riebesell (Germany). Prof. Riebesell's research aims to address physiological, ecological, biogeochemical and, in recent years, evolutionary responses to ocean change. He combines approaches ranging from single species lab experiments to large-scale mesocosm studies on natural plankton communities.

Christina McGraw (Australia). Dr. McGraw is a chemical engineer who is a field-leading innovator in the design of experimental manipulations systems (ocean acidification under trace metal clean conditions. She is currently working on the design of novel sensors for multiple driver research.

Sinead Collins (UK). Dr. Collins is one of the pioneers of experimental evolutionary global change biology. Her expertise thus crosses disciplinary boundaries from evolutionary biology to marine science.

Aurea Ciotti (Brazil) Dr. Ciotti is a field-leading optical oceanographer who studies the remote sensing of phytoplankton communities in order to better assess how changing ocean conditions are altering community structure. She is a member of the International Ocean- Colour Coordinating Group.

Marion Gehlen (France). Dr. Gehlen is a renowned modeler focusing on global ocean biogeochemical processes in a changing climate. She is currently co-chair (along with Katja Fennel (Canada) of the Marine Ecosystem and Prediction Task Team.

Jorge Navarro (Chile). Professor Navarro is a leading researcher on the impact of ocean changes on commercial bivalves such as mussels. His multi-driver research has targeted larval to adult bivalves to assess which part of the life cycle is most susceptible to changing ocean conditions.

Kunshan Gao (China). Prof. Gao is recognized as the leading authority in China on ocean acidification and primary producers, including both microplankton and macrophytes. His recent work has focused on understanding the responses of phytoplankton to multi-variate climate change processes.

Relationship to other international programs and SCOR Working groups

The proposed working group will provide much needed linkages across a range of national programmes that are focusing on various aspect of multiple drivers, such as those investigating ocean acidification (BIOACID, Germany, www.bioacid.de/; UK Ocean Acidification Research Programme (UKOA) www.oceanacidification.org.uk/), the wider ramifications of aspects of multiple drivers on biogeochemistry (US Ocean Carbon Biogeochemistry, www.us-ocb.org/) or ecology (Japanese NEOPS (The New Ocean Paradigm on its Biogeochemistry, Ecosystem, and Sustainable Use), ocean.fs.a.u-tokyo.ac.jp/index-e.html). Other invaluable relationships will be formed with organisations such as the Ocean Acidification International Coordination Center, whose prior experience in running training workshops will help our proposed WG to excel in achieving our TOR #5.

At the international level, our SCOR working group will also liaise with other initiatives such as the recently established Gordon Research Conference (and Gordon Research Symposium for early career scientists) on Ocean Global Change Biology (for details of the inaugural July 2014 meeting see <https://www.grc.org/programs.aspx?id=15855>; for the 2016 GRC and GRS see <https://www.grc.org/conferences.aspx?id=0000771>). Several of the proposed full members of this WG are active participants in organizing the 2016 meeting.

Proposed full members also have strong linkages to other international programmes that have begun to focus some of their efforts on the field of multiple environmental drivers and marine biota. These include SOLAS (Surface Ocean Lower Atmosphere Study) which has identified "Multiple stressors and ocean ecosystems" as one of eight themes as part of their 2015-2025 research plan (http://www.solas-int.org/about/future_solas.html). Boyd has strong links with the SOLAS programme. Multiple drivers has also been the focus of the IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) programme which is holding a workshop on "Marine and human systems - Addressing multiple scales and multiple stressors" In late 2015 (<http://www.imber.info/>). Both Gattuso and Riebesell have long established links with the IMBER programme.

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APPENDIX 4

Proposal for a Working Group on Translation of Optical Measurements into particle Content, Aggregation & Transfer

Title: Translation of Optical Measurements into particle Content, Aggregation & Transfer

Acronym: TOMCAT

Summary/Abstract

Sinking particles transport organic carbon to the deep sea, where they form the base of life. The magnitude of particle export and the rate at which particles are consumed determine carbon sequestration in the oceans, and directly influence atmospheric carbon dioxide concentrations and global climate.

Traditionally, sinking particles have been collected using sediment traps. However, the limited spatial and temporal coverage of sediment traps have led to new technologies that focus on optical measurements to allow the collection of large data sets describing both frequencies and types of sinking particles. These can be used from ships or installed on remote platforms, promising greater spatial and temporal coverage. Yet, whilst technologies to image particles have advanced greatly during the last two decades, techniques to analyze the often immense data sets have not. One short-coming is the translation of optical particle properties (e.g. the image) into particle characteristics such as carbon content and sinking speed.

Moreover, different devices often measure different optical properties, leading to difficulties in comparing results. This working group aims to bring together experts in observation, experimentation, theoretical modelling, and data analyses to systematically improve the process of converting in-situ particle measurements to global export estimates. Final outcomes will include publications detailing intermediate steps and a framework outlining the most efficient way of converting large volumes of particle measurements into export estimates. The output of this working group should have high impact on future ocean research by enabling efficient use of the rapidly developing field of optical sensors.

Scientific Background and Rationale

The oceans play a critical role in controlling the climate by storing large quantities of carbon dioxide (CO₂) in the interior. The interaction between atmosphere and deep ocean storage is driven in large parts by the biological processes associated with production, sinking and remineralization of organic matter in the ocean. These processes, collectively known as the biological carbon pump, keep atmospheric CO₂ concentrations ~200 ppm lower than if the oceans were abiotic (Parekh et al. 2006). The size of ocean carbon storage is determined by the amount of organic matter exported and the rate at which sinking organic matter is reworked and respired in the mesopelagic zone (region between 100-1000 m depth) (Kwon et al. 2009). Accurate estimates of these two processes (export and remineralization of sinking organic matter) are therefore key to understanding the ocean carbon cycle and how it regulates atmospheric CO₂ concentrations.

One of the big challenges in estimating export and remineralization is the accurate measurement and characterization of sinking particle fluxes. Traditionally, export flux is collected using sediment traps, which collect particles at a certain depth over a period of several days to months. Owing to the limited spatial and temporal coverage of sediment traps, characterization of export flux is restricted. Short-comings include the inability to resolve variations in export flux over short time periods and across space. Moreover, particles are pooled in the sediment traps, making it hard to characterize the origin and composition of the individual particles. Rather, sediment traps give bulk estimates only and no information on the individual particles making up the bulk flux. Especially particle size is an important parameter determining how and how fast it sinks, how much material an object contains, and who can find and eat it. Knowing the sizes and abundance of the settling particles is the starting point for understanding how they interact with the marine environment.

As an alternative to sediment traps, most current large-scale assessments on the role of sinking particles in the marine carbon cycle focus on measuring dissolved biogeochemical tracers such as nutrients, oxygen or pH. These tracers reflect the net processes of particle transport and the circulation. Major observational programmes that use dissolved tracers include GO-SHIP (Global Ocean Ship-Based Hydrographic Investigations Program) and SOCCOM (Southern Ocean Carbon and Climate Observations and Modeling), which uses biogeochemical sensors on profiling floats. The focus on dissolved tracers is partly driven by two advantages; the sensor techniques are relatively advanced, and estimated rates are integrated over space and time thus reducing observational needs. However, these observations are unlikely to deliver any predictive understanding of how particle fluxes will respond to environmental change as they fail to identify the processes that control the sinking and transformation of particles.

Recent developments in in situ optical sensors may offer the opportunity to overcome some of these problems. Optical sensors use in situ photography ('imaging') or information on light transmission ('non-imaging') combined with automatic particle recognition to estimate particle type, size and distribution.

Commonly used devices include the Video Plankton Counter (VPR, Davis et al. 1992), the Underwater Video Profiler (UVP, Gorsky et al. 1992), Laser Optical Plankton Counter (LOPC, Herman et al. 2004), and backscattering sensors. Optical devices can be used from ships or installed on remote platforms (e.g. Argo floats), allowing greater spatial and temporal coverage than sediment traps. They provide high-resolution descriptions of particle frequencies and types and can inform about particle origin. Information about the particle transformation mechanisms can be inferred from observations of particle abundance and size-distributions at different water depths. Lastly, the use of optical devices has become increasingly attractive as they are becoming constantly more affordable.

The translation of optical particle properties into export flux estimates is, however, difficult due to missing information on carbon content and sinking speed. To understand the functioning of the ocean's biology and chemistry, it is necessary to determine how much mass is contained in each particle, their sinking velocity, and the summed contribution of all particles at different depths through the water column. The interpretation of optical measurements is further complicated as different optical devices often measure different optical properties leading to difficulties in comparing results.

The challenge now is to systematically improve the use of optical devices for understanding particle dynamics and export. This includes the comparison and inter-calibration of the outputs of available optical particle devices, as well as collation and distribution of knowledge on how to efficiently convert such optical information into particle export estimates. The working group would advance the processing of data from both imaging and non-imaging instruments, with a strong emphasis on comparing results from field programmes that have deployed both types of systems simultaneously. This will allow for optimization of information gained from already collected data (e.g. non-imaging sensors on profiling floats) and is expected to lead to recommendations on how to enhance current and future programmes by using optical devices. One of the most important aspects of the working group would be to assess which optical properties (e.g. backscattering, transmission or spectral information) and which processing techniques can best provide information on particle densities and chemical compositions, as this - along with sinking rates - is one of the weakest links between obtaining images and estimating material fluxes.

This working group would tackle an extremely timely challenge as the volume of data from optical sensors is steadily increasing, but much of the data are not worked up. This effort thus relies heavily on international collaboration and knowledge exchange, not least as it requires the collection of data from a broad range of ocean environments.

Terms of Reference

This working group will focus on converting optical particle information into sensible characterization of particle flux and export. It aims to

- (1) compare current devices that optically measure particles and document the advantages and disadvantages of each device.
- (2) inter-calibrate the outputs of different devices and/or highlight calibration difficulties.
- (3) define key parameters to use for interpretation of the optical information and decide which measurements are most important for characterizing particle export.
- (4) improve techniques/algorithms for the conversion of optical observation into fluxes.
- (5) decide on how to best analyse the increasingly larger data sets.

- (6) develop software examples and codes, placed on a public repository.
- (7) deposit optical particle data in an internationally-recognised database that can be actively added to as new data is collected (to allow for large scale analysis and future data exchange)
- (8) advise on future methods to maximize data collection and interpretation.

Working plan

The working group would be comprised of individuals with a wide range of expertise (observation, experimentation and theoretical modelling), which will help to facilitate discussion and problem solving. The working group will focus on four stepping stones to fulfill the terms of reference. The starting point for each stepping stone is the initial workshop that will bring together the experts and share the current state of knowledge. The working group will then identify sub-groups (where considered sensible), leaders, and will finalize a timeline for data analysis, synthesis and publication. The working group will meet once a year to ensure timely progress.

The first step would be the technology analysis, which will focus on optical instruments that have been deployed in various regions of the world's oceans and have collected an extensive database on particles. The working group will compare the outputs of these instruments. The main questions will address

- What data format is produced?
- Are the data comparable between instruments?
- Are there products that could be produced/recorded, but are not currently produced, which would facilitate either data analysis and/or data comparison between instruments?
- Is there a technology which seems to excel and appears particularly promising?

This step will further focus on validation and inter-calibration of the different devices. The working group would develop recommendations for standard methods to calibrate any of the instruments across different size ranges of particles. Subsequently, the working group would coordinate field programmes in different oceanic regions to cross-calibrate different optical sensors, taking particular focus on comparing imaging (UVP/LOPC/VPR) and non-imaging (backscatter/beam attenuation) techniques. We have identified three cruises across the Atlantic (40°N, 20°S, and 54°S; lead by the National Oceanography Centre, Southampton, UK) that will provide the opportunity for inter-calibration throughout the mesopelagic zone (the region between 100-1000 m depth).

Next, the working group will discuss information on how optical properties correspond to particle characteristics such as sinking speed and carbon content, which are key to estimating export fluxes. Special emphasis will further be put on identifying the type and source of the particles, and how particles change with depth. This step aims to discuss our current knowledge and hypotheses, and drive the community to focus research on filling the knowledge gaps. The final product should be a quantitative relationship between the optical properties of particles (whatever appears to be the most sensible in view of the available technologies) and particle characteristics (sinking speed and biochemical contents).

The third step will be to test the proposed relationship with the large data sets that have been collected so far. One of the outcomes should include a sensitivity analysis of how good optical measurements translate into real fluxes. If more research is needed, the details should be highlighted in this phase. An important outcome will be a better understanding of the frequency and resolution that is needed for reasonable export estimates. Overall, the resulting synthesis should greatly advance our understanding of spatial and temporal patterns of particle export.

Finally, a framework will be written that recommends the most efficient way of converting large-volume optical measurements into export estimates. This framework should have high impact on future ocean research as it will enable efficient use of the fast-developing field of optical sensors on remote platforms.

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

- (1) Review paper prioritizing research to fill identified knowledge gaps
- (2) Publication on inter-calibration of currently used optical devices
- (3) Sensitivity analysis of how good optical measurements translate into real fluxes
- (4) Framework of how to convert optical measurements into export fluxes and how to cope with large data sets

- (5) Data synthesis showing spatial and temporal patterns of particle export globally (high-impact publication)
- (6) Development of software examples and codes, placed on a public repository such as GitHub
- (7) Deposition of optical particle data in a common database that can be actively added to as new data is collected

Table 1. Time line of activities related to Terms of Reference

TOR	2016				2017				2018				2019			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Meetings																
1 Review paper																
2 Inter-calibration efforts																
2.1 Fieldwork/cruises		40°N				20°S		54°S								
2.2 Publication & recommendation																
3 Key parameters for conversion																
4 Improve algorithms																
5 Tackling large data sets																
6 Code repository																
7 Database																
8 Framework																

Capacity Building

Only a few nations use optical devices to measure in situ particles, a fact which is reflected in the composition of the list of proposed Full Members. We hope that the outcomes of this working group will highlight the benefits of optical measurements and encourage both collaboration as well as increased investment into their application, which may be especially attractive as optical devices are becoming increasingly more affordable. To realize these goals, the working group will seek funding to organize a summer school/training course on use of optical particle counters and how to access and analysis data from these instruments. The group will also develop and release example codes (e.g. in R and Matlab) on a public repository (such as GitHub) thereby allowing other researchers access to the codes for their own research. The group will also encourage students from developing countries to apply for the POGO-SCOR Fellowship Program for Operational Oceanography to transfer technology to developing countries.

We will further recommend standardized data documentation (i.e. units, etc.) and encourage submission of data on optical particles to a common database. We would encourage that every deployment of an optical instrument would be registered, so that even if the data is not available, details of the deployment are recorded to facilitate data sharing, data synthesis and collaboration.

The database will be supported by the British Oceanographic Data Centre (BODC). BODC is a UK national facility for looking after and distributing data concerning the marine environment. BODC has 26 years' experience in making high-quality data readily available to UK research scientists in academia, government and industry. They play an active role in the international exchange and management of oceanographic data, sitting on panels such as the International Oceanographic Data and Information Exchange (IODE). BODC will contribute to the working group by

- advising on best data practices and help formulate metadata standards to facilitate the collation of data into a database and its re-use in the wider scientific community, ensuring knowledge exchange. This will not only ensure the longevity of these important and valuable data but will help make them interoperable with other knowledge bases.
- using their experience of working on a wide range of national and international projects to help develop a suitable data policy.
- using their expertise in data-basing to develop a central inventory of deployments and will make data accessible through a central repository, hosted at BODC.

Working Group composition

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

Name	Gender	Place of work	Expertise relevant to proposal
1 Sari Giering (chair)	F	United Kingdom	Biological carbon pump, particle export measurements using sediment traps and Marine Snow Catcher, measuring optical properties of particle characteristics
2 Klas Ove Möller	M	Germany	Video Plankton Recorder (VPR), expertise in automatic particle recognition and characterization from photos, large volume data acquisition
3 Sünne Basedow	F	Norway	Laser Optical Plankton Counter (LOPC), expertise in particle recognition from transparency and size, size spectra, large data acquisition
4 Lionel Guidi	M	France	Underwater Video Profiler (UVP), expertise in automatic particle recognition and characterization from images, large volume data acquisition and analysis
5 Morten Iversen	M	Germany	In situ and ex situ photogrammetry of particles, connecting optical properties of particle characteristics
6 Andrew McDonnell	M	USA	Marine particle dynamics, in situ imaging of particles and zooplankton
7 Adrian Burd	M	USA	Theoretical modelling of particle dynamics
8 Catarina R Marcolin	F	Brazil	Automatic particle recognition LOPC and Zooscan, size spectra, large data acquisition and analysis
9 Sandy Thomalla	F	South Africa	Linking Southern Ocean optical property measurements and biogeochemistry to characterize plankton community and particle export
10 Tom Trull	M	Australia	Southern Ocean particle flux measurements, In situ measurement of particle sinking rates, use of gel traps to collect and characterize sinking particles, deployment and interpretation of optical sensor equipped moorings and Bio-Argo profiling floats.

Associate Member (no more than 10)

Name	Gender	Place of work	Expertise relevant to proposal
1 Emma Cavan	F	United Kingdom	Observations of dynamics of slow and fast sinking particles, correlation between particle images and sinking speed
2 Uta Passow	F	USA	Combination of lab-based experiments, mesocosm studies and field work to better understand particle dynamics and processes
3 George Jackson	M	USA	Modelling coagulation processes and sedimentation in marine ecosystems. Analyzing particle distribution data taken with multiple instruments. Comparing observations of particle size distribution with model predictions.
4 Nathan Briggs	M	France	Use of backscatter and fluorescence data to estimate large particle concentration, chlorophyll content, and export, esp. from autonomous platforms.
5 Dhugal Lindsay	M	Japan	In situ imaging, trophic level interaction
6 Lou Darroch	F	United Kingdom	Data management, collating data from research cruises and physical data repositories, standardising metadata from in-situ marine sensor networks

Working Group contributions (max. 500 words)

Detail for each Full Member (max. 2 sentences per member) why she/he is being proposed as a Full Member of the Working Group, what is her/his unique contribution?

Sari Giering (Researcher at the National Oceanography Centre, Southampton, UK):

Sari is a marine biogeochemist with research focus in carbon export, zooplankton ecology and particle dynamics. She has extensive expertise in using a combination of field measurements, models and data synthesis to better constrain the ocean carbon cycle.

Morten Iversen (Head of Helmholtz Young Investigator Group SeaPump at the Alfred Wegner Institute, Germany):

Morten's research focuses on understanding how food web composition influences particle export dynamics, specifically how particle size and composition determine sinking speed and particle remineralization. His group is developing several new camera systems and new in situ methods to collect intact marine particles.

Andrew McDonnell (Associate Professor at the University of Alaska Fairbanks, USA):

Andrew's research focuses on assessing the biogeochemical role of various particle processes such as particle formation, sinking, lateral transport and remineralization. He uses a wide range of laboratory and field methods including sediment traps, in situ photography and particle incubations.

Adrian Burd (Associate Professor at the University of Georgia, USA):

Burd's research focuses on mathematical and computer modeling of marine particles and their transformations relevant to biogeochemical cycling. His work has shown how particle aggregation and disaggregation are important for interpreting particle measurements and in understanding and predicting export flux, biogeochemical cycles, and trace metal cycling in the oceans.

Klas Ove Möller (Researcher at the University of Hamburg, Germany):

Klas' expertise is in optical sampling methods (e.g. Video Plankton Recorder) and automatic image classification. He further looks at biological and physical forcing on plankton and particle distribution patterns from small- to mesoscale as well as patchiness structures.

Sünnje Basedow (Researcher at the University of Nordland, Norway):

Sünnje uses the laser optical plankton counter (LOPC) to look at spatial distributions and size spectra of zooplankton and particles. She has compared the LOPC to the VPR and Multinet for intercalibration of instruments and currently focuses on calculating energy flow and trophic linkages within the pelagic community based on size spectrum theories.

Lionel Guidi (Researcher at Laboratoire d'Océanographie de Villefranche sur Mer, France):

Lionel's expertise is optical sampling measurements (especially the Underwater Vision Profiler, UVP), automatic particle recognition, large data compilation and analysis, and conversion of imaging data into flux estimates. Recent efforts included a global synthesis of particle size distribution and related estimate flux profiles as calculated from the UVP.

Catarina Marcolin (Researcher at University of São Paulo, Brazil):

Catarina uses optical systems such as the LOPC and ZooScan to automatically detect and measure plankton and particles in situ and ex situ. Her expertise includes coding for large data set analysis.

Sandy Thomalla (Senior Scientist at Southern Ocean Carbon and Climate Observatory, South Africa):

Sandy's research focuses on linking optical property measurements (scattering, absorption, attenuation) with the biogeochemistry (species composition, carbon content, size structure, photophysiology) in order to optically characterize the plankton community and predict carbon export potential. She further uses bio-optics floats with upward facing transmissometers to estimate particle flux.

Tom Trull (Professor of Marine Biogeochemistry at the Antarctic Climate and Ecosystems Cooperative Research Centre University of Tasmania, and Senior Principal Research Scientist CSIRO Oceans and Atmosphere Flagship Hobart, Australia)

Tom is an expert in Southern Ocean particle flux measurements, including in situ measurement of particle sinking rates, use of gel traps to collect and characterize sinking particles, deployment and interpretation of optical sensor equipped moorings and Bio-Argo profiling floats. He further aims to expand the global use of biogeochemical and bio-optical sensors on Argo floats to measure ocean ecosystem productivity and export.

Relationship to other international programs and SCOR Working groups (max. 500 words)

To our knowledge the only SCOR working group that focused on particle export was WG116 'Sediment Trap and

²³⁴ Th Methods for Carbon Export Flux Determination' (approved 1999). As outlined above, the development of optical sensors would complement sediment-trap-based export estimates and help to understand the biological carbon pump. This working group would further complement WG134 'The Microbial Carbon Pump in the Ocean' (approved 2008) in the effort of understanding the ocean carbon cycle.

Key References (max. 500 words)

Davis CS, SM Gallager, MS Berman, LR Haury & JR Strickler (1992) The Video Plankton Recorder (VPR): Design and initial results. Archiv für Hydrobiologie–Beiheft Ergebnisse der Limnologie 36:67-81.

Gorsky G, C Aldorf, M Kage, M Picheral, J Garcia & J Favole (1992) Vertical distribution of suspended aggregates determined by a new Underwater Video Profiler. Annales de l'Institut Oceanographique de Paris 68:13-23.

Herman AW, B Beanlands & EF Phillips (2001) A review of OPC and an introduction to the next generation of OPC: The Laser OPC. Journal of Plankton Research 26:1135-1145.

Kwon EY, F Primeau & JL Sarmiento (2009) The impact of remineralization depth on the air-sea carbon balance. Nature Geoscience 2:630-635.

Parekh P, MJ Follows, S Dutkiewicz & T Ito (2006) Physical and biological regulation of the soft tissue carbon pump. Paleoceanography 21:PA3001.

APPENDIX 5

Proposal for a Working Group on International Quality Controlled Ocean Database (IQuOD)

1. [Summary](#)

Historical ocean temperature profile observations provide a critical element for a host of ocean and climate research activities. These include providing initial conditions for seasonal-to-decadal prediction systems, evaluating past variations in sea level and Earth's energy imbalance, ocean state estimation for studying variability and change, and climate model evaluation and development. The International Quality controlled Ocean Database (IQuOD) initiative represents a community effort to create the most globally complete temperature profile dataset, with comprehensive metadata and uncertainty information to promote progress in all of the above research avenues. In particular, IQuOD will facilitate improvements in expendable bathythermograph (and other) bias corrections and improved ocean state estimate products for forecast initialization and climate change studies through more complete metadata and uncertainty information. Internationally agreed "best practice" approaches to data quality control will be developed, documented and shared with the wider research community through open-source code bases. The freely available IQuOD database will be based on, and served alongside, the World Ocean Database – the most complete and widely used ocean profile database in the world. An IQuOD SCOR working group will be fundamental to progress 5 key elements of the wider IQuOD initiative: (1) development and application of algorithms to populate missing profile metadata; (2) development and documentation of "best practice" automated quality control procedures; (3) development and application of uncertainty estimates for each observation in a profile; (4) assembly and distribution of the IQuOD database; and (5) knowledge transfer and capacity building through international collaboration.

2. [Scientific Background and Rationale](#)

2.1 Importance of subsurface ocean temperature observations

Subsurface temperature is an essential ocean variable required to monitor variability and change in the physical ocean, Earth's energy flows, global and regional sea level, and also the overall state of health and wealth of the marine environment (FOO, 2012).

Variations in ocean temperature give rise to changes in mixed-layer depth, stratification, mixing rates, sea ice extent, and atmosphere and ocean circulation. All of these changes in the physical environment can affect marine biology, directly and indirectly through changes in marine biogeochemistry, such as nutrient and oxygen recycling, uptake of (anthropogenic) carbon emissions, ocean acidification, etc (Pörtner et al., 2014).

Changes in ocean heat content are directly derived from subsurface temperature. Since 1970s, heat uptake by the global ocean accounts for more than 90% of the excess heat accumulated in the Earth system associated with anthropogenic climate change (Rhein et al., 2013). While this ocean heat uptake mitigates surface warming, it increases the ocean's volume through thermal expansion, accounting for about 1/3 of the observed global mean sea level rise (Church et al., 2013).

Subsurface ocean temperature observations also underpin a number of modeling activities (e.g., www.godae.org/What-is-GODAE.html). In particular, high quality long-term ocean temperature records with well characterized uncertainty estimates are needed to evaluate and constrain global climate and Earth system models in order to better quantify the physical drivers of past and current change, and also to predict future changes in both the marine and terrestrial environment (Flato et al., 2013).

Improved understanding of global climate change represents one of society's most pressing challenges and also the most demanding application of subsurface ocean temperature data. This is because it requires the highest quality, most consistent and complete database, to place modern changes in the context of past changes (e.g., mean trends and extremes), to separate the influence of natural drivers from human activities (Bindoff et al., 2013), and to improve the effectiveness of risk management assessments (identification of vulnerabilities, adaptation and mitigation responses).

2.2 The challenge

There is an increasing demand for a climate-quality global ocean temperature profile database (including complete metadata and well characterized uncertainty estimates) to underpin a host of climate change research activities carried out by both observational and modeling communities. Historical subsurface temperature observations, however, have been largely collected for purposes other than understanding global change, by a mix of evolving technologies (e.g., instruments with various accuracies and biases), and in many instances only available with reduced vertical resolution and/or incomplete metadata. Despite dedicated efforts by independent groups, the global historical database still contains a relatively large fraction of biased, duplicate and poorly quality controlled temperature observations that can confound global ocean and climate change research.

2.3 The IQuOD initiative

The overarching goal of the IQuOD initiative is to produce and to freely distribute the highest quality, most complete and consistent historical subsurface ocean temperature global database, along with (intelligent) metadata and assigned uncertainties.

With an internationally coordinated effort organized by oceanographers, with data and ocean instrumentation expertise, and in close consultation with end users (e.g., climate modelers), the IQuOD initiative will assess and maximize the potential of an irreplaceable collection of ocean temperature observations (tens of millions of profiles collected at a cost of tens of billions of dollars, since 1772) to fulfil the demand for a climate-quality global database that can be used with greater confidence in a vast range of climate change related research and services of societal benefit. Current IQuOD membership includes groups from Argentina, Australia, Brazil, Canada, France, Germany, India, Japan, Mexico, Norway, Russia, Senegal, Spain, South Africa, UK, and USA.

2.4 Rationale and timeliness for an IQuOD-SCOR working group

Only by focusing expertise and resources into a single best practice international community effort, we will be able to deliver a much needed historical “climate quality” subsurface temperature database to the global ocean and climate research communities. No single group has the combined expertise and resources to develop, implement and apply the best standard quality control procedures, in an effective and timely manner.

An internationally coordinated SCOR working group, potentially co-sponsored by IAPSO, and with formal support from the IOC Committee on International Oceanographic Data and Information Exchange (IODE), will provide the best mechanism to progress 5 critical steps towards the overarching goal of the IQuOD initiative during the next 3 years. These are: (1) development and application of algorithms to populate missing profile metadata; (2) development and documentation of “best practice” automated quality control procedures; (3) development and application of uncertainty estimates for each observation in a profile; (4) assembly and distribution of the IQuOD database; and (5) knowledge transfer and capacity building through close international collaboration.

Strong international participation is essential to draw on the widest possible pool of expertise and for IQuOD to be adopted as the definitive database for ocean and climate research activities. The IQuOD community has shown itself to be a well-organized international group – having already held two international workshops (in Hobart, Australia June 2013 and Silver Spring, USA in June 2014).

However, insufficient funding has prevented key members from attending these workshops. Funding from SCOR would allow the IQuOD initiative to gain 'critical mass' to ensure good progress over the next 3 years. This progress would be used to leverage further funding for task team activities as well as to expand the membership of the IQuOD community.

There are two main elements to the timeliness of the IQuOD-SCOR working group. The first is that there is an urgent need to capture and retain the knowledge of the older instrumentation types from researchers who are nearing retirement age. The second is that the Argo array of profiling floats has now provided about a decade of quasi-global observations and improved understanding of the ocean mean state and variability with which to refine our quality control procedures and better discriminate between good and bad data points in the historical record.

3. [Terms of Reference](#)

1. To develop, implement and document algorithms for assignment of “intelligent” metadata – i.e. an informed guess as to likely values for missing information – for temperature profiles where crucial metadata is missing.

2. To evaluate and document the most effective combination of automated quality control (AutoQC) procedures for temperature profile observations. International collaboration will be required for the design and coordination of benchmarking experiments using high quality reference datasets.
3. To establish and implement a set of optimal automated quality control procedures, by reaching international community consensus and using the knowledge gained in the benchmarking tests from ToR-2 (above); to produce and publish a reference guide for best practices in automated quality control of ocean temperature profiles; and to develop and freely distribute an open-source quality control software toolkit to promote wide and rapid adoption of best practices by the oceanographic community.
4. To examine and document the feasibility of machine learning and other novel computational methods for enhanced quality control, to potentially minimize labor costs associated with human expert quality control procedures.
5. To develop, implement and document internationally agreed best practice methods for assignment of uncertainty estimates to each temperature observation.
6. To freely disseminate (interim) versions of the IQuOD global temperature profile database (and added value-products) as it evolves over the next 3 years, in user-friendly file formats.
7. To share knowledge and transfer skills in instrumentation, regional oceanography, quality control procedures and data stewardship with international scientists in both developed and developing nations.

4. Work Plan

The IQuOD working group will progress the Terms of Reference in Section 3 by convening annual meetings over the next 3 years (upon funding by SCOR), together with regular email exchange, online meetings, information exchange through web-based access (www.iquod.org) and code development via the Mozilla Science Lab (gitHub) validation suite forum (www.mozillascience.org/projects/autoqc).

SCOR-funded meetings will be scheduled to coincide with relevant group meetings (e.g., SOT/SOOPIP, GTSP, XBT Science Team, GO-SHIP, Argo, IAPSO/IUGG, GODAE) to encourage interactions with both data experts and user groups, and maximize visibility and community participation in IQuOD activities. We will seek joint sponsorship and/or endorsement for IQuOD from IAPSO, WCRP/CLIVAR and US CLIVAR (Section 9).

The main activities for the work plan are:

(1) Development and application of algorithms for inclusion of intelligent metadata

We will develop and apply algorithms to attach “intelligent metadata” to historical temperature profiles with missing metadata. These algorithms will be developed as informed guesses, based on the available metadata. For instance, XBT manufacturer can often be inferred by the nationality of the vessel or research cruise, and likely probe type can be inferred from profile termination depth. Our initial focus will be on improving XBT metadata, but will later be expanding to include additional instrument types. XBT data comprise the largest fraction of the historical temperature observations and about 50% of these observations in the World Ocean Database have missing metadata (e.g., probe type, manufacturer, logging system, etc; Abraham et al., 2013). Inclusion of intelligent metadata will facilitate refinements to instrumental bias corrections and will promote a more homogeneous long-term ocean record critical for climate change research, data assimilation and modeling efforts.

(2) Development, implementation and dissemination of best practice automated quality control procedures

We will share expertise by performing a series of quantitative “benchmarking” automated quality control (AutoQC) tests among several data center groups and will establish an agreed best practice approach. Benchmarking results will be published in an open access peer-reviewed journal and will form the basis of the SCOR-funded IQuOD AutoQC toolkit, including open access reference guides and software tools made freely available to the wider oceanographic community. Data flagged as questionable by the best practice AutoQC tests will be carried forward to an IQuOD Task Team on “Enhanced Quality Control Procedures” (these activities are outside the scope of the SCOR working group).

(3) Development of uncertainty estimates

We will develop and document estimates of the random error for each individual observation, based on the current literature and manufacturer specifications. In liaison with end user communities, we will consider the wider treatment of uncertainties – such as that associated with XBT bias corrections in light of incomplete metadata – and how to best combine several sources of uncertainty.

(4) Global database assembly and distribution

The starting point for the IQuOD database will be NOAA's National Centers for Environmental Information (NCEI) World Ocean Database, which is the most complete global repository of ocean temperature profiles. We will ensure that the data format can accommodate all of the additional information that the IQuOD working group will provide. NCEI will also serve the IQuOD database (interim) versions (and any related gridded products), as it becomes available along the course of the next 3 years. IQuOD data products will also be served alongside Coupled Model Intercomparison (CMIP) data for climate model evaluation in collaboration with colleagues from the Program for Climate Model Diagnostics and Intercomparison (PCMDI, see attached letter of support).

Timeline

Year 1: will focus on the development and delivery of 'first cut' algorithms for intelligent metadata and random error assignments. We will also work towards coding up of all partner AutoQC procedures in a standard, open-source programming language (python). Version 1 of the IQuOD database will include intelligent metadata and initial uncertainty estimates. The first SCOR working group meeting will focus on achieving an agreed roadmap to progression of these tasks.

Year 2: will focus on the benchmarking of the various AutoQC procedures using a number of high quality regional reference data sets. These reference datasets have been quality controlled by skilled operators familiar with the regional oceanography, e.g., the QuOTA dataset (<http://www.marine.csiro.au/~cow074/quota/quota.htm>). The benchmarking analysis will identify the most effective combination of AutoQC checks and the work will be submitted to an open access scientific journal. The AutoQCed database, in combination with any advances in random error and intelligent metadata assignment, will constitute version 2 of the IQuOD database. The second SCOR working group meeting will serve to discuss the outcomes of Year 1, to share the results of the benchmarking tests and to provide an international forum for a consensus on best practices for AutoQC procedures for temperature observations.

Year 3: will focus in the preparation and submission of scientific papers related to the AutoQC benchmarking exercise; on the publication of version 3 of the IQuOD database with updates and improvements from the previous two years, including related documentation (reference guides and software tools). We will also be report on the feasibility of using machine learning (or other novel computational) methods for the expert quality control step, through publication of a discussion article. The third SCOR working group meeting will be organized as a large international workshop for knowledge transfer and capacity building, to encourage rapid and wide adoption of best standards for quality control of historical temperature profile data, inclusion of intelligent metadata and uncertainty. We will also seek additional funding sources to ensure maximum international participation, particularly from developing countries not yet involved in IQuOD.

5. Deliverables

1. (Years 1-3 and ToR 1-7) Versions 1 to 3 of the IQuOD database will be served from the NCEI website annually. Version 1 will contain all available metadata and intelligent metadata for XBTs, with initial uncertainty estimates. Version 2 will contain Automated QC flags and any other improvements to version 1. Version 3 will further contain updates and improvements from version 2.
2. (Years 1-2 and ToR 1, 5) Algorithms developed for assigning intelligent metadata and uncertainties will be published in an open-access peer-reviewed journal as part of the IQuOD v1 documentation. The source code will be made publicly available.
3. (Years 2-3 and ToR 2, 3) The IQuOD Automated QC algorithms will be documented and the source code made available on an open source software repository. The benchmarking results will be published in an open-access peer-reviewed journal as part of the IQuOD v2 documentation.
4. (Year 3 and ToR 4) The IQuOD community will publish a discussion article on the potential for novel methods (e.g. machine learning) to improve automated quality control systems.

6. Capacity Building

One of the key aims of IQuOD is to provide a long-lasting database for oceanography and climate change studies. It will be maintained at the National Centers for Environmental Information (formerly the National Oceanography Data Center, USA) alongside the World Ocean Database. IQuOD will facilitate new ocean and climate research based on the highest possible data quality with the most complete uncertainty and metadata information. All data, documentation and processing algorithms will be placed in the public domain to ensure maximum utility of working group activities for the wider research community.

The global IQuOD database will draw on and preserve knowledge and skills from a large community of data experts. These skills and knowledge pertain to a number of areas, including: instrumentation; quality control methods; data homogenization techniques; and regional oceanography. Knowledge transfer will be initially facilitated through international workshops but we expect to achieve longevity through fostering a new community of ocean scientists from both developed and developing nations. Guidance on “best practices” and open-access documentation will ensure that the progress made by this community is recorded and long lasting.

The SCOR working group will actively help build capacity by funding participants from developing nations to attend workshops and working with the community to leverage further funding from other sources.

7. Working Group Composition

7.1 Full members

	Name	Gender	Place of work	Expertise
1	TVS Udaya Bhaskar	M	Indian National Centre for Ocean Information Services (INCOIS), India	Automated and manual quality control; data processing; development of gridded products; web hosting; and ocean climate science.
2	Tim Boyer	M	National Centers for Environmental Information (former NODC), NOAA, USA	Data aggregation, quality control; database management; interoperability (file format); gridded data products; web hosting, and ocean climate change science.
3	Marcela Charo	F	Departamento Oceanografia, Servicio de Hidrografia Naval, Ministerio de Defensa, Argentina	Quality control; database management (Southwestern Atlantic Ocean); calibration and sensor expertise; software development, and ocean climate science.
4	Christine Coatanoan	F	Coriolis Data Center, IFREMER, France	Quality control procedures, data validation, management and objective analysis.
5	Catia Domingues (co-chair)	F	University of Tasmania, Australia	User: Global ocean content and implications for sea level. Steering team member of the WCRP Grand Challenge on sea level change and coastal impacts. Steering team member of the CLIVAR Research Foci CONCEPT-HEAT. Member of the CLIVAR Global Synthesis and Observations Panel.

6	Viktor Gouretski	M	University of Hamburg, Center for Earth System Research and Sustainability, Germany	Ocean instrumentation, quality control of hydrographic data, data processing and analysis, instrumental bias assessment and correction, uncertainty estimation, ocean climate change science (Southern Ocean and global).
7	Shoichi Kizu	M	Tohoku University, Japan	Theoretical knowledge on quality control, ocean instrumentation and bias corrections.
8	Alison Macdonald	F	Woods Hole Oceanographic Institute, USA	Quality control of temperature and salinity in density space, production of hydrographic data sets, database management, ocean instrumentation and calibration, uncertainty estimation, property transports and decadal scale property differences.
9	Matt Palmer (co-chair)	M	Met Office, UK	User: Climate modeling, ocean reanalysis. WCRP CLIVAR Global Synthesis and Observations Panel co-chair. Steering member for CLIVAR Research Foci CONCEPT-HEAT.
10	Ann (Gronell) Thresher	F	CSIRO, Australia	Auto and manual quality control procedures, ocean instrumentation and sensors, data management and software development. Extensive scientific, GTSP, WOCE and Argo quality control experience.

7.2 [Associate members](#)

	Name	Gender	Place of work	Expertise
1	Lijing Cheng	M	International Center for Climate and Environment Sciences, Institute of Atmospheric Physics Chinese Academy of Sciences, Beijing, China	XBT bias assessment, development of bias correction, and ocean climate science.
2	Mauro Cirano	M	Oceanographic Modeling and Observation Network (REMO), Tropical Oceanography Group (GOAT), Federal Univ. of Rio de Janeiro, Brazil	Data assimilation, numerical modeling, observational and modeling network.

3	Rebecca Cowley	F	CSIRO Marine and Atmospheric Research, Australia	Hydrographic data calibration and processing, quality control, data management, instrumental bias correction, and ocean climate science. Chair of XBT SOOPIP (Ship of Opportunity Implementation Program) under WMO-IOC JCOMMOPS (Joint Technical Commission for Oceanography and Marine Meteorology in situ Observations Programme Support Centre).
4	Sergey Gladyshev	M	P.P. Shirshov Institute of Oceanology, Moscow, Russia	Quality control, data management, ocean instrumentation and ocean climate science.
5	Simon Good	M	UK Met Office Hadley Centre, UK	Data aggregation, quality control; database management; interoperability (file format); gridded data products; software development, web hosting, and ocean climate change science.
6	Francis Bringas Gutierrez	M	Atlantic Oceanographic and Meteorological Laboratory, (AOML, NOAA), USA	Data acquisition, quality control, and management.
7	Katherine Hutchinson	F	University of Cape Town - Department of Oceanography (UCT), South Africa	Instrumental bias assessment and Southern Ocean science.
8	Gabriel Jorda	M	University of the Balearic Islands, Mediterranean Institute for Advanced Studies (IMEDEA CSIC-UIB), Spain	Hydrographic data analysis, atlas production (Mediterranean), ocean modeling and ocean climate science.
9	Sergio Larios	M	Centro Nacional de Datos Oceanograficos, Universidad Autonoma de Baja California, Instituto de Investigaciones Oceanologicas (CENDO - IIO – UABC), Mexico	Data acquisition and processing, quality control, database management, web hosting, outreach (teaching data visualization tools).
10	Toru Suzuki	M	Marine Information Research Center, Japan	Data archaeology, quality control and data management.

8. Working Group Contributions

TVS Udaya Bhaskar is Scientist-in-Charge for ocean observational data and is involved in data search, rescue and archaeology of historical in situ data of the Indian Ocean. He has considerable experience in quality control of in situ data and is involved in developing new quality control methods.

Tim Boyer oversees the World Ocean Database (WOD) project for the National Center for Environmental Information (NCEI, former National Oceanographic Data Center (NODC)) at the National Oceanographic and

Atmospheric Administration (NOAA) in the United States. He has been involved in collaborative international work for the World Data Center – Oceanography (WDC-O) and in using ocean temperature profile data to study ocean heat content change.

Marcela Charo is a data scientist with wide experience in planning and acquisition of oceanographic data, on-board sensor calibration, quality control of various instruments (XBT, CTD, Thermosalinograph) and sensors (temperature, conductivity, oxygen, fluorescence). She also has extensive experience in post-processing and data management after cruise acquisition to ensure high quality measurements now and in the future.

Christine Coatanoan is an expert on quality control applied to oceanographic datasets (floats, buoys, research vessels, ships of opportunity, drifters, gliders, sea mammals), which are collected at the Coriolis data center in France. She is also involved in the Argo program, and has experience in data validation using objective analysis.

Catia Domingues (co-chair) is an expert on the application of observational data sets to the understanding of variability and change in ocean heat content and implications for sea level. Her role in the project is scientific oversight and end user engagement to promote the greatest utility of IQuOD products for downstream applications (e.g., climate science and services).

Viktor Gouretski is responsible for quality assessment and analysis of global hydrographic data as a member of the Integrated Climate Data Center (ICDC) at the University of Hamburg, Germany. He has considerable experience in the quality assessment of hydrographic data obtained during the World Ocean Circulation Experiment (WOCE) and during pre-WOCE period, particularly from the Southern Ocean. His role in the IQuOD project is the development and assessment of automated quality control procedures and the development of bias correction schemes for the bathythermograph data and uncertainty estimation.

Shoichi Kizu is an Associate Professor at Tohoku University. He has carried out numerous studies on oceanographic instruments through data analysis and field and laboratory experiments, and participates in a Japanese research project on the management, service and application of observational data.

Alison Macdonald has expertise in quality controlling and analysing multiple parameters from large hydrographic data sets including repeat hydrographic sections. She is currently an active participant in the GO-SHIP program and was previously involved in large global observational programs (WOCE/CLIVAR). She is particularly interested in contributing to the discussions and formulation of the uncertainty estimates for the IQuOD database.

Matt Palmer (co-chair) is Lead Scientist for Sea Level Research at the Met Office Hadley Centre with expertise in ocean observations and climate model applications. He has considerable experience in delivering science through teamwork, having been involved in coordinating coupled model assessment and leading the delivery of scientific projects for UK government, the European Union, and commercial research projects.

Ann (Gronell) Thresher has been working in upper ocean temperature (UOT) data since the inception of WOCE, developing the principles of scientific quality control and applying this to both the data collected by Australian institutions and further developing this and applying it to the QuOTA database of Indian Ocean UOT data, a similar effort to that proposed for IQuOD. This includes development and implementation of a semi-automated quality control system which has helped illustrate the need for the IQuOD project.

9. [Relationship with Other Programs and SCOR Working Groups](#)

International Oceanographic Data and Information Exchange (IODE)

Recommendation IODE-XXIII.3: ESTABLISHMENT OF THE IODE PROJECT INTERNATIONAL QUALITY CONTROLLED OCEAN DATABASE (IODE-IQUOD)

The IOC Committee on International Oceanographic Data and Information Exchange,

Recognizing that the goal of the International Quality-controlled Ocean Database (IQuOD) is to construct the most complete, consistent and high quality ocean temperature (later including other Essential Climate Variables) historical database, with intelligent metadata and assigned uncertainties, to freely distribute for use in ocean, climate and Earth system research and applications of societal benefit,

Recognizing further that the IQuOD effort is organized by the oceanographic community and includes experts in data quality and management, data instrumentation, oceanographers, climate modelers and the broader climate-related community,

Noting the interlinked relationship with the Global Oceanographic Data Archaeology and Rescue (GODAR) and the World Ocean Database (WOD) Projects through Recommendation IODE-XXII.10 (2013) and the Global Temperature and Salinity Profile Programme (GTSP) established through Recommendation IODE-XV.4 (1996),

Noting further the potential contribution of the IQuOD to the JCOMM-IODE Marine Climate Data System (MCDS),

Convinced that joint work between the IODE and the IQuOD will be mutually beneficial,

Recommends the establishment of IQuOD as an IODE project; the establishment of the IODE Steering Group for the International Quality controlled Ocean Database (SG-IQuOD); and that the membership of the Steering Group shall initially include the Chair of GTSP, representatives of WOD and GODAR projects and of the Task Team on the MCDS.

Encourages all IOC Member States, Programmes, relevant organizations and projects, to collaborate with the IQuOD,

Invites the IQuOD Project Leaders to report on progress of the project to the Sessions of the IODE Committee.

In addition to being IQuOD members, Toru Suzuki, Charles Sun and Tim Boyer are also involved with IOC/IODE-related projects, such as GTSP, GODAR, MCDS and WOD.



15 April 2015

Letter of support for "IQuOD: International Quality-controlled Ocean Database"

To Whom It May Concern:

In our function as co-chairs of the international programme [GODAE OceanView](#) which provides coordination and leadership in consolidating and improving global and regional ocean analysis and forecasting systems, we hereby state our support for the IQuOD (International Quality Controlled Ocean Database) initiative. IQuOD represents the first globally coordinated effort with the goal to develop the most complete, consistent and high quality ocean profile database to support a range of ocean, climate and Earth system research and services of societal benefit.

The particular aspects of the project that we would like to highlight as of direct benefit to the GODAE OceanView community are:

- Provision of a highest quality reference data set, which can be used for bench-marking ocean data assimilation systems and producing global and regional ocean analyses
- Comprehensive uncertainty estimates on a per observation basis, which will enable refinements to data assimilation schemes and could also be adopted in operational systems
- Development of improved and internationally agreed "best practice" automated QC algorithms that can be adopted by the operational data centers of the GODAE community

We intend to follow the project's progress and, as a community, be directly involved in using IQuOD data products, promoting dialogue on data quality and articulating our requirements and priorities as an end user. There are existing linkages between IQuOD and GODAE OceanView through the Ocean Reanalysis Intercomparison Project (ORA-IP) and through the activities of the CLIVAR Global Observations and Synthesis Panel, which we hope to exploit fully as IQuOD gathers momentum.

With best wishes,

Andreas Schiller, CSIRO, Australia

Fraser Davidson, Fisheries and Oceans, Canada

Co-Chairs of the GODAE OceanView Science Team (GOVST)

For further information about GODAE OceanView please visit our website (www.godae-oceanview.org)

Program for Climate Model Diagnostics and Intercomparison (PCMDI)

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IQuOD Science Team
23rd April 2015

REF: IQuOD Project ("International Quality-controlled Ocean Database") Case for Support

To Whom It May Concern:

We are writing in support, and with the intention to collaborate with the IQuOD (International Quality Controlled Ocean Database) initiative. IQuOD represents the first globally coordinated effort with the goal to develop the most complete, consistent and high quality ocean profile database to support a range of ocean, climate and Earth system research and services of societal benefit.

IQuOD data products will be of direct benefit to a diverse range of climate modeling and research activities, including:

- Initial conditions and hindcast skill assessment for seasonal-to-decadal prediction
- Climate model evaluation and development
- Detection and attribution of historical climate change
- Development of observational constraints on future climate change

As part of this collaboration, we will work with the IQuOD team to help facilitate the integration of IQuOD data products into the World Climate Research Program's (WCRP) and Coupled Model Intercomparison Projects (CMIP) Earth System Grid Foundation (ESGF) data infrastructure. Making the IQuOD data available in this way will ensure maximum utility of IQuOD data products in climate and Earth system modeling research. We are also interested in working closely with the IQuOD team as the database evolves to include salinity observations in the future, which will be a valuable extension for assessing changes in the hydrological cycle.

We believe that a lack of critical diagnostic analyses of the ocean component of coupled climate models remains a key weakness in our understanding of future climate change – as the global oceans provide a fundamental control on the rate of climate change experienced. The IQuOD initiative is very much required.

Yours sincerely,

A handwritten signature in blue ink, appearing to read "Paul J. Durack and Peter J. Gleckler".

Paul J. Durack and Peter J. Gleckler
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US CLIVAR

IQuOD activities will be strategically placed to support the new 15-year US CLIVAR Science Plan (<http://www.usclivar.org/sites/default/files/documents/2014/USCLIVARSciencePlanFINAL-v3.pdf>). To achieve its mission, a list of scientific goals has been set with progress dependent on assessments of the adequacy of historical records, including the historical ocean temperature database (the focus of the IQuOD initiative). IQuOD activities will underpin the following US CLIVAR Science Plan goals:

- Understand the role of the oceans in observed climate variability on different timescales.
- Understand the processes that contribute to climate variability and change in the past, present, and future.
- Better quantify uncertainty in the observations, simulations, predictions, and projections of climate variability and change.
- Improve the development and evaluation of climate simulations and predictions.
- Collaborate with research and operational communities that develop and use climate information.

Janet Sprintall (Scripps Institution of Oceanography, USA) is the IQuOD representative and has previously been a member of the US CLIVAR Science Steering Committee (2012-2014).

CLIVAR Research Foci (RF) on planetary heat balance and ocean heat storage (CONCEPT-HEAT)

To advance understanding on the magnitude of the Earth's energy imbalance, how it is changing over time and implications for future climate change, there is a need to reduce inconsistencies between data and model products as well as to properly assess uncertainties in global and regional estimates – including the contribution from ocean heat storage, for both historical and modern periods. One activity recommended by the CONCEPT-HEAT RF is the improvement of the quality and completeness of the global database of historical ocean temperature profiles and its consistency with modern observations from the Argo era, including coordinated support for data and metadata archaeology. IQuOD will be coordinating with CONCEPT-HEAT to achieve the above goals. Catia Domingues and Matt Palmer (IQuOD co-chairs for the proposed SCOR working group) are members of the Science Steering Committee for CONCEPT-HEAT.

CLIVAR Global Synthesis and Ocean Panel (GSOP)

The IQuOD will be one of the future priorities for the World Climate Research Programme (WCRP) CLIVAR GSOP panel, as noted during the SSG meeting in Moscow, November 2014 (ICPO Informal Report 196/14). Matt Palmer and Catia Domingues (IQuOD co-chairs for the proposed SCOR working group) are respectively a co-chair and a panel member of the CLIVAR GSOP.

WCRP Grand Challenge on regional sea level change and coastal impacts

Thermal expansion induced by ocean heat storage is one of the two major contributions to the global mean sea level rise observed during the late 20th century. Thermal expansion is also expected to be a major component of future sea level rise. Improvement of the data quality, consistency and completeness of the global temperature database as part of the IQuOD activities will be critical to refine the global and regional sea level budgets as well as to constrain sea level predictions (near term) and projections (long term scenarios). Catia Domingues (one of the IQuOD co-chairs for the proposed SCOR working group) has been a co-chair for the scoping team and is now co-leading one of the work packages for the WCRP Grand Challenge on sea level change.

Other WCRP and CLIVAR research activities (not listed above)

Improvement of the quality and completeness of the global database of historical ocean temperature profiles and its consistency with modern observations from the Argo era, through IQuOD will also be relevant to the progress of a number of international community activities, such as the following WCRP Grand Challenges (<http://www.wcrp-climate.org/gc-regionalclimate>) and CLIVAR Research Foci (<http://www.clivar.org/science/clivar-research-foci>):

- Regional climate information (from seasonal to decadal prediction and long term projections)
- Intraseasonal, seasonal and interannual variability and predictability of monsoon systems
- Decadal variability and predictability of ocean and climate variability
- Understanding and predicting weather and climate extremes

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

We are planning to submit a proposal to IAPSO to financially co-sponsor IQuOD jointly with SCOR. There have been already some discussions with Isabelle Ansorge, Chris Meinen and Ken Ridgway, who were fully supportive

of our plan and encouraged us to submit a proposal. As noted above, IQuOD has been already endorsed by IOC/IODE.

SCOR sponsored project – Southern Ocean Observing System (SOOS)

One of the objectives of the SOOS is to facilitate and enhance global southern ocean observations, including historical records. In addition to being IQuOD members, Steve Diggs (Scripps, USA) and Roger Proctor (IMOS, Australia) are also co-chair and steering member of the SOOS data management sub-committee, respectively.

SCOR Working Group 142 – Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders

Hernan Garcia is an associated member of SCOR WG 142 and an IQuOD member with interests to use the IQuOD operating template to improve the quality of global databases for historical ocean salinity and oxygen.

SCOR/IAPSO WG 127 – Thermodynamics and Equation of State of Seawater The thermodynamic equation of state for seawater, 2010 (TEOS-1)

IQuOD activities will be using the seawater tools derived by TEOS10 (e.g., conservative temperature) to more accurately estimate ocean heat content changes.

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APPENDIX 6

Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) Program

SCOR-IOC Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) Program Activities, 2014-2015

This document presents the last activities of the GEOHAB project that finished at the end of 2014, and the transition period along 2015 toward its continuation as the new initiative GlobalHAB. Raphael Kudela and Elisa Berdalet, Chair and Vice-chair of GEOHAB, respectively, in representation of all the SSC members along the life of the program, as well as the whole scientific community engaged in the research on harmful algal blooms, **express their deep gratitude to the sustained support of SCOR to this programme and its continuation as GlobalHAB.**

1. Representation at IPHAB Meeting, April 2015.

GEOHAB was represented by the SSC Vice-Chair (Elisa Berdalet) at the XII IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB-XII) meeting held in Paris, on 28-30 April 2014. The Progress Report presented at the IPHAB meeting can be found at http://hab.iocunesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=1502.

Because the IPHAB meeting takes place once every two years, Berdalet presented an update of GEOHAB activities during the 2014-2015 period. The activities (and their corresponding science highlights) conducted until July 2014, were already in our 2014 report to SCOR. The activities performed since July 2014 are presented in the next sections of this document.

Berdalet acknowledged the decision of SCOR to accept to co-sponsor GlobalHAB, which was also appreciated by IOC IPHAB. With this funding, GlobalHAB will initiate the GlobalHAB SSC and foster the implementation of recommended workshops and activities agreed at the Final Open Science Meeting of GEOHAB (Paris, April 2013). **Berdalet emphasized the need for IPHAB member states to contribute additional funds to the implementation of GlobalHAB.**

She briefly presented the main components of GlobalHAB, as they had been presented to SCOR in its 2014 General Meeting (Bremen, September 2014). Namely, the Terms of Reference, the proposed structure, Agency Representatives (IOC and SCOR Secretariats), conceptual Scientific Steering Committee, reporting plan, timeline and expected outcomes during the period 2015-2017.

IPHAB decisions concerning GlobalHAB can be found at http://hab.ioc.unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15249. Essentially, IPHAB

- **Decided** to establish with SCOR an IOC-SCOR GlobalHAB Scientific Steering Committee in accordance with the draft Terms of Reference, as approved by SCOR and attached to this Decision as Annex I
- **Invited** other international scientific coordinating bodies to support GlobalHAB activities; and
- **Urged** Member States and their institutions to provide advice and resources to help implement GlobalHAB objectives.

2. Science Highlights

2.1. Summary for policy makers

This document, that constitutes one of the final products of GEOHAB, was led by Raphael Kudela, Elisa Berdalet, and Henrik Enevoldsen. The *Summary for Policy Makers* was delivered on June 2015 and disseminated by IOC (<http://www.unesco.org/new/en/natural-sciences/iococeans/single->

viewoceans/news/new_publication_on_harmful_algal_blooms_for_policy_makers/#.VeXWJngdzsJ. It can be download free at this link and it is also included in the Addendum of this document.

2.2. Co-sponsoring and participation at the Scientific Symposium on Harmful Algal Blooms and Climate Change
GEOHAB co-sponsored this symposium held in Göteborg, Sweden, on 19-22 May 2015; Raphael Kudela one of the conveners. Kudela and Berdalet also presented the oral communication "**From GEOHAB to GlobalHAB - International Research and Coordination of HABs Leading to Improved Societal Benefits**" at the symposium. Information about the symposium can be found at https://pices.int/meetings/international_symposia/2015/2015-HAB/organizers.aspx. Two publications with the symposium findings are in preparation.

2.3. Representation of GEOHAB at the 16th International Conference on Harmful Algae (ICHA) meeting in New Zealand (October 2014).

The venue allowed the final public outreach/meeting efforts for GEOHAB. The organizers of the conference facilitated a booth where posters synthesizing the activity of GEOHAB were exhibited, and GEOHAB distributed printed copies of the reports resulting from the programme, including the last published Synthesis Report. Members of the GEOHAB SSC provided information to many attendants of the conference who were interested about the future GlobalHAB programme.

3. Publications

GEOHAB Open Science Meeting Report

The SSC convened a synthesis GEOHAB Open Science Meeting at IOC Headquarters in Paris, France in April 2013. The SSC finalized the report and it was presented at the ICHA in New Zealand (October 2014). The Report can be freely downloaded from the GEOHAB web site (www.geohab.info).

Publication of a special issue

As part of the synthesis, the GEOHAB SSC, in coordination with the GEOHAB Core Research Projects (CRPs), identified a series of publications targeting *Oceanography* magazine. The additional funds received in August 2015 (H. Enevoldsen) will allow the publication of 6 papers in the mentioned journal by Spring-Summer 2016.

Appendix 7 Integrated Marine Biogeochemistry and Ecosystems Research (IMBER) Project

Annual Report to SCOR August 2015

A. Introduction

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER, www.imber.info) is an international global environmental change research project, co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and the International Geosphere-Biosphere Programme (IGBP, ending in 2015 after 30 years). The goal of IMBER science is to develop 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 2005 IMBER Science Plan and Implementation Strategy (SPIS) outlined questions and approaches to address this goal. The SPIS was updated in 2010 when the Global Ocean Ecosystems Dynamics (GLOBEC) project ended and its activities were incorporated into IMBER. Having completed its first 10 years, IMBER is now planning its next scientific phase. A new SPIS that will form the basis for the next decade of IMBER research has been developed and will be submitted to SCOR for review and approval in Fall 2015. The current structure of IMBER (Fig. 1) provides the starting point for implementation of the SPIS.

IMBER's strong commitment to curiosity-driven science provides the foundation for its new 10- year research plan. However, the environmental issues facing society, particularly those relating to global environmental change, are issues that challenge natural and social sciences and humanities. Integration of the understanding provided by curiosity-driven natural science and the problem-driven, societally relevant science requires research that cross the interfaces between these disciplines (transdisciplinary research). A clear message from the 2014 IMBER Open Science Conference (OSC) and community consultation associated with development of the SPIS was that transdisciplinary research must be part of any future research agenda. This is underscored by the science discoveries and highlights presented in the next section, most of which are drawn from publications subsequent to the OSC.

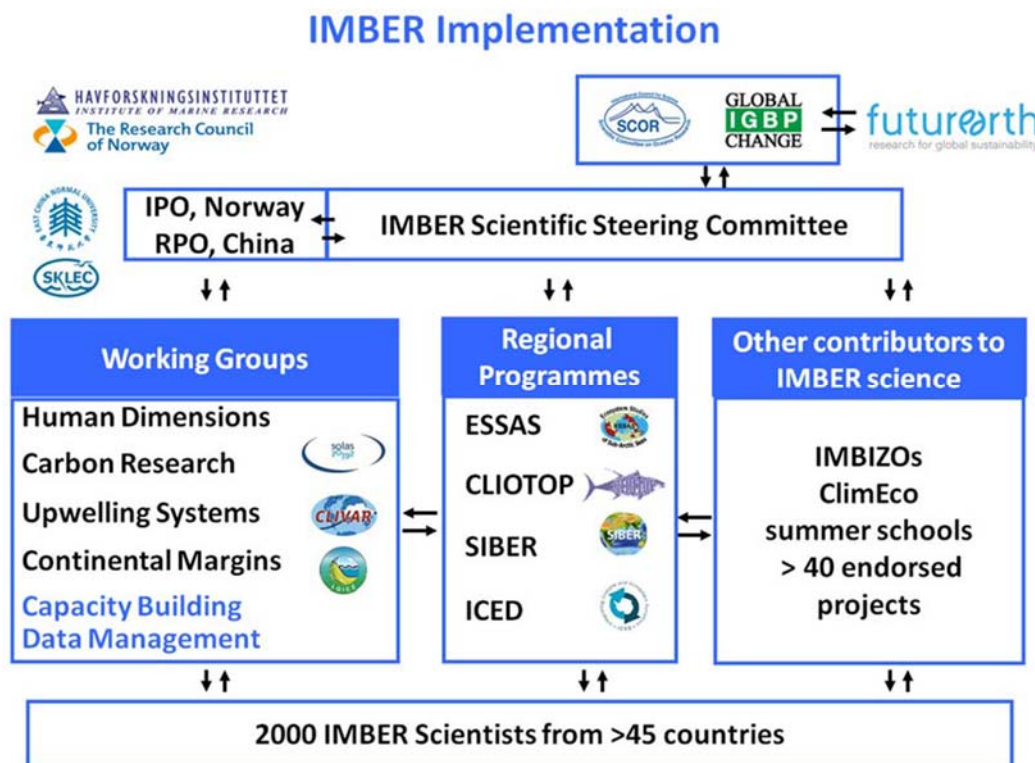


Fig. 1. Structure of IMBER.

Selected recent IMBER discoveries and highlights

- IMBER advanced understanding of climate effects on marine ecosystems in the Anthropocene
- IMBER advanced understanding of natural-human science interactions in marine systems
- IMBER is developing societal-ecological decision support frameworks for marine systems
- IMBER promoted and undertook capacity building and knowledge transfer activities
- IMBER research informs sustainable use of marine ecosystems

Selected recent discoveries and highlights from IMBER regional programmes, working groups and related research projects are:

From: Ecosystem Studies of Sub-Arctic Seas (ESSAS):

- The Atlantic Multidecadal Oscillation (AMO), with a 60-80 year periodicity (Fig. 2), was shown to extend into the high latitudes and Arctic regions, as observed in temperature and sea-ice data (*Drinkwater et al., 2014*)

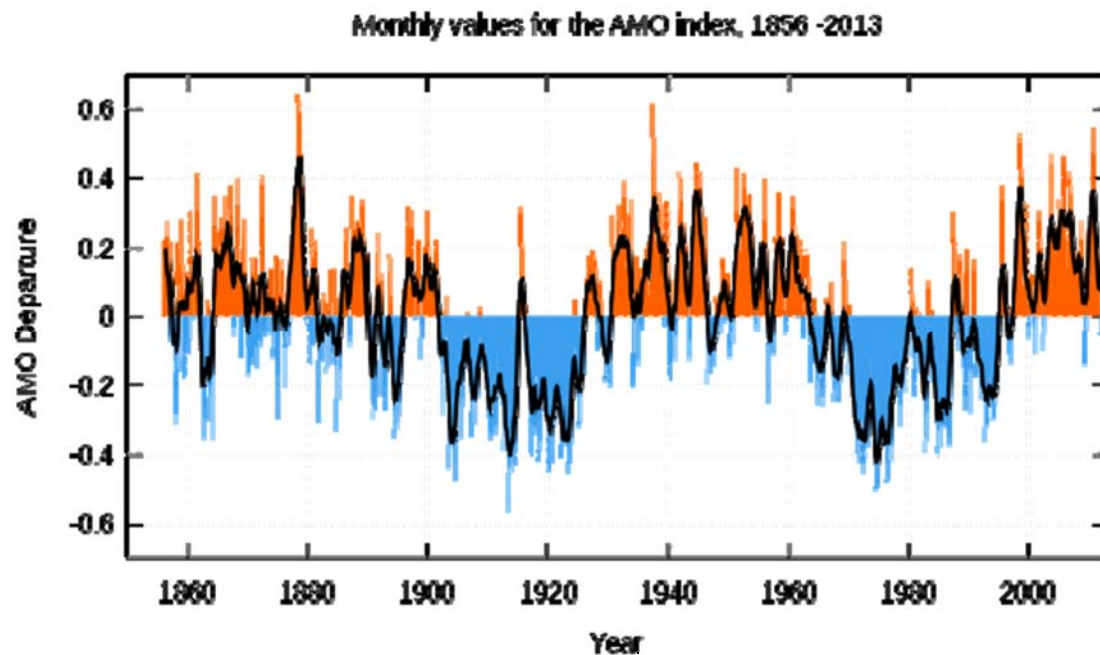


Fig. 2. 157 year development of the Atlantic Multidecadal Oscillation Index expressed as standardized anomalies and de-trended, i.e. excluding the anthropogenic signal. (<http://www.esrl.noaa.gov/psd/>).

- Contrary to the general perception of increased primary production in frontal regions, enhanced production is not observed in association with the Polar Front in the Barents Sea and the Arctic Front in the Norwegian Sea. The International Polar Year (IPY) project NESSAR (Norwegian component of the ESSAS) was the first to demonstrate that these frontal regions are primarily density compensating with strong interleaving between the warm, saline Atlantic waters and the cold, low saline Arctic waters. Turbulence near the fronts is relatively weak. Although mixing occurs through both double diffusion and current shear, it is not strong enough to mix nutrients into the surface layers during the stratified period. No secondary upwelling circulation was observed and, hence nutrients are low in the frontal region once the spring bloom is over (*Drinkwater and Tande, 2014*).
- Circulation on the Bering Sea shelf, through the Bering Strait and on the Chukchi Sea shelf, is tightly coupled, with transport anomalies through the Strait driven by the longitudinal location of the Aleutian Low (*Danielson et al., 2014*).
- Much of the diatom production on the Bering Sea shelf is consumed by protists in the microzooplankton, rather than by zooplankton such as copepods and krill, as previously believed. These microzooplankton are also

important in the food web, supporting a large summer zooplankton biomass on the shelf, when they can be more abundant than phytoplankton (Sherr *et al.*, 2013; Stoecker, *et al.*, 2014).

From: Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED):

- Antarctica's Ross Sea is projected to lose more than half its summer sea ice by 2050 and more than three quarters by 2100. This will be a dramatic change for the area, which is one of the few polar regions that has experienced an increase in summer sea ice coverage over the past few decades. This loss of sea ice has important implications for biological production of the Ross Sea (Smith *et al.*, 2014).
- Winter fast-ice trends over the past 100 years for the South Orkney Islands, Antarctica, demonstrate marked inter-annual variability and long-term changes. These findings indicate the need for caution in interpreting changing ice conditions based on shorter-term satellite series (Murphy *et al.*, 2014).
- Despite inhabiting one of the strongest currents in the world's oceans, Antarctic krill appear to be able to influence their distribution at large oceanic scales through behavior that facilitates maintenance of population centers (Tarling and Thorpe, 2014).
- Due to warming, species richness may increase in Antarctic water masses as sub-Antarctic species increasingly encroach southwards (Ward *et al.*, 2014).
- Changes in penguin abundance and distribution can be used to understand the response of species to climate change and fisheries pressures, and to gauge of ecosystem health (Waluda *et al.*, 2014).
- Zooplankton faecal pellet production is a key control of the efficiency of deep carbon transfer in the Scotia Sea. This area contains the largest seasonal uptake of atmospheric carbon dioxide yet measured in the Southern Ocean (Manno *et al.*, 2015).
- Dissolution dominating calcification processes in polar pteropods are close to the point of Aragonite undersaturation (Bednaršek *et al.*, 2014).
- IMBER/ICED scientists contributed to a Southern Ocean biogeographic atlas, www.biodiversity.aq.

From: Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER):

- The Indonesian Throughflow (ITF) is a chokepoint in the upper ocean thermohaline circulation that carries Pacific water through the strongly mixed Indonesian Sea and into the Indian Ocean. This suggests that most of the ITF nutrient supply goes into the thermocline waters, where it can support new production and impact Indian Ocean biogeochemical cycling (Ayes *et al.*, 2014).

From: Climate Impacts on Ocean Top Predators (CLIOTOP):

- From the 137-year long record of the El Niño-Southern Oscillation (ENSO), no significant trend can be detected, and the recent multi-decadal variability is similar to earlier decades. ENSO has not fundamentally changed over the period of large increase in atmospheric CO₂, and the potential of predicting the future states of the fisheries and ecosystems are quite limited. (Harrison and Chiodi, 2015)
- Major uncertainties in modelling frameworks are broadly categorised into those associated with (i) deficient knowledge in the interactions of climate and ocean dynamics with marine organisms and ecosystems; (ii) lack of observations to assess and advance modelling efforts and (iii) an inability to predict with confidence natural ecosystem variability and longer term changes as a result of external drivers (e.g. greenhouse gases, fishing effort) and the consequences for marine ecosystems. As a result of these uncertainties and intrinsic differences in the structure and parameterisation of models, users are faced with considerable challenges associated with making appropriate choices on which models to use. A key research direction is the development of management systems that are robust to this unavoidable uncertainty. (Evan *et al.*, 2015)

From: SOLAS/IMBER Carbon (SIC) Working Group:

- The Surface Ocean CO₂ Atlas (SOCAT, www.socat.info), compiled by the international marine carbon community, provides access to quality-controlled surface CO₂ data (Fig. 3). The first two versions were released in 2011 and 2013, respectively. Version 2 contains 10.1 million quality-controlled, surface ocean fCO₂ (fugacity of CO₂) values from 1968 to 2011 for the global oceans and coastal seas. Version 3 of the Atlas was released on 7 September 2015 (Bakker *et al.*, 2014; Pfeil *et al.*, 2013; Sabine *et al.*, 2013).

- Scientific applications of SOCAT include: 1) quantification of the ocean carbon sink and 2) ocean acidification and their temporal and spatial variation, 3) validation of ocean carbon models and coupled climate carbon models, and 4) provision of constraints for atmospheric inverse models used to estimate land carbon sink (*Landschützer et al., 2014; Lauvset et al., 2015; Rödenbeck et al., 2014; Séférian et al., 2014; Tjiputra et al., 2014*).
- SOCAT synthesis products represent an impressive achievement in coordinating international researchers to deliver publicly accessible and uniformly quality-controlled data for marine carbon and ocean acidification research that can be used for research and to inform international policy and climate negotiations.

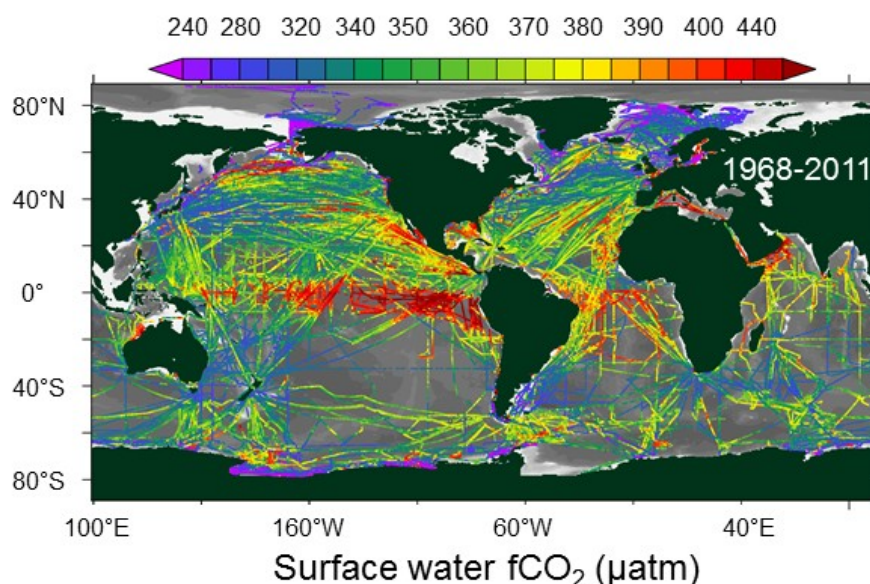


Fig. 3. The global distribution of surface water $f\text{CO}_2$ values in SOCAT version 2 for 1968 to 2011 (<http://www.socat.info/>; Bakker et al. (2014))

From: Capacity Building Task Team:

- IMBER is proactive in building and strengthening the scientific capacity of early to mid- career researchers, and scientists from developing countries. A major activity in facilitating capacity building is the biannual international, transdisciplinary ClimEco (Climate and Ecosystems) summer school. To date, more than 300 students and early career researchers, many from developing countries, have attended the four summer schools organized by IMBER (*Hofmann et al., submitted*).

From: Human Dimensions Working Group (HDWG):

- IMBER-ADApT (Assessment based on Description, Responses and Appraisal for a Typology) developed by the HDWG, is an integrated assessment framework built on knowledge learned from past responses to global change issues. It will enable decision makers, researchers, managers and local stakeholders to make more efficient decisions for marine sustainability, and to evaluate most effectively where resources should be allocated to reduce vulnerability and enhance resilience of coastal people and communities to global change (*Bundy et al., 2015*; <http://www.imber.info/index.php/eng/Science/Working-Groups/Human-Dimensions/IMBER-ADApT>).

From: Continental Margins Working Group:

- The quest for resources is driving exploration and exploitation on continental margins, including the Arctic margins. Disasters, such as the 2010 BP-Deepwater Horizon oil spill, are likely to occur with increasing frequency and exacerbate on-going threats, such as coastal hypoxia. The IMBER-LOICZ Continental Margins Working Group (CMWG) found that the prevailing Law of the Sea promotes exploitation, but with

insufficient responsibility and accountability to stem unsustainable development on continental margins. Recommendations from CMWG activities focus on reforms based on better understanding of the social-ecological systems (*Levin et al., 2015*), assessment of risks associated with development, and effective governance (*Glavovic et al., 2015*).

From Endorsed projects:

GALATHEA

- Nutrient availability is considered to be a primary control on size structure of phytoplankton communities, with small cells being more competitive at low nutrient concentrations. However, research from the GALATHEA project indicates that temperature also appears to have a direct effect, with small cells dominating the community structure in warmer water. This temperature effect on cell size has implications for the ocean as a carbon sink because of the slower sinking rate of small cells (*Mousing et al., 2014*).
- Localised vertical mixing between 200 m and the depth of the deep chlorophyll maximum (DCM, approximately 130 m) stimulates phytoplankton activity and alters the distribution of zooplankton. Eel larvae in the Sargasso Sea tend to be concentrated in areas of deep mixing. This deep localized mixing may be responsible for heterogeneity in plankton distributions. Research continues to better understand the processes leading to this vertical mixing (*Richardson et al., 2014*).
- It is expected that ocean warming will lead to increased bacterial activity and faster remineralisation of particulate organic carbon (POC) in the surface layers, which increase POC export to deep waters, potentially decreasing the strength of the biological pump. This temperature sensitivity of remineralisation in the global ocean has now been quantified and is an important input for modelling of the ocean carbon cycle (*Bendtsen et al., 2015*).

PERSEUS

- Changes in the structure and functioning of the Black Sea food web between 1960 and 2000 were investigated with four models developed to evaluate trophic transfers. These models showed new energy pathways resulting from changes in trophic components and the conversion of significant amounts of system production to detritus. This shift in the food web led to various ecosystem-wide changes (*Akoglu et al., 2014*).
- The project provided the first climatology of the seasonal thermocline slope and the upper- ocean heat storage rate in the Mediterranean Sea. This has Implication of sub-basin circulation patterns and the ocean heat storage. Climatologies of the mixed layer depth and temperature in the Mediterranean Sea was also updated (*Houpert et al., 2014*).
- Biogeochemical data of the surficial and sub-surficial sediments of the Adriatic Sea were processed using statistical Q factor data analysis. Four different biogeochemical facies were identified, indicating that the biogeochemical and sedimentary processes of the Adriatic Sea have changed slightly in the last century (*Spagnoli et al., 2014*).
- The connection between climate variability and anchovy spawning and recruitment in the Black Sea and other ecosystems, was studied using a two-way coupled lower trophic level and anchovy bioenergetics model. Temperature was the dominant factor influencing early life stages and the population dynamics of Black Sea anchovy through its effect on anchovy egg production and recruitment success. Each 2°C decrease in summer mean temperature resulted in a 12- to 19-day delay in egg production. This strong link between climate variability and anchovy spawning and recruitment could have important prediction potential for short-term anchovy stock estimations for fisheries management (*Guraslan et al., 2014*).
- Human activities, such as shipping, aquaculture, and the opening of the Suez Canal, have led to the introduction of nearly 1000 alien species into the Mediterranean Sea. The local taxonomic identity of the alien species is dependent on the dominant maritime activities/interventions and the related pathways of introduction. Further research is needed to better understand how biodiversity changes will affect Mediterranean Sea food webs, ecosystem functioning, and the provision of ecosystem services (*Katsanevakis et al., 2014*).
- Climate variation has increased surface temperature and stratification, producing a decrease in winter mixing. Oxygen and nutrient dynamics in the middle pycnocline have been decoupled. Nutrient concentrations in the upper layer decreased with the decrease in anthropogenic eutrophication. Warm periods (series of warm winters) led to a decrease of oxygen in the Cold Intermediate Layer (CIL), an elevation of the hydrogen sulphide boundary and a decrease of nutrients in the surface layer. Cold periods (series of cold winters) lead to

an increase of oxygen in the CIL, deepening of the hydrogen sulphide boundary and increase of nutrient in the surface layer (*Pakhomova et al., 2014*).

- Biomass size distribution, light absorption properties and carbon and nitrogen uptake rates were analysed in phytoplankton assemblages along coast–offshore gradients in the Alboran Sea. Surface nitrate concentration was $>1 \mu\text{M}$ at the coastal stations and less than the detection limit at the offshore stations. Phytoplankton community biomass was dominated by diatoms at the coastal sites; dinoflagellates and picoplankton contributed <30 and 7% , respectively (*Mercado et al., 2014*).
- Studies of nutrients and phytoplankton during a deep convection episode showed that nutrient supplies were equivalent to the annual river discharge and that these events counterbalance decreased surface silicate to nitrate ratio. New hypotheses were proposed to explain triggering of the intense spring bloom (*Severin et al., 2014*).
- An overview of the pressures impacting the Southern European Seas (SES) and their roles in altering the environmental status was undertaken. Additional knowledge and improved understanding is needed to undertake a scientific Good Environmental Status (GES) evaluation. Some of the indicators for the *Marine Strategy Framework Directive* (MSFD) are almost impossible to evaluate for operational purposes (e.g. those related to biodiversity, food web structure, marine litter and microplastics, underwater noise and energy). Additional targeted scientific priorities were identified for the SES to help reduce uncertainties and gaps in data and knowledge (*Crise et al., 2015*).
- The swarms of Portuguese Man-of-War (*Physalia physalis*) that appeared in summer 2010 in the Mediterranean Sea had dramatic consequences, including the region's first recorded human fatality attributed to a jellyfish sting. Analyses of the meteorological and oceanographic conditions of the Northeast Atlantic Ocean in the months prior to the appearance of *P. physalis* and simulation of the probable drift of Atlantic populations into the Mediterranean basin suggested that the swarms resulted from an unusual combination of meteorological and oceanographic conditions the previous winter, and was not a permanent invasion due to favourable climatic changes (*Prieto, et al., 2015*).
- Trawls in the coastal areas of the Eastern Mediterranean and Black Sea found up to 1211 items of litter per km^2 . Plastics were the most abundant (mostly bags and bottles) litter, up to 95% of the total, in all study areas. More than half of marine litter items were of medium size: $10 \times 10 \text{ cm}$, $<20 \times 20 \text{ cm}$. The results are presented in a recent report, supporting the Marine Strategy Framework Directive (MSFD) implementation, as well as efforts to discourage plastic carrier bag use (*Ioakeimidis et al., 2015*).
- A visual census of marine litter on the seafloor of the Saronikos Gulf (Greece) was combined with environmental education in a novel two-day research cruise, in which schoolchildren actively participated in using a Remote Operated Vehicle (ROV). Marine litter proved to be an ideal theme to enhance the environmental awareness of schoolchildren (*Ioakeimidis et al., in press*).
- The first observation-based acidification trends in the water masses of the Atlantic basin over the past two decades were presented and compared with climate model results. Observations and model output confirm that pH changes in surface layers are dominated by the anthropogenic component. In mode and intermediate waters, the anthropogenic and natural components are of the same order of magnitude and sign (about -0.002 yr^{-1}). Large changes in the natural component of newly formed mode and intermediate waters are associated with latitudinal shifts of these water masses caused by the Southern Annular Mode in the South Atlantic and by changes in the rates of water mass formation in the North Atlantic (*Aida et al., 2015*).

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- Identifying the magnitude of a trend and the point in time when this signal emerges from the background noise of natural variability is essential for the detection of climate change. Even strong trends, in both the physical climate and carbon cycle system, can be masked by variability over decadal timescales in areas with high natural variability. Because natural variability, unlike the trend, is affected by the seasonal cycle, observational data must be interpreted with caution. Intra-annual variability may obscure the representativeness of irregularly sampled seasonal measurements taken over a year and, thus, the interpretation of any observed trends (*Keller et al., 2014*).
- Global CO_2 emissions from fossil-fuel combustion and cement production will increase by 2.5% ($1.3\text{--}3.5\%$) to $10.1 \pm 0.6 \text{ GtC}$ in 2014, 65% above 1990 emissions. The cumulative emissions of CO_2 (from 1870–2014) will reach about $545 \pm 55 \text{ GtC}$ (*Le Quéré et al., 2014*).

- It has been argued that controlling only the Earth's temperature (e.g. the 2°C target) may not be sufficient to control the other impacts of climate change. Six target variables (air temperature, sea-level rise, aragonite, primary production levels, soil, and carbon loss) were analysed under different limits using a state-of-the-art cutting-edge Earth system model. The results showed that allowable carbon emissions were considerably reduced, suggesting that mitigation efforts focused solely on a temperature target will not limit the risk arising from human-induced emissions (*Steinacher et al., 2013*).
- By 2100, under the high CO₂ emission scenario RCP8.5, pH reductions exceeding -0.2 (-0.3) units are projected to be about 23% (~15 %) for waters of North Atlantic deep-sea canyons and ~8% (3 %) waters over seamounts, including seamounts proposed as sites for marine protected areas. The spatial pattern of impacts reflects the depth of the pH perturbation and does not scale linearly with atmospheric CO₂ concentration. Impacts may cause negative changes of the same magnitude, or exceeding the current target of 10% of preservation of marine biomes set by the Convention on Biological Diversity, implying that ocean acidification may offset benefits from conservation/management strategies that rely on regulation of resource exploitation (*Gehlen et al., 2014*).

Too Big To Ignore (TBTI, <http://toobigtoignore.net/>)

- **To address the marginalization of small-scale fisheries in policy and governance, an Information System (ISSF, <http://issf.toobigtoignore.net/>), containing information such as fishing area, gear type, targeted species and catch fate, has been developed.** As of March 2015, ISSF contained 1,740 records contributed by 400 individuals from 140 countries. This extensive and comprehensive information system makes possible for the first time the development of evidence-based descriptions of the existence and importance of small-scale fisheries around the world (Jentoft and Chuenpagdee, 2015).

B. Activities of 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 and Arctic marine ecosystems and their sustainability. The recent expansion of ESSAS research interests into the Arctic resulted in modifying the name to Ecosystem Studies of Sub-Arctic and Arctic Seas, which retains the programme acronym. Comparative ecosystem studies are an important part of ESSAS research and this provides a basis for interactions with other IMBER regional programmes.

ESSAS held an annual science meeting (in conjunction with its Science Steering Committee (SSC) meeting) at the University of Washington in Seattle, WA, USA on 15-17 June 2015. The theme of the symposium was “The Role of Ice in the Sea”. Session themes included:

- Humans, Ice and the Sea in the Subarctic and Arctic Past
- The Role of Sea Ice in the Arctic and Subarctic
- Ecological Roles of Glaciers in the Sea
- Socio-economics of Management for Resilience

An ESSAS-related special issue of the journal *Progress in Oceanography* on “Modelling and observational approaches to understanding marine ecosystem dynamics” will be published in 2015. In addition, 11 papers describing results from the Norway-USA Climate Change and Marine Ecosystems Workshop will be submitted to *Elementa: Science of the Anthropocene* before the end of 2015.

RACArctic (Resilience and Adaptive Capacity of Arctic marine systems under changing climate), a joint Japan-USA-Norway activity, was recently awarded 500k Euros from the Belmont Forum to synthesise information from regional studies.

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

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

Highlights from ICED science over the past year are described in section B. In addition, ICED scientists provided input for the IPCC AR5 chapter on polar regions. Several studies focused on assessments of changes in Antarctic ecosystems are ongoing. Also, end-to-end models that include carbon are being developed to provide scenario projections. An ICED community paper on scenarios is being developed. ICED will strengthen the science areas as outlined in the new IMBER Science Plan, and will work to establish a strong role for ICED within CCAMLR, SCAR and Future Earth.

ICED has engaged stakeholders through a partnership with the World Wildlife Federation (WWF) to hold a workshop on krill and its fishery. The WWF provided links to fisheries and NGOs. The Marine Stewardship Council certification of the krill fishery also encourages interaction between the various stakeholders.

A joint AnT-ERA / AntClim21 / ICED session on ‘Impact of climate change on Antarctic biota’ was convened at the SCAR Open Science Conference in Auckland, New Zealand on 28 August– 3 September 2014.

Revision of the online fieldwork map tool is underway, and a Southern Ocean wiki, led by the ‘Sentinel’ programme is being developed.

Climate Impacts on Oceanic Top Predators (CLIOTOP) Regional Programme

CLIOTOP aims to organise large-scale comparative efforts to elucidate key processes involved in the impact of both climate variability (at various scales) and fishing on the structure and function of open ocean pelagic ecosystems and their top predator species. The ultimate objective is to develop a reliable predictive capability for the dynamics of top predator populations and oceanic ecosystems combining the effects of fishing and climate.

www.imber.info/CLIOTOP.html.

A special issue of *Deep-Sea Research II* (26 papers) was published following the 2nd CLIOTOP symposium. Meetings organized by CLIOTOP Working Groups have generated a large amount of scientific results as indicated by the publications listed on the IMBER website at (<http://imber.info/Science/Regional-Programmes/CLIOTOP>). CLIOTOP has been ongoing for almost 10 years, and is now assessing its scientific objectives and structure in terms of the new IMBER SPIS. Currently, CLIOTOP research is done through working groups, several of which will soon be concluded. The CLIOTOP SSC is now discussing a new structure for a proposed CLIOTOP phase III, for the next five years. As a start towards this process, the IMBER SSC at its meeting in June 2015 supported the continuation of CLIOTOP as a regional programme, gave a mandate to modify the programme structure, and recognized the need for flexibility in how limited resources are allocated.

CLIOTOP organised a workshop on “Variability in the movement patterns of marine predator populations: physiological, behavioural and environmental drivers” as part of the Bio-logging 5 Symposium on 22-26 September 2014 in Strasbourg, France.

CLIOTOP also participated in the Euro BASIN workshop on ‘Futures of the North East Atlantic Ocean by 2040 - a Stakeholder Consultative Workshop’ in November 2014.

Several sessions proposed for the ICES/PICES 3rd International Symposium on Climate Change Effects on Marine Ecosystems in Santos City, Brazil, March 2015 were initiated by CLIOTOP.

The 3rd CLIOTOP Symposium will be held from 14 to 18 September 2015 in San Sebastian, Spain. The title of the symposium is ‘The Future of Oceanic Animals in a Changing Ocean.’

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). It focuses on understanding climate change and anthropogenic forcing on biogeochemical cycles and ecosystems in the Indian Ocean, 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).

SIBER's project office is hosted at INCOIS in Hyderabad, India and recently a regional office (headed by Louis Wicks) was established in Perth, Australia.

SIBER has actively supported the deployment of (new) biogeochemical sensors in the Indian Ocean. SIBER activities in the past year have been in support of the second International Indian Ocean Expedition (IIOE-2), which will be launched at the International Indian Ocean Expedition Symposium in Goa, India, 30 November-4 December 2015. The Symposium will coincide with the 50th anniversary of the National Institute of Oceanography in Goa. Data collected on IIOE-2 cruises will be submitted to national repositories, in accordance with the IOC data-sharing policy regulations.

The Eastern Indian Ocean Upwelling Research Initiative (EIOURI) has emerged as a major SIBER activity. This is a 5-year process study under the IIOE-2 in the Eastern Indian Ocean, focusing on upwelling.

SIBER has strong collaborations with various regional organizations (e.g., Indian Ocean Panel of CLIVAR and IOGOOS). A positive result is that this collaboration provides a model for CLIVAR-IMBER collaboration.

C. Activities of IMBER Working Groups and Task Team

SOLAS-IMBER Carbon (SIC!) Working Group

IMBER currently has three joint SOLAS-IMBER carbon (SIC!) working groups that consider carbon in the surface ocean systems (SOS), carbon in the interior ocean (IOC) and ocean acidification (SIOA).

Surface Ocean Systems (SIC!-SOS)

The main goal of this group is the continued development of the Surface Ocean Carbon Atlas (SOCAT).

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). Recent activities focused on the analysis of carbon data from hydrographic surveys to determine the change in the ocean's anthropogenic CO₂ content since the 1990s. This analysis is now in the final stages (paper draft completed) and the synthesis project should be completed by early 2016. This group also contributed to the planning of the upcoming joint GO-SHIP/Argo/IOCCP meeting in Galway on the topic of "Sustained ocean observing for the next decade" <http://www.gaic2015.org>, assisted in the development of essential ocean variables (EOV), led by IOCCP (see <http://www.ioccp.org/foe>), and also assisted in the development of global dataset of ocean interior variables (GLODAPv2, led by CarboChange).

SOLAS-IMBER Ocean Acidification (SIOA)

The SIOA working group coordinates international efforts and synthesis activities for ocean acidification research. Within a single decade ocean acidification has gone from a research area of limited interest to one that is now considered to be a priority for ecology and environmental sciences. This rapid expansion has made it difficult for experts to share information and train new scientists from different countries.

The Ocean Acidification International Coordination Centre (OA-ICC), initiated and mainly driven by the SIOA, is in its final year of funding (2013-2015), and a proposal has been submitted to IAEA in Monaco for three additional years of support. The Centre 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 and is chaired by a SIOA member. The OA-ICC produced several key products that have become fundamental building blocks for the ocean acidification research community and 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 including data from almost 600 publications); 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 https://www.iaea.org/ocean-acidification/download/Resources/OA_slides-generalaudience_17feb2013.pdf.

The 4th Ocean in a High-CO₂ World Symposium will be held in Hobart, Australia on 3-6 May 2016. SIOA organised several side events at the IPCC *Our Common Future Under Climate Change* conference in Paris in July 2015, and produced a variety of outreach material.

Continental Margins Working Group (CMWG)

The CMWG is co-sponsored by IMBER and Future Earth Coasts (previous LOICZ). As human activities dominate key global processes in the Anthropocene, there is an urgent need to secure sustainability by implementing transformative governance strategies to safeguard Earth's life-support systems for long-term human well-being. Nowhere is this endeavour in greater demand than at the ocean-land interface – the continental margins, which are experiencing pressures from:

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

The CMWG published a synthesis paper in *Current Opinion in Environmental Sustainability* that outlines the threats to continental margin systems and potential consequences if mitigation actions are not initiated.

The CMWG is currently being restructured with a new IMBER co-chair (K Limburg) and membership. The CMWG is discussing the focus for this next phase of research. This may be regional, with particular focus on Arctic issues and regional seas. New members will be chosen for their expertise to undertake the work of the CMWG.

Data Management Committee (DMC)

The Data Management Cookbook (<http://imber.info/index.php/Science/Working-Groups/Data-Management/Cookbook>) remains an important and significant product of the DMC. Data management workshops have been organised at the IMBIZOs and the OSC. At IMBIZO IV the DMC will provide advice and guidance on all data-related issues. The SSC discussed if a separate committee is still needed for data management. The consensus was that continuation of DMC would be only with a revised focus and mandate (e.g. social science data use), which will require membership with different expertise. It is noted that even managing just a meta-database requires a dedicated data liaison person. Making use of international *in situ* data organizing activities, e.g. “Data kind.org” might be an approach for submitting metadata that identifies IMBER data. A plan for the future is needed if DMC shall continue, however the DMC has earlier recommended: to fully integrate data management activities in all IMBER project-wide events; to ensure that endorsed projects are prepared to comply with IMBER DM policies; and to organise 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 less developed countries, enhance research capabilities globally in relevant IMBER activities, and strengthen graduate education in ocean sciences. The IMBER SSC believes that the CBTT has completed its mandate and will disband this group. Capacity building will continue as it is now included in all regional programmes and working groups, and through activities, such as the summer schools and IMBIZOs.

The CBTT has produced a synthesis document describing the IMBER capacity building activities during the past ten years. It is anticipated that this document will be published later in 2015. This will be the legacy of the CBTT.

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. One of its major achievements has been the development of the I(MBER)-ADApT decision support tool (see section B).

I-ADApT has been published and is now being tested using the 23 case studies submitted thus far. The case studies developed as part of the Human-Ocean-Human workshop held at IMBIZO III are being collated into an I-ADApT synthesis book, which affords the ability to include information that is not as quantitative or synthesized to the level that is needed for a peer-reviewed publication. The HDWG wants to ensure that the information underlying the case studies is preserved.

On a longer term the intention is to develop a database of global case studies as an open-access web site to help decision makers, researchers and stakeholders decide how to respond when faced with difficult choices and trade-offs. There is an open invitation and template to supply case studies to the I-ADApT system. Because of the complex interactions and feedbacks between humans and the ocean, the case study template includes questions about the natural, social and governing systems, the stressors that affect them, their response and an appraisal of that response.

IMBER-CLIVAR Upwelling Working Group

Interest from CLIVAR in biophysical interactions and dynamics in upwelling regions resulted in formation of a joint working group on upwelling. A workshop held at the *Climate Change in the Oceans* conference in Santos, Brazil in March 2015 identified priority research areas for the working group. An Upwelling Workshop will be held at IMBIZO IV and participants will also be asked to suggest research topics that can be pursued in a 3-5 year timeframe. The 10 current working group members represent most of the global upwelling systems.

D. Other IMBER activities

ClimEco Summer Schools

IMBER ClimEco Summer Schools are held every two years and are a successful capacity building mechanism for engaging 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’*, was held in early August 2014, at East China Normal University, Shanghai, China. It focused on indicators that inform 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. Sixty-four participants from 30 countries were selected from almost 170 applications received. SCOR provided support for two students from developing countries.

Topics covered in lectures included 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 enabled participants to try out the methods and techniques covered in lectures. Several participants provided datasets so groups could select indicators and use them to evaluate the state of a system or species. Students presented their results at the end of the course. The event received excellent reviews from the participants.

Planning is now underway for ClimEco5, which will be held at the University of Rio Grande do Norte in Natal, Brazil in early August 2016. The focus of this summer school will be on *‘Towards more resilient oceans: Predicting, managing and mitigating future changes in the ocean and their impacts on human societies’*. Advertising and fund-raising for the summer school will begin in Fall 2015.

IMBIZO IV

The IMBIZO IV will be held in Trieste, Italy on 26-30 October 2015. The IMBIZO has been expanded to four concurrent workshops and several integration sessions. Funding has been secured from several sponsors, including SCOR, to support students and early career researchers. The planning and preparation for the IMBIZOs is a major effort for the IPO.

Development of the new IMBER Science Plan and Implementation Strategy (SPIS)

The new SPIS is based on a position paper that was discussed at the IMBER Open Science Conference (OSC) in June 2014. The current version includes a new vision and research goal for IMBER, and is developed around three Grand Challenges (GC) and four Innovation Challenges (IC). Specific research questions relating to the GCs and ICs are intended to provide the basis for implementation of research programs. The SPIS will be submitted to SCOR and

Future Earth (FE) in October 2015 for joint review.

IMBER will maintain its focus on fundamental biogeochemistry and ecosystem research, but will expand to include aspects of sustainable oceans, human well-being, biodiversity conservation, and making science relevant to society. Another issue is to ensure that IMBER science is available in a form that can be used to influence decision-making that will safeguard marine ecosystems and their dependent human societies. Achieving this will require the involvement of a diverse science community that is drawn from a range of different disciplines, including quantitative global change social science, international relations, and ocean geopolitics. IMBER will also engage in activities that enhance integration among and between IMBER's regional programmes, working groups and endorsed projects.

IMBER contributions to IGBP synthesis and celebration at AGU

IMBER submitted a manuscript to the IGBP synthesis special issue of *Anthropocene*. Minor comments were received from reviewers, which are now being addressed. A revised manuscript will be submitted in late September. It is anticipated that this special issue will be published in late 2015.

A final IGBP celebration event will be held at the Fall Meeting of the American Geophysical Union in San Francisco on 14-18 December 2015. IMBER is co-convening a session at the meeting on 'Observing Open Ocean Biogeochemistry with Profiling Floats', and a session on 'Trajectories of change in the Southern Ocean'.

IMBER and Future Earth (FE)

At its June 2015 meeting, the IMBER SCC decided to go forward with a request to become a core project of FE. The positive and negative aspects of this transition were discussed by the SSC. The primary negative aspects are the current lack of FE funding for core projects, the apparent lack of marine focus in FE, and the strong FE focus on social science and policy. The lack of focus on the marine environment in the FE provides an opportunity for IMBER to take the lead in developing the ocean part of FE. A transition statement, based on the new SPIS, will be submitted to FE in Fall 2015.

A potential new Integrated Marine Science Network

Martin Visbeck (Future Ocean, GEOMAR, Kiel, Germany) proposed the establishment of a network of marine-related core projects (IMBER, SOLAS, LOICZ, PAGES, IOCCP, CLIVAR) sponsored by SCOR, WCRP, GOOS and FE, to improve collaboration and communication, and to make marine science a stronger force in FE. In general, IMBER supports this proposal, but has emphasized that this must be a distinct group, not part of FE. The coordination and administration of the network is still under discussion, as well as topics or regions that would be of interest to all the projects.

Status of the International Project Office (IPO, Norway) and the Regional Project Office (RPO, China)

The IPO will continue to be hosted by the Institute of Marine Research (IMR) in Bergen, Norway until April 2017. In February 2015, Einar Svendsen (oceanographer from IMR) was appointed as Executive Officer of IMBER. In spring 2015, the IPO was relocated within IMR to be closer to the management team of the *Hjort Centre for Marine Ecosystem Dynamics*, sponsored by the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, the University of Bergen and Uni Research. This has increased interaction with a broader research community, and allows easy exchange of information on activities and publications.

Discussions with the Norwegian Research Council and the leadership of IMR have been initiated to secure funding for a second 5-year period.

The IMBER Regional Project Office (RPO) was established under a Memorandum of Understanding between IMBER and its host institution, the East China Normal University in Shanghai, China, in 2010. The initial three-year support was renewed for an additional three years (2013-2016). The RPO is essential for engagement of the research community in the Asia-Pacific region. It also provides excellent support and assistance to the IPO.

Dr. Yi Xu replaced Dr. Liuming Hu as the Deputy Executive Officer of the RPO in December 2014. She is the IMBER liaison for the Continental Margins Working Group and submitted a first-stage funding proposal to the Asia-Pacific Network (APN) to hold a CMWG workshop in Shanghai, China in 2016. Securing support for the RPO after 2016 is a priority and the process for doing this needs to be initiated.

E. IMBER SSC member nominations

There are currently 15 IMBER SSC members. New members appointed in early 2015 are Masao Ishii (Japan), Ruben Escribano (Chile), and Svein Sundby (Norway). Four new SSC members will be appointed this year, and one current member (Bundy) will be extended for one year, as was done for some SSC members last year, to even out the distribution of new members.

Rynearson is eligible for appointment for a second term. In February 2015, IMBER solicited the research community for nominations for their replacements with the following expertise, identified by the IMBER Executive Committee:

- physical-biological interactions, and ecosystem functioning and dynamics
- fisheries as related to (sustainable) ecosystem-based management
- food web dynamics and diversity, and top predator interactions
- integrated studies of social, ecological and biogeochemical marine systems
- economics of marine resources

Twenty-five nominations were received. The Executive Committee ranked the nominations, and a short-list of eight nominees was tabled for discussion at the SSC meeting. It was recommended that in addition to expertise, fund raising and networking skills are also important. The agreed-upon nominees were put forward to SCOR and IGBP for approval.

Eileen Hofmann will end her term as Chair at the end of 2015. There was no call for nominations with regard to the Chair. Rather, the Executive Committee identified individuals who are/have been involved with IMBER. The Executive Committee suggested Carol Robinson (University of East Anglia, UK and former IMBER SSC member) as a possible candidate for Chair. Hofmann contacted Robinson and she agreed to be nominated. Hofmann will remain as *ex officio* Past Chair for one year.

F. IMBER cooperation

IMBER has been closely collaborating for many years with SOLAS (see SIC!) and LOICZ (see CMWG) and recently with CLIVAR, and with projects and other organizations.

a. Too Big To Ignore (TBTI)

IMBER is a partner of the TBTI project. TBTI has reached its midpoint and now includes over 200 scientists from 45 countries. TBTI is conducting a global analysis, based on information systems, to better understand small-scale fisheries (SSF). IMBER information that might relate to SSF can be added at <http://issf.toobigtoignore.net>, and this can be used for case studies for I-ADApT. There will be collaboration at IMBIZO IV. It is suggested that a transdisciplinary cluster might provide topics for the ClimEco5 summer school.

b. Ocean Carbon Biogeochemistry (OCB)

OCB continues to actively support IMBER by advertising its activities and events, and by providing financial support for activities. This year OCB is providing travel support for five participants from the USA to attend IMBIZO IV. There are plans to hold a half-day session on IMBER science at the 2016 OCB summer workshop.

c. GEOTRACES

Deals with biogeochemical cycles and large scale distribution of trace elements and isotopes, featuring a worldwide set of sampling transects across ocean basins.

d. WCRP

CLIVAR, a core project of WCRP and its Indian Ocean panel work closely with SIBER. CLIVAR will hold an OSC on 19-23 September 2016 in Qingdao, China and several IMBER-related sessions will be convened as this conference. IMBER and CLIVAR are forming a Joint Upwelling WG.

e. GOOS/Copernicus

SIBER has strong connections with IO-GOOS, and IMR is involved with EURO-GOOS through Copernicus (European Programme to establish European capacity for Earth Observation). GOOS uses a system of global and

regional models of different parts of the world ocean, which consider primarily ocean physics but with some primary production included. Increased alignment with GOOS will help IMBER deal with the challenge of ocean data.

f. ICES

ICES science issues are similar to those considered by IMBER, but are limited to the North Atlantic and adjacent seas, and more increasingly into the Arctic. In addition to the science, ICES gives environmental and fisheries advice to member countries, which is turning into ecosystem-based management advice. The IMBER IPO will have an information booth at the ICES Annual Science Conference in Copenhagen, Denmark in September 2015

g. IOC

IOC activities and focus are consistent with those of IMBER. However, implementation of activities differs. IOC is advanced in observations and tsunami warnings and designed the essential ocean variables. The IMBER IPO was represented at the last IOC assembly and used this opportunity to explore funding opportunities. IOC agreed to support two participants from developing countries to attend the Upwelling workshop at IMBIZO IV and to support participants for the CLIOTOP Symposium.

h. Hjort Centre

The Hjort Centre on Ecosystem Dynamics is co-located with IMBER at IMR. There are many overlaps and strong collaboration is developing.

i. PICES

IMBER and PICES have a long-term successful collaboration and partnership. This has ensured that representatives from both communities are able to attend project activities, such as summer schools and science meetings.

j. CARBOCHANGE

This is an IMBER-endorsed project that ended in 2015. Results are given in Section B.

G. Selected IMBER Publications

IMBER-related activities have produced more than 1,000 refereed research papers since its implementation; about 150 papers were published in 2014-2015.

Publications related to recent discoveries and highlights

- Akoglu, E., et al. 2014. An indicator-based evaluation of Black Sea food web dynamics during 1960– 2000. *Journal of Marine Systems* 134, 113–125. <http://dx.doi.org/10.1016/j.jmarsys.2014.02.010>
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Communication and Outreach

IMBER's main communication tool is the project website (www.imber.info), which has an average of about 250 visitors each day. A new IMBER website is being developed that will be hosted at IMR. Software changes by the internet service provider in France were such that the existing IMBER website could no longer be supported. This transition has caused disruptions in availability of the IMBER website. Once the new site at IMR is launched, it will have a new, more regularly updated, news section, and the community will be encouraged to regularly send news items or articles to be featured on the website. The new IMBER website will also be accessible from a range of devices such as mobile phones and iPads.

The *IMBER Update Newsletter*, www.imber.info/index.php/News/Newsletters, is emailed to

~2000 scientists three times each year, and re-directed through multiple channels to about 10,000 researchers:

- **Issue n°28** - June 2015, included articles about a new ESSAS Arctic project, Canadian research in the North, a generic concept for the vertical behaviour of fish eggs in the world oceans, observing changes in the surface ocean carbon, and a world-wide evaluation of the use of ecosystem drivers of stock production in tactical fisheries management.
- **Issue n°27** - September 2014, included articles about science highlights from the IMBER Future Oceans Open Science Conference in Bergen. This included the following:
 - Predicting Fish from Physics: Strengths, weaknesses and ways forward;
 - Mesopelagic fishes in the California Current: ecosystem role, climate change impacts and the need for global observations of marine fish populations;
 - From watching to acting: adaptation in marine systems;
 - *Trichodesmium* Growth Rates: Modelling the Fundamental Niche;
 - *Phaeocystis pouchetii* bloom from the perspective of heterotrophic bacteria;
 - Should we shift towards collaborative management? Case study of the Asturian (northern Spain) gooseneck barnacle fishery;
 - Time of emergence of trends in ocean biogeochemistry;
 - Recent climatic changes enhance ongoing ocean acidification in the California Current System;
 - Diving depth of elephant seals influences mercury bioaccumulation in the north Pacific.

Other IMBER-related activities that were included featured GLODAPv2, a new and updated global ocean carbon data product, and The 2014 Community Event of the Surface Ocean CO₂ Atlas.

An electronic IMBER *eNews Bulletin* is published monthly, which provides information about IMBER and IMBER-relevant activities and events. Calls for funding proposals, job opportunities, workshop and conference announcements are also included.

The IMBER contact database is continuously updated with information for about 2,300 marine researchers.

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.

H. Support from SCOR

IMBER greatly appreciates the ongoing support received from SCOR, and the additional support for specific IMBER activities provided or managed by 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.

Funding request

We are requesting funding to support students and researchers from developing countries to attend the ClimEco5 summer school that will be held at the University of Rio Grande, Natal, Brazil in early August 2016.

Amount requested: 7,500 USD

I. Strategic development

IMBER is in 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 June 2014 OSC indicated that there is a

strong community of researchers engaged in IMBER science. The new Science Plan and Implementation Strategy will provide guidance for marine research for the next phase of IMBER.

At the same time, the organizational structure for international global environmental change research is changing. The IGBP, which co-sponsors IMBER with SCOR, will end in December 2015 and the core projects currently sponsored by the IGBP have been invited to become core projects under Future Earth.

IMBER has a history of connecting natural and social sciences and promoting integration across disciplines and communities. Many of IMBER's coordination and networking activities match the integrated approaches desired by FE. As a result, IMBER is well placed to take the lead in developing marine-focused efforts under FE. The transition to a combined SCOR-FE core project should not require modifications to IMBER science goals or implementation strategy.

As with SCOR, the new SPIS will form the basis for a request to FE to incorporate IMBER as core project. The request will include a description of what IMBER can bring to FE in terms of science and as an international network of researchers. The request will also include what IMBER expects from FE, such as support for SSC meetings and integrated activities, funding at the same level as provided by SCOR, and specific assistance with fund raising, outreach, communication and engagement of stakeholders. It is anticipated that the formal IMBER request to FE will be made in Fall 2015.

K. Budget

The SCOR omnibus grant from the National Science Foundation, which provides support for IMBER, was recently renewed for three years. NASA agreed to provide a one-year supplemental funding to the existing grant that supports activities of the HDWG, ESSAS and the SIOA. A three-year proposal to support NASA-relevant research in IMBER will be submitted in 2016. The limited funding available for IMBER activities has necessitated a reduction in the support provided to IMBER working groups and regional programmes.

APPENDIX 8

Surface Ocean – Lower Atmosphere Study (SOLAS)

Reporting period: June 2014- August 2015 Version of 2 Sept 2015 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

In September 2014, Eric Saltzman, Chair of the SOLAS Scientific Steering Committee since July 2011, stepped down unexpectedly due to his employment by the U.S. National Science Foundation. A fast-tracked search for a new Chair began led by Emilie Breviere, Brian Ward and Alfonso Saiz-Lopez. In the meantime, Cecile Guieu, vice-chair took on the role of interim Chair. In December 2014, Veronique Garcon, who was an SSC member for 6 years from 2007 to 2012, was approved by the SOLAS sponsors to serve as SOLAS SSC Chair beginning in January 2015. Her term will end in December 2017.

In January 2015, VV SS Sarma from India, Maurice Levasseur from Canada, Emmanuel Boss from USA and Cristina Facchini from Italy joined the SSC. SOLAS has an Executive Committee composed of the Chair, Cecile Guieu, Lisa Miller and Christoph Heinze.

The SOLAS SSC met in Rehovot, Israel, 16-18 June 2014 for its 14th SSC meeting and will meet on 11-13 September 2015 in Hamburg, Germany, following the SOLAS Open Science Conference 2015 in Kiel, Germany.

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 on 31 Dec
Boss	Emmanuel	USA	M	Ocean optics and biogeochemistry	Remote sensing, cross themes	2017
Engel	Anja	Germany	F	Microbial biogeochemistry, sea surface microlayer	Microlayer, cross themes	2017
Facchini	Cristina	Italy	F	Physical and chemical processes in multiphase atmos. systems	Themes 4 and 5: aerosols, clouds and atm chem	2017
Gao	Huiwang	China	M	Atmospheric deposition and ecological effect	Theme 3: Atm deposition	2017

Garbe	Christoph	Germany	M	Air-sea physical interaction	Theme 2: fluxes of mass and energy, ESA connection	2016
Garçon	Veronique	France	F	Marine biogeochemistry and ecosystems dynamics	Integrated topics	2017
Graco	Michelle	Peru	F	Biogeochemical cycles in upwelling systems, OMZ	Integrated topics	2017
Guieu	Cecile	France	F	Marine ecosystems/nutrients	Theme 3: Atm deposition	2015
Heinze	Christoph	Norway	M	Carbon cycle modeling/paleocean	Theme 1: greenhouses gases	2015
Koren	Ilan	Israel	M	cloud physics	Theme 4: aerosols, clouds	2015
Levasseur	Maurice	Canada	M	Ocean biogeochemistry, dimethylsulfide, Arctic, ice algae	Theme 4: aerosols, clouds	2017
Miller	Lisa	Canada	F	Sea-ice/CO2 exchanges	Integrated topics, PICES connection	2016
Nojiri	Yukihiro	Japan	M	Ocean carbon	Theme 1: greenhouses gases	2015
Saiz- Lopez	Alfonso	Spain	M	Atmospheric halogens/modelling	Theme 5: Atm chem., IGAC connection	2016
Sarma	VVSS	India	M	Biogeochemical cycling of C and N in the ocean and estuaries, stable isotopic geochemistry/ocean acidification	Theme 1: greenhouses gases	2017
Ward	Brian	Ireland	M	Air-sea physical interaction	Theme 2: fluxes of mass and energy, WCRP liaison	2016

In December 2015:

- Cecile Guieu, Yukihiro Nojiri and Christoph Heinze will rotate off the SOLAS SSC after two terms.
- Ilan Koren will end his first term on the SOLAS SSC.

I.b. Development of the SOLAS Mid-term strategy

Since 2008, SOLAS has supported the development of 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 following publication describes the MTS themes:

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

Over the last 12 months a lot of effort has been dedicated to advance the new science plan; therefore, some topics of the Mid-term strategy have less progressed than in previous years:

- **Sea-ice biogeochemistry and interactions with the atmosphere**

Recent activities of the MTS on sea-ice are intrinsically linked to the SCOR WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII), chaired by Jacqueline Stefels and Nadja Steiner, which will end in 2016. Below is a summary report on WG 140 activities for 2014/2015, by Jacqueline Stefels.

Overview of activities:

Task Group 1 on Methodologies and Intercomparisons (Leads: Lisa Miller and Lynn Russell):

A review of sea-ice methodologies has been published in *Elementa: Science of the Anthropocene*: Miller et al. (2015) Methods for biogeochemical studies of sea ice: The state of the art, caveats, and recommendations. This paper is the first of a Special Feature in *Elementa* on sea-ice biogeochemistry that is initiated by WG 140. TG1 has stimulated discussion and compiled information on opportunities to organize an intercalibration field campaign on a reasonable time scale. Several options are still under discussion.

Task Group 2 on Data (Leads: Klaus Meiners and Martin Vancoppenolle):

The collation of chlorophyll datasets from both the Arctic and the Antarctic are almost finalized and partly published. Several new collaborations have been established around the collation of other parameters: inorganic carbon budget, organic carbon budget, macro nutrients, iron, algal biodiversity.

Task Group 3 on Modeling (Leads: Nadja Steiner and Clara Deal):

A paper on “What sea-ice biogeochemical modellers need from observationalists” has been submitted to *Elementa* as part of the WG 140 special issue. The WG 140 Special Feature within the open-access journal *Elementa: Science of the Anthropocene* is a major product of this TG and of WG 140 as a whole. It will contain a collection of synthesis papers reviewing particular biogeochemical processes in sea ice and respective model applications, but also research papers are accepted. Currently, 20 contributions are planned, of which 7 are published/submitted.

The life span of WG 140 under the umbrella of SCOR is coming to an end. Hence, new avenues need to be explored in order to continue this new and highly successful collaboration between modelers and experimentalists. The network is a very good mix between young and senior researchers from all over the world. The group now consists of 85 scientists from 16 countries. During the SOLAS OSC a discussion session will be dedicated to discuss the future.

- **Air-sea gas fluxes at Eastern Boundary upwelling systems**

The Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), in cooperation with some established experts, have set up a global ocean oxygen network. This group intends to connect scientists from around the globe, including coastal and open ocean scientists; modelers, biological, chemical and physical oceanographers. Preliminary possible objectives/goals have been identified:

- Identification and linking existing oxygen databases
- Identification and linking real time/continuous oxygen observations and monitoring systems (Argo, moorings)
- Developing integrated oxygen research that links coasts and seas, developing global, cross-basin/teleconnection research
- Understanding oxygen interactions with other climate and human stressors
- Promoting better global and regional climate models of oxygen, understanding feedbacks between atmosphere and ocean
- Advancing understanding of forces shaping ocean oxygenation
- Linking oxygenation to fisheries production and dynamics
- Understanding animal migrations and movements in the context of ocean oxygenation

- Socio-economic consequences of oxygenation changes (gains and losses)
- Linking oxygenation to H₂S emission
- Roles of oxygen in shaping global and local patterns of biodiversity
- Calibrations and proxies to learn about the roles of oxygenation in ocean biogeochemical and biodiversity from the paleo record
- Linking oxygen to harmful algal blooms

The first meeting of this network will take place before the 2015 AGU Fall Meeting 2015 in San Francisco.

Other activities related to this MTS Theme include the following:

- A session has been proposed at the IMBER IMBIZO IV on 26-30 Oct. 2015 in Trieste, Italy.
- Another session entitled “Eastern boundary upwelling systems: Natural laboratories for studying the impacts of multiple stressors on marine ecosystems” has been proposed at the AGU Fall meeting in December 2015 in San Francisco, USA
- The SOLAS Chair will participate in the 9th World Ocean Forum at Busan, South Korea on 20-22 October 2015, and will give an invited lecture entitled “Biogeochemical cycles and marine ecosystems in a changing oceanic stratification” within Session 3 Ocean Science and Climate-Environment.
- The SCOR group WG 144 “Microbial Community Responses to Ocean Deoxygenation” is preparing a “White paper” on “Recommendations for best practices for investigations in oxygen-deficient marine systems” and is holding a workshop at the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany from 30 August to 3 September 2015.
- An ITN Marie Curie VOYaGE (Variability of Oxygen in Marine ecosystems and Climate change) proposal was submitted for the 2015 call H2020-MSCA-ITN without success and will be resubmitted in 2016.

• **Ship plumes: impacts on atmospheric chemistry climate and nutrient supply to the oceans** Interest in this topic has increased over the last couple of years, such that an invited plenary talk is scheduled to take place at the SOLAS Open Science Conference 2015 in Sept. in Kiel, Germany, as well as a discussion session.

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 working 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. A one-day workshop on SOCAT and SOCOM (Surface Ocean pCO₂ Mapping Intercomparison) is being planned on the Monday 7 Sept. 2015, a day before the opening of the SOLAS Open Science Conference 2015. This side event of the SOLAS OSC15 has been chosen to release the SOCAT version 3. SOCAT version 2 provided 44 years of surface water fCO₂ (fugacity of CO₂) values from 1968 to 2011 for the global oceans 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 included in 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.

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 Global Carbon Budget (www.globalcarbonproject.org/carbonbudget/) uses SOCAT for quantification of the annual ocean carbon sink. The

Surface Ocean pCO₂ Mapping intercomparison (SOCOM) is a recent initiative that compares surface ocean CO₂ gridded products, derived by a variety of methods, many of them based on SOCAT.

***WG2-Interior Ocean.** Chair: Nicolas Gruber (Switzerland)- update from 1 Sept 2015. WG2 has focused its recent activities entirely on the analysis of the carbon data from the hydrographic surveys with the aim to determine the change in the ocean's anthropogenic CO₂ content since the 1990s. They are now in the final stages (paper draft completed), and hope to finish this synthesis project by early 2016. WG2 contributed also to the planning of the upcoming joint GO-SHIP/Argo/IOCCP meeting in Galway on the topic of "Sustained ocean observing for the next decade" <http://www.gaic2015.org>. In addition, they continue to support the development and application of biogeochemical sensors on Argo floats, although this area has developed a lot of momentum and is strong enough to move forward without much need for help from WG2. WG2 likely will reengage in full in this area when time is ripe to address data synthesis and integration in a global/basin-scale manner.

***WG3-Ocean Acidification.** Chair: Jim Orr (France), update from May 2015

The last annual meeting of the SIOA working group was in May 2015, 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. The IAEA Project Officer is Lina Hansson and the Programme Manager is Michel Warnau. There is an OA-ICC web site (www.iaea.org/ocean-acidification) and a news stream (news-oceanacidification-icc.org). 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.

With regard to science, the OA-ICC continues to support the development of a Global Ocean Acidification Observing Network (GOA-ON; www.goa-on.org), in particular by encouraging the participation of developing countries. The GOA-ON science plan was recently printed and copies are available on request. The OA-ICC co-organised with the Centre Scientifique de Monaco (CSM) the 3rd international workshop of the socio-economic impacts of ocean acidification (Monaco, 12-14 January 2015). The OA-ICC co-supported the expert meeting 'Oceans 2015 initiative', on 20-22 April in Monaco, with the goal to translate greenhouse gas emissions trajectories into an impact scenario for ocean acidification and warming. The OA-ICC offers two online databases related to ocean acidification: a bibliographic database and a data compilation on the biological response to ocean acidification.

With regard to communication, the OA-ICC provides daily updates on ocean acidification through its news stream. The OA-ICC was present at the UNFCCC COP20 in Lima, Peru in December 2014 and at the 16th session of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea in New York City on 6-10 April 2015.

In terms of capacity building side, OA-ICC provide travel grants to conferences; for example, the travel grant provided by the OA-ICC to the SOLAS Open Science Conference 2015 is allowing 4 scientists from developing countries to participate to the conference.

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 data exist, the data originator 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 on-going effort. Scientists can help expanding the SOLAS Metadatabase 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).⁶ In 2015, the leaders of the task team and Alfonso Saiz- Lopez (SOLAS SSC member) met at the EGU 2015 and decided to write a Perspectives document with the envisioned future for the Task, which would include some new aspects in the field that were not specifically targeted in the Task's White Paper. Work is under progress. Everyone interested by the activities of this task team can subscribe to the HitT mailing list at <http://www.hitt-task.net/>. - The EGU session 2015 "Halogens in the troposphere" was very well attended and a repeat of this session has already been approved for EGU 2016. Fall AGU in 2015 will include a session on "Wintertime Atmospheric Chemistry: emissions, dispersion, aerosols, halogens and unusual oxidants." Several other sessions at AGU will also be relevant to HitT. A workshop on "Global importance of tropospheric halogens" (main organisers Martyn Chipperfield, Leeds; Roland von Glasow, UEA); was planned for autumn 2015, but will be postponed to 2016, if new funding can be arranged.

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 are Huiwang Gao (Ocean University of China, China), Guangyu Shi (Chinese Academy of Sciences, China) and Mitsuo Uematsu (University of Tokyo, Japan).

ADOES leaders reported on the progress of the WESTPAC ADOES Working Group (2012- 2015) during the 10th Intergovernmental Session of the IOC Sub-Commission for the Western Pacific (WESTPAC-X) at Phuket, Thailand on 12-15 May 2015. The 4-yr lifetime of the working group is completed. A new working group with a new title and new terms of reference is desired, along with the recruitment of more scientists from the Southeast Asian countries on the studies of dust and smoke from forest fires and their impacts on ocean ecosystems.

-The ADOES activity was introduced as a part of the WESTPAC posters during the 28th Session of the IOC Assembly at UNESCO Headquarters in Paris France on 18-25 June 2015. A research cruise for SOLAS and GEOTRACES was conducted around the Ryukyu Islands, including the East China Sea, by a new R/V *Shinsei Maru* (1,629 t) belonging to JAMSTEC, Japan from 25 June to 6 July 2015. Young foreign scientists (Post doc and graduate students) from South Korea, China and Brunei joined the cruise.

A research cruise for ADOES and China SOLAS was conducted from the East China coast to the Northern West Pacific by R/V *Dongfanghong 2*, lasting 40 days from March to May 2015. More than 60 young scientists joined this cruise to investigate atmospheric chemistry processes, atmospheric deposition flux and marine nitrogen cycle.

A workshop entitled "Sources, formation and deposition of particles in rural and marine atmospheres and potential climate impacts" is being held on 27-28 August 2015 in Qingdao, China. About 30 scientists from China, USA, UK and Japan were invited, and dozens of young scientists, including post-docs and graduate students, will attend. The talks will cover observation and modelling of dust aerosols, inorganic and secondary organic aerosols, cloud condensation nuclei (CCN) activity of aerosols, incubation experiments for responses of phytoplankton to elements from atmospheric deposition and primary organic aerosols from marine sources, etc.

SOLAS/IGAC Task Team: Air-Ice Chemical Interactions (AICI)

The IGAC/SOLAS Air-Ice Chemical Interactions Task Team (AICI) was created in 2003. The goal of AICI is to assess the significance of the processes observed in the polar regions at the air- ice interface at local, regional, and

⁶ Update: Roland von Glasow unfortunately passed away in September 2015, so there will need to be a replacement co-chair appointed by SOLAS.

global scales by bringing together the laboratory, field, and modeling communities. The co-chairs of AICI are V. Faye McNeill (Columbia University, USA) and Thorsten Bartels-Rausch (Paul Scherrer Institut, Switzerland). The main activity of AICI/OASIS in 2014-2015 was the CASSII (Chemical Atmosphere-Snow-Sea Ice Interactions) workshop, which was held in Cambridge, UK in October 2014. Below is reported the write-up of this meeting published in the IGAC newsletter. The next workshop will take place in Paris, France in Spring/Summer 2016.

More than 60 scientists from 15 countries in Europe, North America and Asia gathered last October in Cambridge (UK) for a 3-day workshop on Chemical Atmosphere-Snow-Sea Ice Interactions. The meeting objectives were to discuss research status and future science priorities of a highly inter-disciplinary field of research, which is being fostered by the IGAC activities AICI (Ice Air Chemical Interactions) and OASIS (Ocean – Atmosphere – Sea Ice - Snowpack). CASSII was organized locally by the British Antarctic Survey and generously sponsored by IGAC and EGU to enable the participation of 15 early career scientists.

Within the AICI/OASIS community it is now recognized that the air-snow-sea ice system plays an important role in the global cycling of nitrogen, halogens, trace metals or carbon, including greenhouse gases (e.g. CO₂ air-sea flux), and therefore may also influence climate.

Its impact on atmospheric composition is illustrated by dramatic ozone and mercury depletion events that occur within or close to the sea ice zone (SIZ) mostly during polar spring and are catalyzed by halogens released from SIZ ice, snow or aerosol. Recent field campaigns in the Arctic and Antarctic highlight the importance of the SIZ as a biologically active area and as a chemical reservoir and reactor, even during polar night. The growing literature on lab experiments and field studies allows to develop and improve parameterizations of processes at the snow grain or even molecular scale for use in regional or global climate models. But to date climate models with coupled snowpack or sea ice chemistry are still in their infancy. The research of the past 15 years has been reviewed recently in two AICI special issues of *Atmospheric Chemistry and Physics* (ACP 2007 & 2013).

Much progress has been achieved since the inception of OASIS in 2002. However, large uncertainties remain regarding the regional or global impacts of air-ice-ocean chemical exchange processes, e.g. their role in the natural variability of tropospheric ozone, for the surface energy budget or for cloud formation in the high latitudes. More research is needed to understand chemical species and processes involved, the role of ice microbial communities as chemical sinks or sources, as well as feedbacks with a very dynamic snow and ice environment, which is currently undergoing rapid change. For example, the sources of reactive halogens (e.g. bromine and iodine) and of their precursor species such as organic halogens are still poorly known, but are important to assess the variability of polar tropospheric ozone or quantify linkages to the formation of cloud condensation nuclei and clouds. Complex questions are impossible to answer within a single scientific discipline, hence it will be critical to better integrate the communities of atmospheric and cryospheric sciences as well as oceanography. This can be achieved for example through special sessions or town hall meetings at scientific conferences, but also by better publicizing of ongoing projects, collaboration opportunities or an “expert” directory. For further detail see the scientific program and list of attendees of CASSII at http://www.antarctica.ac.uk/about_bas/events/cassii2014/index.php.

I.f. SOLAS Open Science Conference 2015

The OSC15 will take place in Kiel, Germany at the Christian-Albrechts-Universität zu Kiel during the week of **7-11 September 2015**. The local organising committee (LOC) is composed of Hermann Bange (GEOMAR), Gernot Friedrichs (Univ Kiel), Christa Marandino (GEOMAR), Birgit Schneider (Univ Kiel), Emanuel Soeding (Future Ocean Cluster of Excellence Kiel) and a young post doc Jonathan Durgadoo (GEOMAR). 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. in the afternoon; 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” of the summer 2015.

The Scientific Organising Committee is composed of the SSC and one member of the LOC. The conference website was set up on Conference Manager, a SCOR-leased tool (www.solas-int.org/osc2015.html). The registration opened on 1 Sept. 2014 and early registration closed on 1 June 2015. As of August 2015, 230 participants from 33 different countries have registered, 80% will present a poster. SCOR kindly provided a travel grant for scientists from developing countries to attend the conference; the grant was distributed to 10 scientists. The Ocean Acidification-International Coordination Centre also provided a travel grant that allowed 4 scientists from developing countries to attend.

For this edition of the OSC, SOLAS is inviting 9 keynote speakers and selected 22 other speakers from the poster abstracts pool, a strong new feature of this OSC. Among the 22 speakers, 6 are from developing countries and 11 are early career scientists. The conference scientific theme will be future-forward looking; the themes of the 8 plenary sessions are the ones forming the SOLAS 2015-2025 science plan. The plenary talks are followed by 3 to 4 parallel discussion sessions each day, which were proposed by the community and poster sessions. The full programme may be found at <https://www.confmanager.com/main.cfm?cid=2778&nid=16562> or on the conference app Whova.

As side event of the conference, a workshop for early career scientists will take place in two parts, one on the 7 Sept. and the other on 11 Sept., Seventeen early career scientists will learn how to present their research to an audience in various situations. This workshop was organized by the early career scientist from the LOC. Two additional side-events will take place on 7 Sept. in parallel to the SOPRAN final event and the ECS workshop. Representatives of international programmes with a marine component will meet and discuss potential topics needing a collaborative and integrative approach across programmes to advance. And a SOCAT/SOCOM (Surface Ocean CO₂ Atlas/Surface Ocean pCO₂ Mapping Intercomparison) workshop will take place and launch the release of the SOCAT V3. On the 11 Sept., there will be a Nordic SOLAS gathering. SOLAS also took the opportunity to organize a dinner on 8 Sept. to assemble the 17 SOLAS national representatives that will be present at the conference, to promote the role that the national representatives play and also to engage them into the implementation strategy planning of the SOLAS next phase.

After the conference, the IPO is planning to run a survey to collect the participants' comments and feedback. Short reports informing about the outcome of the parallel discussion sessions will be collected and made available on the SOLAS website.

I.g. SOLAS 2015-2025: Science Plan and Organisation

SOLAS celebrated its 10-year anniversary in 2014! The SOLAS community has accomplished a great deal towards the goals of the original Science Plan & Implementation Strategy and Mid-term Strategy as the open-access Synthesis Book on '*Ocean Atmosphere Interactions of Gases and Particles*' edited by Peter Liss and Martin Johnson highlights. But, there are still major challenges ahead that require coordinated research by ocean and atmospheric scientists. With this in mind, in 2013, SOLAS have begun an effort to define research themes of importance for SOLAS research over the next decade. These themes have become part of a new Science Plan for the next phase of SOLAS (2015-2025). SOLAS being a bottom-up organisation, a process in which community consultation played a central role, see below for details, was adopted. In December 2014, a complete version of the new Science Plan was submitted to the current SOLAS sponsors (SCOR, IGBP, WCRP and iCACGP) and also Future Earth for review. Feedback were received in June 2015, all very positive. The SOLAS SSC is currently addressing the comments in order to have the approved version of the Science Plan by the end of 2015.

The draft of the new science plan submitted to the SOLAS sponsors is available at http://www.solas-int.org/about/future_solas.html.

Table of content: *Executive summary Introduction Science plan*

Core themes

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: Interconnections between aerosols, clouds and ecosystems Theme 5: Ocean biogeochemical control on atmospheric chemistry

Crosscutting themes

Integrated topics

SOLAS science and geoengineering SOLAS science and society

Organisation and management Organisation

Communication, capacity-building, and global networking Data management

Linkages to other projects and activities Outlook

Acronyms Appendix References

Details of the procedure followed to produce the new Science Plan:

- Following the SOLAS Open Science Conference 2012, where the SOLAS community met in May 2012 in Seattle, USA to share SOLAS research results, the SSC identified 8 research themes which could compose the SOLAS next phase (2015-2025).
- In Summer 2013, short White Papers on the 8 themes were written.
- In Fall 2013, an online community consultation took place, providing an opportunity to the community to share their ideas and participate early on in designing the next phase of SOLAS. The themes were presented at various venues (workshops, conferences...).
- In December 2013, a workshop was held in Plymouth, UK for early-career scientists to brainstorm and discuss the scientific scope of the next phase of SOLAS. Shortly after the workshop, the participants delivered a detailed document summarising their discussions with the goal to advise the SSC.
- In January 2014, a workshop took place in Galway, Ireland with some SSC members with the aim to take into consideration the inputs from the community consultation and the advising document from the early-career scientists' workshop. The scientific themes of the SOLAS next phase were revised and refined. The scientific scope is divided into five themes, and two sections, one describing the interconnected nature of the five themes as integrated topics and one highlighting the societal relevance of SOLAS science.
- In July 2014, following the 14th SOLAS SSC meeting in Israel, a draft of the Science Plan of the next SOLAS phase (2015-2025) was circulated to a large number of SOLAS engaged scientists, the SOLAS national representatives for example, for review.
- Over summer 2014, the SSC took the numerous reviews into account and delivered in fall/winter 2014 the final version of the plan.

L.h. Engagement with Future Earth: Research for Global Sustainability

Since the Future Earth interim Secretariat was opened, SOLAS has had regular communication with the officers on various topics. The communication continues now that the permanent Secretariat is in place. Also, communication is regular with Corinne Le Quéré, Future Earth Science Committee member, via Skype. The SOLAS Chair and the Future Earth Executive Director Paul Shrivastava have met on a couple of occasions. SOLAS continues to contribute to various structural documents of Future Earth, lately on the Knowledge Action Network and, in particular, the Ocean one.

In December 2014, SOLAS submitted to Future Earth its transition statement in order to get co-sponsored. In April 2015, SOLAS received the reviews from Future Earth and addressed them in May. In June 2015, SOLAS was informed by Future Earth that the application has been approved and that the Memorandum of Understanding is about to be signed. As per August 2015, SOLAS has not yet signed the MoU.⁷

L.i. Possible topics across projects/programmes with a marine component for co-design and co-production of knowledge in marine sciences

A meeting took place in March 2015, co-organised by SCOR in Kiel, Germany, where SCOR projects (IMBER, SOLAS) and others (IOCCP, PAGES, CLIVAR) met to discuss about the position of marine sciences in the context of the Sustainable Development Goals, Future Earth etc. Following that meeting, SOLAS started an effort to develop cross-projects topics. In April 2015, at the IGBP SC meeting in Vienna, SOLAS, IMBER, LOICZ, IGAC and PAGES agreed to a small number of potential topics; these were sent with some descriptive paragraphs to Future Earth projects or soon to be with a marine component for addition and development. More recently, this document was sent to other relevant international programmes, such as GESAMP, WCRP, CliC, GEOTRACES, ecoSERVICES etc. On 7 September 2015, some representatives of programmes will meet for an afternoon discussion on this subject to design the way forward.

As of August 2015, the document is a draft and a non-exhaustive list of possible topics for co-design and co-production of knowledge in marine sciences. The ultimate intention of this document is to foster interactions between international projects on co-designed and co-produced knowledge in marine sciences.

⁷Update: The MoU was signed at the 2015 SOLAS SSC in September 2015

The topics listed so far include the following:

- Extreme events in EBUS
- Atmospheric chemistry services
- Changes in the Arctic: threat or opportunity
- Environmental risk from deep-sea mining
- Conservation of reef fishes and sustainable co-management of inshore small-scale fisheries

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

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. Since 2003, SOLAS offered 6 Summer Schools, 5 in Cargèse, Corsica and the most recent one in 2013 in Xiamen, China. Despite the success of the schools and the frequent requests of information on the next edition of the school, there is no plan underway for another school. This was prevented by the clash created by the SOLAS Open Science Conference 2015 in Kiel, location of the IPO and the uncertainty until recently of the future of the IPO in GEOMAR beyond 2015. However, a new location has been investigated: Cape Verde, in particular the INDP and Ocean Observatory in Mindelo.

II.b. SOLAS synthesis paper in Anthropocene

SOLAS has submitted a paper to contribute to the IGBP synthesis effort to the journal *Anthropocene* in May 2015, after almost 2 years of drafting. Five major achievements have been reported in the short paper: Authors are Emilie Brévière, Dorothee Bakker, Hermann Bange, Timothy Bates, Thomas Bell, Philip Boyd, Robert Duce, Véronique Garçon, Martin Johnson, Cliff Law, Christa Marandino, Are Olsen, Birgit Quack, Patricia Quinn, Christopher Sabine, and Eric Saltzman. This article should be published in time for the IGBP final event at the AGU Fall Meeting in December 2015 in San Francisco, USA. The abstract follows:

The domain of the surface ocean and lower atmosphere is a complex, highly dynamic component of the Earth system. Better understanding of the physics and biogeochemistry of the air-sea interface and the processes that control the exchange of mass and energy across that boundary define the scope of the Surface Ocean-Lower Atmosphere Study (SOLAS) project. The scientific questions driving SOLAS research, as laid out in the SOLAS Science Plan and Implementation Strategy for the period 2004-2014, are highly challenging, inherently multidisciplinary and broad. During that decade, SOLAS has significantly advanced our knowledge. Discoveries related to the physics of exchange, global trace gas budgets and atmospheric chemistry, the CLAW hypothesis (named after its authors, Charlson, Lovelock, Andreae and Warren), and the influence of nutrients and ocean productivity on important biogeochemical cycles, have substantially changed our views of how the Earth system works and revealed knowledge gaps in our understanding. As such SOLAS has been instrumental in contributing to the International Geosphere Biosphere Programme mission of identification and assessment of risks posed to society and ecosystems by major changes in the Earth's biological, chemical and physical cycles and processes during the Anthropocene epoch. SOLAS is a bottom-up organization, whose scientific priorities evolve in response to scientific developments and community needs, leading to the decision to launch a new 10-year phase. SOLAS (2015-2025) will focus on five core science themes that will provide a scientific basis for understanding and projecting future environmental change and for developing tools to inform societal decision-making.

II.c. IGBP landmark synthesis event at AGU Fall Meeting 2015

IGBP, one of the SOLAS sponsors, will come to a close at the end of 2015. To celebrate its scientific and institutional legacy, in particular to Future Earth, IGBP will hold a series of scientific sessions and other events at the Fall Meeting of the American Geophysical Union (AGU) in San Francisco, USA.

The IGBP event at AGU has three aims: (a) present and discuss the results of IGBP's final synthesis; (b) reflect on IGBP's science and policy legacy, and (c) mark the transition of its community to Future Earth. The activities will

include trans-disciplinary and crosscutting scientific sessions, an early-career scientists' gathering (in collaboration with Future Earth), and an evening reception to celebrate the programme's legacy. IGBP is co-sponsoring over 60 scientific sessions covering a range of topics. SOLAS initiated and proposed sessions, also contributed to the planning of the other parts of the events. SOLAS will be present at the IGBP Landmark Synthesis event.

II.d. Future Earth cluster activity

SOLAS is involved in the Future Earth Cluster activity: ArcticSTAR Initiative: Solution- oriented, TrAnsdisciplinary Research for a Sustainable Arctic, Faye McNeill from Columbia University is lead scientist. This cluster brings together several existing communities of Arctic researchers from the natural and social sciences to develop a plan for how Arctic issues, specifically those related to global environmental change and considered priorities by Arctic communities, should be addressed through Future Earth. The breadth and scope of issues linked to environmental change in the Arctic cannot be addressed by any one disciplinary approach, any one nation or programme, or without the active engagement and participation of Northern people. Bringing together Arctic researchers and stake- and rights-holders to share ideas, facilitate collaboration across disciplinary and national boundaries, and co-design and co-produce knowledge is critical to addressing the key scientific and societal challenges posed by environmental change in the Arctic. The overarching goal is to enable a solution-oriented, transdisciplinary approach to Arctic research that will provide critical knowledge regarding how the Arctic region is changing, how these changes impact the diversity of life, human systems and governance in the Arctic and beyond, and how Arctic societies may prepare for and respond to these changes.

ArcticSTAR is the result of a preliminary effort, funded by Future Earth in 2014, which brought together three proposal teams from the 2014 Future Earth call for proposals: 'International, Interdisciplinary Polar Science Network' (PI: V. Faye McNeill), 'Circumpolar Arctic Coastal Communities Observatory Network (CACCON)' (PI: Don Forbes), and 'Arctic Coastal

Governance in a Global Context: Knowledge, Learning, and Multi-Level Decision Making' (PI: Ilan Chabay). The three original proposal teams represent a coalition of existing international, multidisciplinary research networks and communities representing thousands of researchers working on Arctic matters. These groups have ongoing engagement with Arctic residents, Inuit organisations such as Inuit Circumpolar Council Alaska and Canada (ICCA, ICCO) and Inuit Tapariit Kanatami Canada (ITK), as well as the Russian Association of Indigenous Peoples.

II.e. Collaboration with ESA

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 were carried out (2011-2013):

1. OceanFlux GHG, <http://www.oceanflux-ghg.org>
2. OceanFlux Upwelling, <http://upwelling.eu/>
3. OceanFlux SSA, <http://oceanflux.fmi.fi>

ESA is very interested in continuing the collaboration with SOLAS, though additional funding depends on its budget. In order to continue collaboration and identify the areas of common interest, ESA, EGU and SOLAS organised a topical conference on "Earth Observation for Ocean-Atmosphere Interactions Science 2014 - Responding to the new scientific challenges of SOLAS". The conference was held in Frascati (Rome), Italy on 28-31 October 2014. This joint ESA-EGU-SOLAS Conference brought 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. A detailed report has been written and is now being revised by SOLAS. This report should serve as a basis for a synthesis document ESA-SOLAS Earth Observations and SOLAS science priorities that ESA would like to submit to their programmatic review in October 2015.

II.f. Collaboration with PICES

The North Pacific Marine Science Organization (PICES; <http://www.pices.int>) is an intergovernmental scientific organization with the mandate to promote and coordinate marine research in the northern North Pacific and adjacent seas. The present members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian

Federation, and the United States of America.

A ½-day workshop took place on 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 run by Lisa Miller, Minhan Dai and Yukihiro Nojiri. The history of SOLAS, from the 1990s, was reviewed, as well as the activities of the 1st phase of SOLAS. Lower atmospheric aerosol sciences, iron fertilization experiments, and the establishment of the ocean surface pCO₂ database were highlighted.

The five themes, their key questions, and cross-cutting issues of the proposed new SOLAS science plan were introduced. A lot of the discussion was centered on ocean observatories and automated monitoring systems, which includes substantial needs for technological developments.

Lisa Miller is also representing SOLAS at key meetings of the PICES Annual Meeting. After the last Annual PICES Meeting in 2014 in Korea, Lisa reported that the new PICES executive secretary, Robin Brown, expressed curiosity about Future Earth, noting that on the surface, they appear to be a good fit for PICES, but how that would actually happen is unclear. As an intergovernmental organization dedicated to marine science, PICES may make a good partner for SOLAS in trying to find ways to explore Future Earth’s co-design precepts.

Ocean observatories: Quite a bit of discussion is also surfacing in PICES about ocean observatories, and this may be another useful place for future collaborations between PICES and SOLAS. In particular, several PICES scientists are focussing on developing observatories able to continue functioning during typhoons. The Korea Institute of Ocean Science and Technology is working on a robust wave glider and a bottom-mounted cabled observatory developed by the Okinawa Institute of Science and Technology (<http://otc.oist.jp/equipment/observatory.html>) has successfully collected data throughout a typhoon off Okinawa, identifying unexpected covariations between physical and biogeochemical parameters, with profound implications for SOLAS science.

Section on Carbon and Climate (S-CC): The S-CC has begun compiling regional ocean acidification ‘outlooks’, for critical areas around the Pacific. Draft reports are expected to be ready for this year’s annual PICES meeting, in October, and a special topic session on ocean acidification trends is being planned for the 2016 PICES meeting in San Diego. It may make sense for SOLAS to co-sponsor that session.

A surface nutrient data synthesis is being planned for some time after 2016. This is being led by Tsuneao Ono of the National Research Institute of Fisheries Science of Japan.

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 jointly with BrOA (Brazilian Research on Ocean Acidification) at the PICES Climate Change Symposium 2015 in Santos, Brazil, on 23-27 March 2015. The joint workshop (W2/W6) combined invited talks by Silvana Birchenough (Cefas, UK), Rosane G. Ito (Federal University of Rio Grande, Brazil), Christian Vargas (Universidad de Concepción, Chile), and Arne Körtzinger (GEOMAR Helmholtz Centre for Ocean Research, Germany), along with other selected talks and breakout group discussions corresponding to the main BrOA network and SOLAS topics. Most of the participants were directly involved with different Ocean Acidification issues (bioassays, paleoclimate, biogeochemistry). Participants came mostly from Brazil but also from France, United Kingdom, Monaco, Germany, USA, Chile, and Portugal, and actively participated to the discussions. During the breakout discussion session, participants agreed on the need to push a common activity such as creating the Latin American OA network (LAOCA). As there was a strong OA community, it was a unanimous idea that there is a need of a common ground on standardization of methods and data management. The need to use new technologies on sensors and platforms was also agreed. Thus, it was suggested that training workshops involving emerging research groups could be done, such as training courses focusing on standardization of procedures and new technologies for marine CO₂-system measurements. One of the ideas was to suggest the SOLAS International Project Office to have its next Summer School focusing on CO₂-system measurements, including new technologies for autonomous sensors.

A more detailed report is available in the Summer PICES Newsletter p8 at: https://www.pices.int/publications/pices_press/volume23/PPJuly2015.pdf.

SOLAS supported partially 7 early-career scientists to attend the symposium in Santos, Brazil.

The 24th PICES Annual Meeting (PICES-2015) will be held on 14-25 October 2015, in Qingdao, China, under the theme Change and Sustainability of the North Pacific. Unfortunately, the budget of SOLAS does not allow to support participation or to have a SOLAS representative at the PICES annual meeting.

II.g. SOLAS France day workshop

SOLAS Scientists in France organized a one-day workshop, on 29 June 2015 in Paris, France. SOLAS scientists (established and younger) from French institutes from Paris, Toulouse, Marseille, Brest, Nice, Lyon and Lille, shared results and knowledge, with the ultimate goal to determine how SOLAS France can contribute to the next phase of SOLAS. Nineteen presentations were given; most of the talks are available at <http://solas.ipgp.fr>. Dr Sandrine Paillard, Future Earth, Paris global hub, made a presentation on Future Earth 2025 vision and scope and latest developments.

II.h. SOLAS communication

SOLAS website: <http://www.solas-int.org/>

SOLAS News newsletter (NL) emailed to ~2200 scientists and airmailed to ~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 SOLAS News is printed and airmailed from China courtesy of State Key Laboratory of Marine Environment Science, Xiamen University. Since issue 11, SOLAS also implemented an on-screen reader pdf version. Issue 17 (May 2015) proposed articles that introduced the topics and/or keynote speakers of the SOLAS Open Science Conference 2015 and some updates of partners' projects.

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 and the funding from the French CNRS/INSU. The flyer informs on the outline of the new science plan. The flyer has not been circulated yet.

II.i. SOLAS national networks

Twenty-nine nations are part of the SOLAS network. Each has a representative:

Australia: Sarah Lawson and Andrew Bowie
Belgium: Nathalie Gypens (NEW) Brazil:
Leticia Cotrim Da Cunha 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: VVSS Sarma (NEW) 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
Peru: Michelle Graco Poland: Timo Zielinski Russia:
Sergey Gulev
Spain: Alfonso Saiz-Lopez (NEW) Southern Africa:
Carl Palmer Sweden: Katarina Abrahamsson Turkey:
Baris Saglihoglu and Mustafa Koçak
UK: Tom Bell USA: Bill Miller³

Implemented in Jan. 2009, the national representatives of the SOLAS nations are asked to report annually about the SOLAS activities in their country. To facilitate the reporting effort, a template form is provided. In January 2015, 19 reports were received and posted on the SOLAS website. The information contained in the reports has been 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 (posted on the SCOR

meeting page at http://scor-int.org/SCOR_EC_2015.html.

II.j. Endorsed projects

Over the reporting period, SOLAS endorsed the project AIR-SEA LAB. Information about support letter and endorsement are accessible on the website, along with the endorsement submission form.

III. Income and expenses for the past year and budget for the coming year, including funding from all sources (not only SCOR funding)

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 funds the executive officer salary since 1st February 2011 until August 2016. The project officer salary is supported since 1 February 2013 by the German Ministry of Education and Research (BMBF) via the German national SOLAS project 'SOPRAN' Phase 3 until January 2016. The IPO has benefiting since mid-March 2014 from a master student help for the OSC2015 (38 hours per month) funded by BMBF until Sept 2015.

In Spring/summer 2015, GEOMAR confirmed that it will provide office space and the salary of the executive officer, Dr. Emilie Brévière until 2020, however GEOMAR informed that it won't be able to take over SOPRAN once it is ending (Jan 2016), the salary of the project officer, Stefan Konradowitz. As per today unfortunately, no other promising avenue is being investigated.

³ Bill Miller is in the process of being replaced as U.S. representative because he is serving in a rotator position at the U.S. National Science Foundation.

APPENDIX 9 GEOTRACES

1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

Co-Chairs

Ed Boyle, USA
Reiner Schlitzer, Germany

Members

Andrew Bowie, Australia
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
Hajime Obata, Japan
Katharina Pahnke, Germany
Micha Rijkenberg, Netherlands
Alakendra Roychoudhury, South Africa
Géraldine Sarthou, France
David Turner, Sweden
Angela Wagener, Brazil
Liping Zhou, China-Beijing

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

After the very successful release of the first Intermediate Data Product in February 2014, GEOTRACES sustains a very favourable implementation. Its cruise field programme has completed 55 GEOTRACES cruises with 747 section stations completed and about 550 papers published.

2.1 Status of GEOTRACES field programme

The field programme continues to progress very successfully. Overall 66 cruises associated with GEOTRACES (this includes 11 International Polar Year- IPY cruises) have been completed. With one section cruise already completed in the Pacific Ocean (by Japanese scientists) since the last reporting period, the main field effort this year is currently focused on the completion of the GEOTRACES research Arctic Programme with 4 section cruises (from Canada, U.S. and Germany) to be held from July to October 2015.

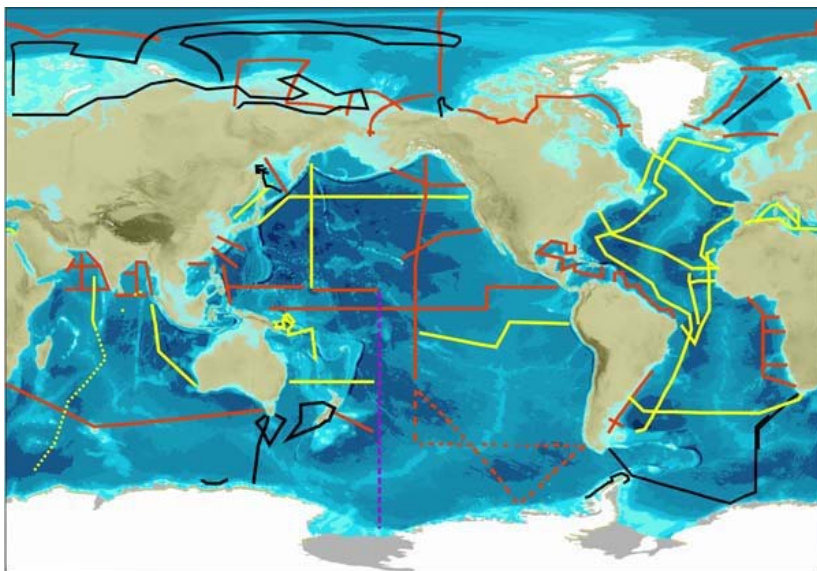


Figure 1: Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey (dotted purple, completed during the past year). In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

2.2 GEOTRACES Intermediate Data Product 2014

A corrected and updated version of the GEOTRACES Intermediate Data Product 2014 (IDP2014) was made available on May 2015. The new version (version 2) of the digital data is available in two new formats (Excel and netCDF). As a result, the IDP2014 is available now in four formats (ASCII, Excel, netCDF, and ODV, <http://www.bodc.ac.uk/geotraces/data/idp2014/>). A special thanks to Reiner Schlitzer for producing this new version of the IDP2014.

In addition, a DOI has been assigned to the IDP2014 which should be cited as follows:

Mawji, E., et al., The GEOTRACES Intermediate Data Product 2014, Mar. Chem. (2015), <http://dx.doi.org/10.1016/j.marchem.2015.04.005>.

GEOTRACES Intermediate Data Product 2014 survey

In order to help improve future Intermediate Data Products, GEOTRACES designed a survey to collect feedback from users of the IDP2014. The survey collected 262 responses, from which only 16% of the respondents were data contributors. Results from the survey can be grouped on: (1) completion of the product and suggestions for improvement; (2) use of data; (3) and dissemination. Results from each of these categories are described below:

- Completion of the product and suggestions for improvement

Results from the survey proved that the product was very successfully received by the community in that 97% of respondents did not notice errors or inaccuracies, 89% did not find any missing data or information and only 11% suggested other organization or packaging. When asking about other formats for the data to be released, 16% suggested other formats mostly netCDF, Excel and Matlab. NetCDF and Excel have already been included in version 2 of the IDP2014.

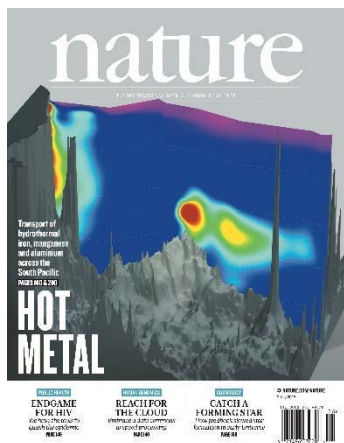
- Use of data

When inquiring about the use of data, “comparison with other data” is the use listed most frequently followed by teaching (and outreach). Other uses reported are data synthesis and modelling.

- Dissemination

76% of the respondents were aware of the IDP2014 prior to the survey (the survey served as an effective means of

dissemination for the other respondents). When asked about how users learned about the IDP2014, GEOTRACES media (website and mailing list) was listed first (total of 44% of the respondents), followed by the GEOTRACES 2014 Ocean Sciences Town Hall and SCOR Booth (24% of the respondents). Word of mouth was listed in third position.



The fact that 24% of the respondents identified the 2014 Ocean Sciences Town Hall and SCOR Booth proves the worth of the time and expenditure of the SCOR Booth at Ocean Sciences. GEOTRACES is very grateful to SCOR for this opportunity.

2.3 GEOTRACES Publications

The GEOTRACES publications database (<http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers>) includes 548 GEOTRACES publications available from the beginning of the project. The following three new Special Issues have been published this year and four more are in preparation:

Progress in Oceanography (Volume 133, Pages 1-78, April 2015)

GEOTRACES Synthesis and Modeling: The role of particles in the marine

biogeochemical cycles of trace elements and their isotopes

Edited by Catherine Jeandel, Olivier Marchal, Phoebe J. Lam and Robert F. Anderson

<http://www.sciencedirect.com/science/journal/00796611/133>

Deep Sea Research Part II: Topical Studies in Oceanography (Volume 116, Pages 1-342, June 2015)

GEOTRACES GA-03 - The U.S. GEOTRACES North Atlantic Transect

Edited by Edward A. Boyle, Robert F. Anderson, Gregory A. Cutter, Rana Fine, William J Jenkins and Mak Saito

<http://www.sciencedirect.com/science/journal/09670645>

Marine Chemistry (Volume 173, Pages 1-342, July 2015)

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

Edited by Sylvia Sander, Kristen Buck and Maeve Lohan

<http://www.sciencedirect.com/science/journal/03044203/173>

GEOTRACES findings featured on the cover of Nature

The work of Joseph Resing et al. (2015, see reference below) was featured on the cover of *Nature* (Volume 523 Number 7559, Thursday 9 July 2015). The cover shows an eGEOTRACES 3D scene view of dissolved iron across the South Pacific Ocean.

Reference:

Resing, J., Sedwick, P. N., German, C. R., Jenkins, W. J., Moffett, J. W., Sohst, B. M., & Tagliabue, A. (2015). Basin-scale transport of hydrothermal dissolved metals across the South Pacific Ocean. *Nature*, 523(7559), 200–203. doi:[10.1038/nature14577](https://doi.org/10.1038/nature14577).

2.4 GEOTRACES Science highlights

Below is a selection of recent GEOTRACES science discoveries. Owing to the large amounts of publications related to GEOTRACES, our criteria this year was to extract those published in the journal *Nature*:

Dissolved Iron Sources in the North Atlantic Ocean Quantified

The relative importance of four different dissolved iron (Fe) sources in the North Atlantic Ocean have been precisely determined for the first time, thanks to GEOTRACES.

Using a novel method based on the stable isotopic composition of dissolved Fe, Conway and John (2014, see reference below) have "fingerprinted" different sources of Fe along a section in the North Atlantic Ocean (GEOTRACES [GA03 section](#)). This has allowed the scientists to determine precisely the relative contribution of these sources to the North Atlantic Ocean. They found that the dominant sources were Saharan dust, which contributes 71-87% of dissolved iron, followed by North American margin sediments (10-19%). Smaller contributions were observed from the African margins (1-4%) and hydrothermal venting at the Mid-Atlantic Ridge (2-6%).

Since Fe is an essential marine micronutrient for phytoplankton, the scarcity of dissolved Fe in surface waters limits biological productivity over much of the oceans. Thus, changes in Fe inputs from different dissolved Fe sources have important implications for patterns of marine productivity and the global carbon cycle. This study therefore represents a significant contribution to our understanding of how dissolved Fe may influence past and future global change.

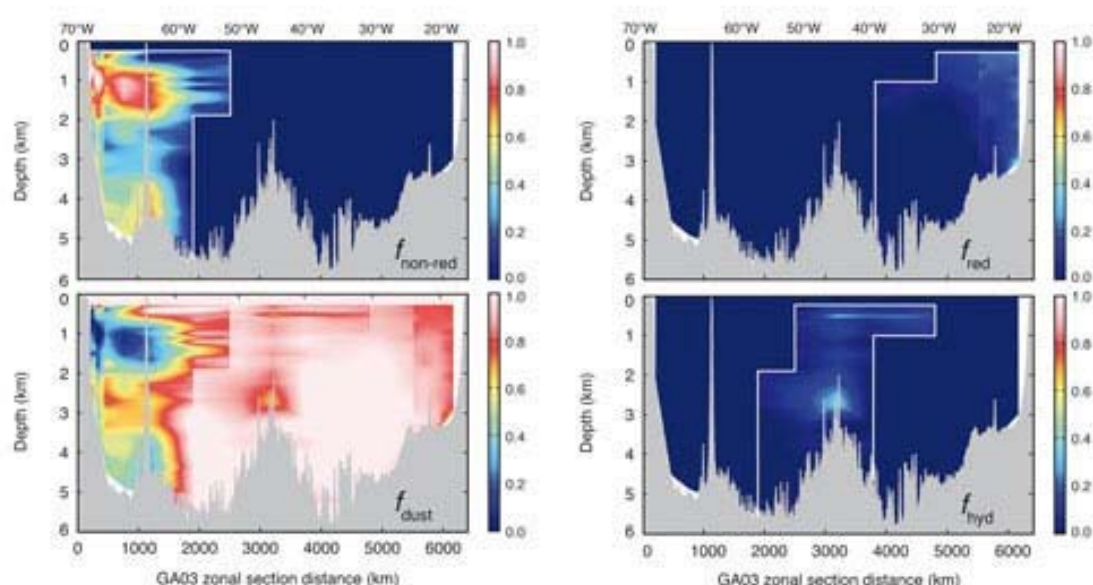


Figure 2: The figure shows the fraction of the seawater-dissolved Fe across the GA03 North Atlantic section that originates from each of four distinct sources : 1. Fe from oxygenated sediments on the North American margin ($f_{\text{non-red}}$); 2. Fe released by dissolution of atmospheric dust (f_{dust}); 3. Fe from reducing sedimentary porewaters on the West African Margin (f_{red}); and 4. Fe from hydrothermal venting on the Mid-Atlantic Ridge (f_{hyd}).

Reference:

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

Field Data Constrain Ocean Mercury Budget

Thanks to recent measurements during several oceanographic expeditions, among them GEOTRACES cruises, estimates of the total amount and spatial distribution of anthropogenic mercury in the global ocean have been 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 above preindustrial levels.

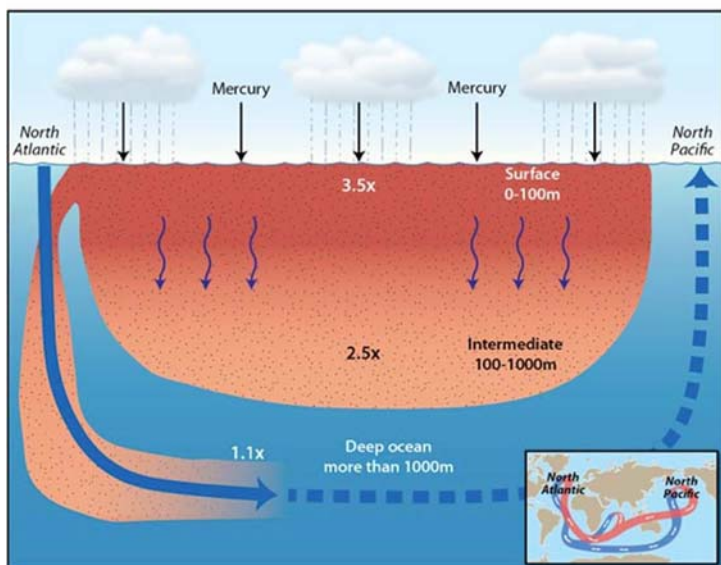


Figure 3: GEOTRACES researchers led by Carl Lamborg found that anthropogenic mercury (primarily atmospheric emissions produced by coal burning and cement production, as well as gold mining) have caused ocean waters down to 100 meters depth to be enriched in the toxic element up to 3.5 times the background level resulting from the natural breakdown, or weathering, of rocks on land. Once in the ocean, mercury adheres to organic particles and sinks or is consumed by progressively larger marine animals. One result is that intermediate levels of the ocean (between 100 and 1,000 meters depth) are also enriched in mercury up to 2.5 times the natural background rate. Even the deepest parts of the ocean have not escaped unscathed. Researchers found signs of pollution-derived mercury in the North Atlantic at depths below 1,000 meters, but those levels decreased as sampling efforts moved away from the North Atlantic basin. This is likely because pollution mercury has not yet moved with deep ocean currents throughout the global ocean, a process that can take as long as 1,000 years (extracted from WHOI's press release). Artwork: Jack Cook, WHOI.

Reference:

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

Seasonal Iron Supply in the Southern Ocean is Dominated by Winter Mixing

An international team of researchers analysed the available dissolved iron data taken from all previous studies of the Southern Ocean, together with satellite images of the area, to quantify the amount of iron supplied to the surface waters of the Southern Ocean. They found that, in contrast to the processes that supply so-called macronutrients in the tropics, seasonal iron supply is dominated by winter mixing, with little iron input afterwards. This is because the vertical profile of iron is distinct from other nutrients, with subsurface reserves located much deeper in the water column and therefore only accessible by the deeper mixing that occurs in winter. This means that after this input pulse, intense iron recycling by the 'ferrous wheel' is necessary to sustain biological activity. This unique aspect of iron cycling is yet to be explained but places important constraints on how climate models represent the iron distribution and how changes in ocean physics impact iron limitation.

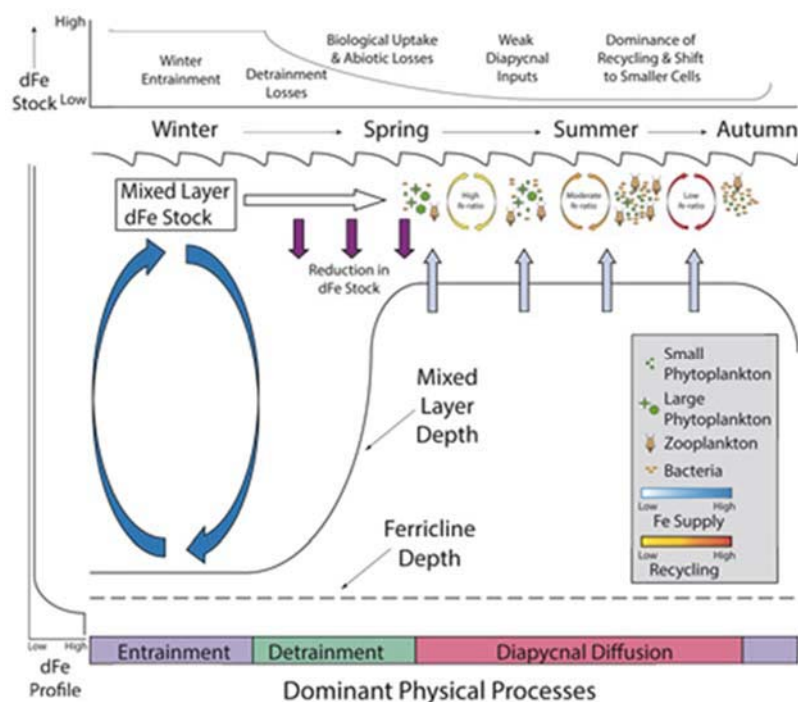


Figure 4: This diagram represents the seasonal variability in Southern Ocean iron (Fe) cycling.

Reference:

Tagliabue, A., Sallée, J.-B., Bowie, A. R., Lévy, M., Swart, S., & Boyd, P. W. (2014). Surface- water iron supplies in the Southern Ocean sustained by deep winter mixing. *Nature Geoscience*, 7(4), 314–320. doi:[10.1038/ngeo2101](https://doi.org/10.1038/ngeo2101)

What Controls the Copper Isotopic Composition in Oceanic Waters?

Takano and co-workers (2014, see reference below) strongly suggest that the isotopic composition of dissolved copper ($\delta^{65}\text{Cu}$) in surface seawater is mainly controlled by supply from rivers, the atmosphere and deep seawater. This is the conclusion of a study involving six vertical profiles of copper (Cu) concentration and isotopes measured in the Indian (1) and North Pacific (5) oceans. The finding contradicts previous interpretations suggesting a strong role of the biological activity in $\delta^{65}\text{Cu}$ fractionation.

At depth, $\delta^{65}\text{Cu}$ values are becoming heavier with the age of deep seawater, likely due to preferential scavenging of the light isotope (^{63}Cu). The authors built a box-model to quantify the oceanic budgets of both Cu concentrations and $\delta^{65}\text{Cu}$. Imbalance in this model suggests that Cu fluxes from continental shelf sediment might affect Cu distribution in the open ocean.

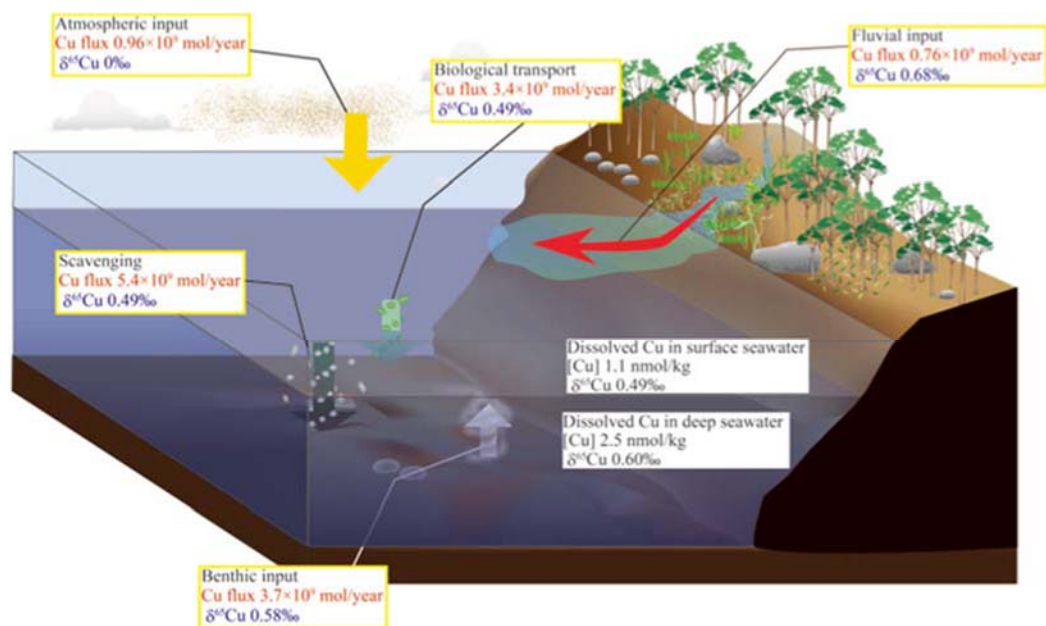


Figure 5: A box-model of Cu in the ocean based on both Cu concentration and isotopic composition.

Reference:

Takano, S., Tanimizu, M., Hirata, T., & Sohrin, Y. (2014). Isotopic constraints on biogeochemical cycling of copper in the ocean. *Nature Communications*, 5, 5663. doi:[10.1038/ncomms6663](https://doi.org/10.1038/ncomms6663)

Shallow Methylmercury Production in The Marginal Sea Ice Zone of the Central Arctic Ocean

Understanding persistent high levels of mercury in Arctic biota has been an elusive goal for nearly two decades. Little is known about where exactly inorganic Hg inputs into the Arctic generate the toxic methylmercury (MeHg) form that bioaccumulates in biota. Lars-Eric Heimbürger and colleagues (2015, see reference below) present the first full-depth high-resolution profiles (> 5200 m-depth) of total mercury (tHg) and MeHg in the central Arctic Ocean (79-90°N). MeHg maxima occur in the pycnocline waters, although noticeably shallower than in the other oceans (150 m in the Arctic versus roughly 1000 m in the Atlantic). These shallow maxima are probably due to the accumulation of settling biogenic particles slowed down by the strong density barrier of the arctic pycnocline which, in turn, will favor their microbial degradation and MeHg production. The shallow MeHg maxima likely result in enhanced biological uptake at the base of the marine food web, yielding elevated MeHg levels in Arctic wildlife. For this study the authors developed a new double isotope-dilution MeHg detection method with exceptional precision and low detection limit. These new findings will guide future Arctic Hg research, notably the international Arctic GEOTRACES multi-ship survey planned for summer 2015 by American, Canadian and German teams.

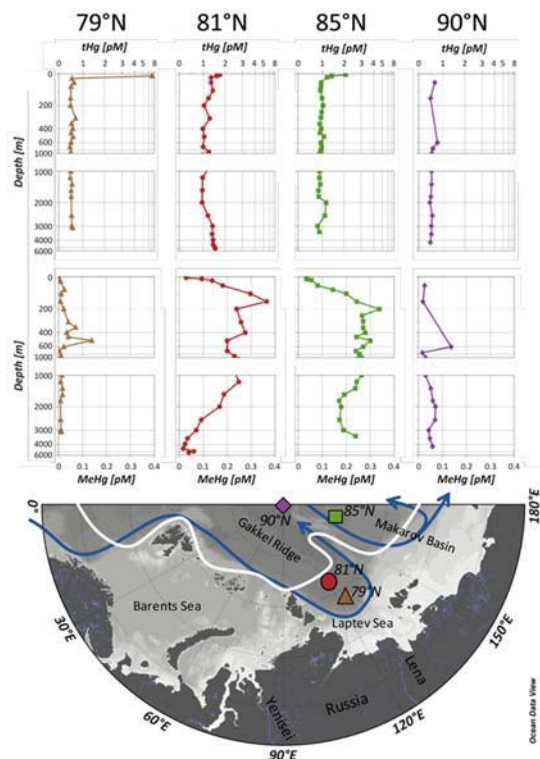


Figure 6: Total mercury (tHg) and methylmercury (MeHg) profiles in picomoles per litre (pM) at the coastally influenced open-water Laptev Sea station (PS78/280:79°N; brown triangles), the open-water Amundsen Basin station at the sea ice edge (PS78/273:81°N; red dots), the > 75% sea ice-covered Makarov Basin station (PS78/245:85°N; green squares), and the permanently sea ice-covered North Pole station (PS78/218:90°N, purple diamonds). The white line indicates the sea ice extent during the time of sampling. The blue line shows the general oceanic circulation of intermediate and Atlantic waters, after Rudels, 2012.

References:

Heimbürger, L.-E., Sonke, J. E., Cossa, D., Point, D., Lagane, C., Laffont, L., Galfond, B.T., Nicolaus, M., Rabe, B., van der Loeff, M. R. (2015). Shallow methylmercury production in the marginal sea ice zone of the central Arctic Ocean. *Sci. Rep.*, 5. DOI: [10.1038/srep10318](https://doi.org/10.1038/srep10318).
 Rudels, B. Arctic Ocean circulation and variability - advection and external forcing encounter constraints and local processes. *Ocean. Sci.* 8 261–286 (2012).

Unexpected Magnitude of the Hydrothermal Iron Inputs in the Deep Pacific

Data from the U.S. GEOTRACES Eastern Pacific Zonal Transect (EPZT, [GP16](#)) demonstrate that lateral transport of hydrothermal iron, manganese and aluminium extends up to 4,000 km west of the southern East Pacific Rise, therefore crossing a significant part of the deep Pacific Ocean. Dissolved iron behaves more conservatively than expected, and the resulting flux is more than four times what was assumed before. Results from a coupled ocean circulation/biogeochemical model demonstrate that this hydrothermal iron input may sustain a large fraction of the Southern Ocean export production.

Nature decided to largely promote this work by reporting a GEOTRACES 3D view of the bottom Pacific showing the hydrothermal vent as a cover (see above).

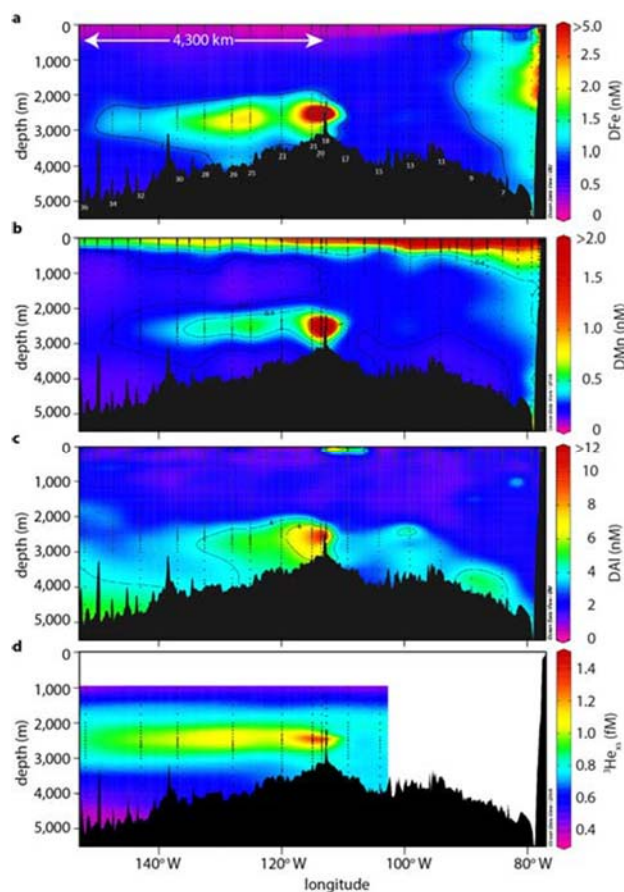


Figure 7: The top three panels show concentrations of dissolved iron, manganese and aluminum measured during the voyage. The bottom panel shows concentration of a form of helium that marks the water as coming from a hydrothermal vent, and its decreasing concentration away from the ridge reflects mixing rather than a chemical reaction.

Credit:

J. Resing / Univ. of Washington.

Reference:

Resing, J. A., Sedwick, P. N., German, C. R., Jenkins, W. J., Moffett, J. W., Sohst, B. M., & Tagliabue, A. (2015). Basin-scale transport of hydrothermal dissolved metals across the South Pacific Ocean. *Nature*, 523(7559), 200–203. doi:[10.1038/nature14577](https://doi.org/10.1038/nature14577).

Coupling Rare Earth Elements Concentrations, Neodymium And Radium Isotopes: A Powerful Tool to Decode Environmental Processes

For the first time, neodymium (Nd) isotopic compositions have been measured together with dissolved and colloidal Rare Earth Elements (REE) concentrations in the Amazon estuary salinity gradient, as part of the [GEOTRACES process study AMANDES](#) (Chief scientist: Catherine Jeandel). The sharp drop of REE concentrations in the low-salinity area (already observed in several estuaries) is clearly driven by the coagulation of colloidal material. While dissolved REE concentrations increase again at mid-salinity, Nd isotopic ratios allow tracing that these REE are released by lithogenic material, weathered and transported by the river to the Atlantic Ocean. The original coupling with radium (Ra) isotopes demonstrates that these dissolution processes are occurring within three weeks in the Amazon plume.

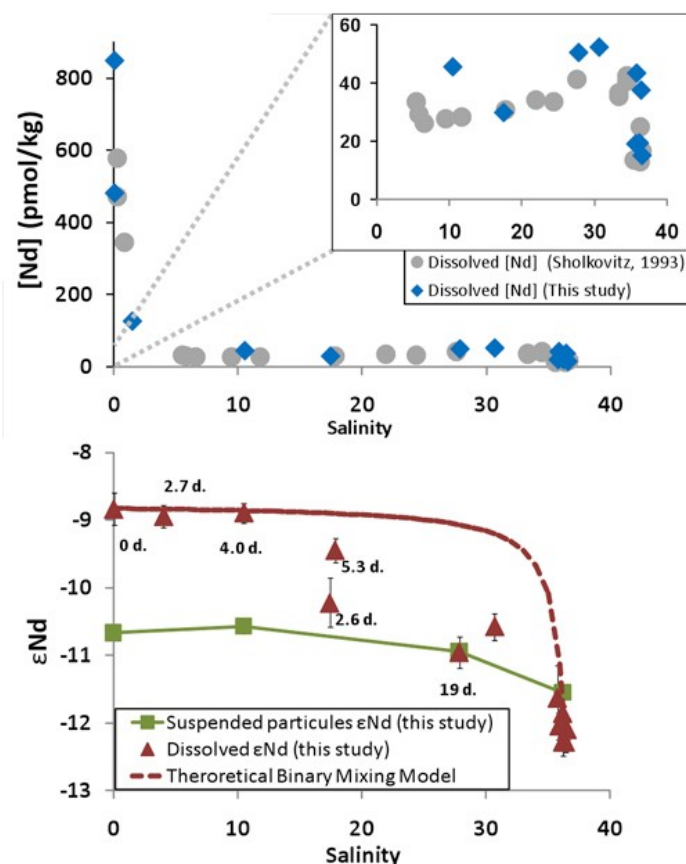


Figure 8: Nd concentrations and isotopic composition in the Amazon River estuary. Upper panel: Amazon estuary [Nd] from Sholkovitz' 1993 study (grey circles) and this study (Blue diamonds) are reported against the salinity gradient. We observe the non conservative mixing between the Amazon river and the Atlantic waters. The sharp drop in [Nd] in the low salinity region is attributed to the coagulation of colloids, the main REE carriers within river. This drop in concentrations is followed by an increase with salinity before reaching typical low Nd levels of marine waters. Lower panel: Amazon estuary dissolved (Red triangles), particulate (Green squares) ϵ Nd and apparent radium ages (in days) values are reported against the salinity gradient. A simple two-endmember (Amazon and Atlantic dissolved Nd) mixing model (red dashed line) is not sufficient to explain ϵ Nd variation within the salinity gradient. The dissolved Nd phase rapidly (19 days) homogenizes with a third source, the suspended sediments.

Reference:
Rousseau, T. C. C., Sonke, J. E., Chmeleff, J., Beek, P. van, Souhaut, M., Boaventura, G., Seyler, P., Jeandel, C. (2015). Rapid neodymium release to marine waters from lithogenic

sediments in the Amazon estuary. Nature Communications, 6, 7592. doi:[10.1038/ncomms8592](https://doi.org/10.1038/ncomms8592).

3. Activities

3.1 GEOTRACES Intercalibration Activities

After the preceding and very busy year reviewing all intercalibration results for the first IDP release, the Standards and Intercalibration (S&I) Committee had a far less stressful, but productive, year. In addition, three new members joined the committee: Karen Casciotti (Stanford University, California, USA) covering N and C isotopes, Walter Geibert (Alfred Wegner Institute, Germany) handling radionuclides, and Tina van de Flierdt (Imperial College, London, UK) covering radiogenic isotopes such as neodymium. Both Karen and Tina were elemental coordinators in the initial 2008-2009 phase of the GEOTRACES Intercalibration programme and cruises, while Walter stood in for Michael van der Loeff for one meeting during the same phase of the programme. Thus, the new members of the committee are experienced with the processes of intercalibration and evaluating results from cruises.

The major accomplishment of the Committee in this period was completion and posting of the newest (Version 2.0) "Sampling and sample handling protocols for GEOTRACES cruises" cookbook on the GEOTRACES website: <http://www.geotraces.org/images/stories/documents/intercalibration/Cookbook.pdf>. This version has many updates for the various TEIs throughout the document and also includes a new section on artificial radionuclides that did not make it into the original version. Additionally, the hydrography requirements and methods were updated to be fully compliant with the GO-SHIP programme protocols. More significantly, the specifications for meeting intercalibration criteria were tightened up, changing the recommendations to requirements. The Committee decided that the cookbook will be updated every two years, so the next update will be in 2017 unless something critical needs to be updated/modified before this. To complement the cookbook, two Intercalibration Procedure documents,

one for cruises with crossover stations and one for those without them, were created to help investigators undertake intercalibration before the S&I Committee sees the results (<http://www.geotraces.org/science/intercalibration/89-intercalibration-documents>). Both documents are only two pages long and should facilitate intercalibration between the relevant investigators largely independent of the Committee.

The Committee met in Galway, Ireland in January 2015 at the National University of Ireland and hosted by Peter Croot. In attendance were Per Andersson attending his last S&I meeting, Peter Croot, Greg Cutter, Walter Geibert, and Maeve Lohan; Karen Casciotti participated via conference software/internet connection. Topics discussed included calibration and reference materials for GEOTRACES TEIs; the latest compilation of TEI acceptability criteria to achieve intercalibration (e.g., nutrients within 2%); updates on recent intercalibration efforts including mercury, ligands (SCOR Working Group 139), cobalt, silicon isotopes, and particles; status of data from post-2014 IDP cruises; data review procedures for the next IDP; and timelines for reviews and plans for the Committee's next meeting. With respect to the latter, the Committee would like to meet in June 2016 and Karen Casciotti offered to host the meeting at Stanford University. Finally, to better track the status of cruises, relevant investigators, and intercalibration status for each TEI, the Committee began a spreadsheet with all the relevant information. This document will be shared with the Data Management Committee to better coordinate and inform collaborations for ensuring a timely and accurate IDP.

For the next year, 2015-2016, the major activities of the S&I Committee will be contacting cruise investigators to ensure that they are conducting their intercalibrations via the established procedures and submitting their results to the Committee, and reviewing these results for the next IDP. With respect to the latter, the Committee will work much more closely with the Data Management Committee to ensure the timely and accurate incorporation of cruise data into the 2017 IDP. The Committee also will continue to identify suitable dissolved and particulate reference materials for the diverse suite of TEIs examined in GEOTRACES and monitor on-going intercalibration activities (e.g., chemical speciation). Finally, Lars-Eric Heimbürger at University of Bremen (Germany) will join the Committee as its newest member, with expertise in mercury and other contamination-prone trace elements.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanographic Data Centre (BODC), whose headquarters is located in Liverpool. The GEOTRACES Data Manager is based at the BODC Southampton, UK office. Regular communication is maintained between the two sites so that support and assistance can be offered to the GEOTRACES Data Manager when required.

GDAC is responsible for the entirety of the GEOTRACES data activities from inception to completion. This takes into account the following components:

- interaction between PIs and national data centres in order to encourage regular and timely data and metadata submissions
- maintaining and modifying GDAC webpages to include updated ocean basin maps (http://www.bodc.ac.uk/geotraces/cruises/section_maps/) and upcoming cruises on the programme page (<http://www.bodc.ac.uk/geotraces/cruises/programme/>)
- liaising with the Data Management Committee and Standards and Inter-calibration Committee to ensure that issues and questions relating to GEOTRACES and its progression as a project can be discussed, and deadlines can be met accordingly.
- input of metadata and data into the BODC database and compilation of documentation to include analysis methodologies
- Collation of data and metadata for the 2017 Intermediate Data Product

GDAC, until recently, has been staffed by a single person. This was Edward Mawji up until February 2015, at which point Abigail Bull took his place as the GEOTRACES Data Manager. BODC has provided extra resources to the GEOTRACES Project in order to aid and provide support to Abigail, primarily with the data processing. When the

GEOTRACES Project expects to experience busy periods (i.e., in the lead up to the 2017 IDP) this extra resource will be invaluable. This data management report will highlight tasks that have been the focal point of GDAC since this Abigail Bull became the Data Manager in February 2015.

Working with the IPO

A sound working mechanism has been established between the GEOTRACES IPO and GDAC, even with the changeover of staff members at BODC. The IPO has been particularly useful in providing guidance to the new GEOTRACES Manager so the GEOTRACES project can continue to run efficiently. When there is a change in staff there is often a period of time dedicated to learning and development – the IPO has provided unending support in this matter and has made the new GEOTRACES Project Manager feel welcome. The IPO has also helped GDAC stay up to date with new cruises, as well as serving reminders of when certain people should be contacted in order to extract various information at relevant times.

Meetings attended

Various visits have been made since stepping into the GEOTRACES Data Manager role. These are essential for building good relationships with national data centres. The meetings attended including the following:

- Visit to the IPO Office in Toulouse, where Abigail met with Elena Masferrer Dodas and Catherine Jeandel. The GEOTRACES Project as a whole was discussed, as well as ways in which the IPO could support Abigail in her new role. Meeting significant GEOTRACES Project participants in person has solidified working relationships. This meeting also presented an opportunity to ask questions and clarify any outstanding issues. Also present was Catherine Schmechtig (Data Manager at French data centre - LEFE Cyber) The formats and submission of French data were discussed, along with retrieval of outstanding cruise reports for French cruises. This proved beneficial, as there is now a strong working relationship and communication method between the French data centre and GDAC.
- Meeting with Reiner Schlitzer in Bremen, Germany. The aim was to meet Reiner before the DMC/SSC meeting in July 2015, and to discuss various data-related items. These included version 2 of the 2014 IDP, the possibility of an interactive map on the GDAC website, IDP parameter codes, and preparation techniques for the 2017 IDP. The meeting was extremely useful in regards to identifying priorities for the project, as well as ascertaining items which should be discussed at the DMC meeting in order to clarify unanswered questions.
- Regular meetings with Alessandro Taglibue (DMC co-chair) in Liverpool – these one-to-one meetings have provided guidance and support to Abigail as the new GEOTRACES Data Manager. Data discussions as well as GDAC DMC items have been addressed in these informal meetings.
- Meeting with Cyndy Chandler (BCO-DMO) in Liverpool – discussion centred around BCO-DMO (the U.S. data centre) and what it can do to assist GDAC in its responsibilities. Further discussions regarding this will take place between 8 and 10 July, when Abigail and Graham Allen (Head of BODC) visited BCO-DMO at Woods Hole, MA, USA.

Data overview

The data management of the GEOTRACES Project is a large undertaking, with a total of 66 cruises (including all cruise legs) associated with the project (this takes into account all section cruises, process studies and “compliant” data). More than 800 scientists have taken part in GEOTRACES cruises, with 15 different nations having run a major GEOTRACES IPY/section/process study cruise.

2014/2015 has been a successful period, where contact has been made with PIs owing data to GDAC: submissions of data and metadata are becoming more forthcoming. It has been recognised that a way of encouraging PIs to submit their data to GDAC more readily is to use inclusion of a PI's data in the 2017 IDP as an incentive.

Summary of completed GEOTRACES cruises to date:

Section cruises	IPY cruises	Process studies	Compliant data
27 cruises (including all legs) with 19 sections	11	21 (including all legs)	5 with 17 sections

In addition, 2 intercalibration cruises have been completed.

Since Abigail Bull started as GEOTRACES Data Manager, one process study cruise has taken place: NBP1409 (GPpr08 Leg2 - PHANTASTIC II cruise)). The PHANTASTIC I cruise NBP1310 02 (GPpr08 Leg1) took place in December 2013–January 2014. This cruise has recently been approved as a GEOTRACES Process Study and so it is new to the GDAC programme page (<http://www.bodc.ac.uk/geotraces/cruises/programme/>). The SSB (Shelf Seas Biogeochemistry) GEOTRACES cruise is on its way to completion, with leg 3 (DY033 – GApr04 leg3) still to take place between 11 July and 3 August 2015. DY018 (GApr04 Leg1) and DY029 (GApr04 Leg2) are already complete. One section cruise, KH14-6 (GP19), undertaken by Japan in the Western South Pacific and Antarctic Sea, took place at the beginning of 2015.

Summary of forthcoming GEOTRACES cruises to take place in 2015/2016:

This year the International GEOTRACES Arctic research programme focuses on field effort from the United States, Canada and Germany. Three Arctic cruises have been planned and funded and will take place between July and October 2015. German cruise M121 (GA08) is scheduled in the SE Atlantic with planned cruise dates of 21 November–27 December 2015.

In summary

The collection and processing of data to be included in the 2017 IDP will be a priority over the coming year. GDAC continues to receive data and metadata from completed cruise. In order to encourage more timely submission, the incentive of having data in the 2017 IDP as well as the recognition that results from such inclusion, will be more formally advertised.

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 a single 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 website and Facebook and Twitter pages; 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.

Outreach effort

Outreach has been the top priority for the GEOTRACES IPO this year. Firstly, several actions have been undertaken to publicize the Intermediate Data Product 2014 (e.g. presentations in international conferences or other international programmes conferences, sending announcements to other international programmes mailing lists). Secondly, the IPO is collecting GEOTRACES outreach materials and activities developed during the five years of the programme and promoting them to be used not only through the GEOTRACES Community but also to other communities. For this, the IPO has developed an Outreach website:

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GEOTRACES Outreach website

An important effort has been made by the IPO to create a website devoted to outreach. This public website displays all the GEOTRACES outreach materials and activities: <http://www.geotraces.org/outreach>. Example of materials available on the website are: cruise blogs, webinars, cartoons, videos, podcasts, textbooks, brochures, posters, publicity documents, etc.

Thirdly, the IPO has helped GEOTRACES national programmes in developing and promoting their outreach initiatives, as for example:

- GEOTRACES Webinar series: Ben Twining (U.S. GEOTRACES) has developed a webinar series devoted to GEOTRACES in collaboration with the Centers for Ocean Sciences Education Excellence (COSEE). The webinar hosted by the COSEE-Ocean Systems office at University of Maine is available here: <http://www.geotraces.org/outreach/other-outreach-materials/webinars>
- Toulouse Knowledge Festival (La Novela) and sharing science with prisoners (Association the stars shine for all): During the French GEOVIDE cruise, Catherine Jeandel (IPO science director, France) set up a project with the Seysses Prison (Toulouse, France). During 6 months (April-October 2014), GEOVIDE scientists communicated with prisoners (via their teachers). They did this before the cruise, during the cruise (thanks to a cruise blog) and after the cruise. The project ended with a session at the Toulouse Knowledge Festival (called La Novela) in October 2014 where a video was projected followed by a debate. For further information:

<http://www.geotraces.org/outreach/other-outreach-materials/videos/1079-geovide-sharing-oceanography-with-prisoners>

In addition, we would like to highlight the following tasks:

- Major GEOTRACES website overhaul: One important task this year was to overhaul the GEOTRACES website. While keeping the same structure to facilitate access to information, the website now has a dynamic new design that provides more visibility to GEOTRACES products, including outreach activities. At the same time, the link within the GDAC website and the IPO website has strengthened. Special thanks to Olivier Boebion (Obs. Oceano. Villefranche sur Mer) and Paule Dossi (DOoWEB) for their technical assistance and advice in upgrading the website.

- Twitter account: Since February 2015, GEOTRACES has a Twitter account that counts 111 followers at the time this report is written. This is in complement to the GEOTRACES Facebook page, which has 235 followers (and with 1453 people reached on a post).
- International Conferences: With the aim of publicising GEOTRACES towards other communities, two abstracts have been submitted and accepted to international conferences presenting the GEOTRACES Programme:
 - « GEOTRACES highlights in the Indian Ocean and plans for the future », oral presentation, presented by L. Demina⁴ (26th IUGG General Assembly, IAPSO Symposium, special session on *the 50th Anniversary of the Indian Ocean Expedition*, Prague, 22 June- 02 July 2015)
 - « Highlights from the GEOTRACES International Programme », poster, to be presented by G. Henderson on Monday 17 August at 17h (Goldschmidt 2015, Prague, August 16-21, 2015)
- Working with GDAC: A very nice working relation has been established between the IPO and the new GEOTRACES Data Manager, Abigail Bull. On March 2015, the IPO organized a meeting in Toulouse for Abigail Bull to meet not only the IPO staff, but also the French Data Manager Catherine Schmechtig.
- Intermediate Data Product 2014 Survey:

The GEOTRACES IPO has assisted DMC co-chairs and the SCOR Executive Director in disseminating the IDP2014 Survey and analysing and presenting the results.

- Some statistics:

80 highlights published (24 since last reporting period) 15 eNewsletter published (bimonthly newsletter)
120 researchers included in the GEOTRACES Researchers Analytical Expertise Database 548 peer-reviewed papers included in the GEOTRACES Publication Database

3.4 GEOTRACES Workshops

First GEOTRACES Brazil Workshop, 21-22 March 2015, Santos, Brazil.

As a result of the Latin America workshop held in 2012 (12-15 November 2012, Rio de Janeiro, a network of researchers has been established and a core community is being structured in Brazil. The *Final Statement* resulting from this workshop is available on the GEOTRACES site:

http://geotraces.org/images/stories/documents/workshops/2015_Brazil/2015_Workshop_GEOTRACES_BRASIL_final_statement_08_05.pdf

Forthcoming:

Coupled meeting and workshop to discuss and synthesise findings from the GEOTRACES programme:

*The biological and climatic impacts of ocean trace-element chemistry, 7–8 December 2015, The Royal Society, London, UK.

For further information: <https://royalsociety.org/events/2015/12/ocean-chemistry/>

A Royal Society Scientific Discussion Meeting to present new results and discoveries about the role of ocean in trace-element cycling in the Earth system. Speakers from eight countries will discuss the oceanic cycles of trace elements, their role in ocean biology, their use to assess past and present ocean processes, and the influence of human activity on ocean trace-element chemistry. The meeting is open to all, with registration at the above website. There is no charge to attend.

*Quantifying fluxes and processes of trace-metal cycling at ocean boundaries, 9–10 December 2015, Chicheley Hall, Buckinghamshire, UK.

For further information: <https://royalsociety.org/events/2015/12/ocean-chemistry/>

This is a workshop-format meeting to synthesise knowledge about the fluxes of trace elements at the four ocean boundaries: from continents across the shelf; from marine sediments; from mid-ocean-ridges; and from the atmosphere. Keynote talks will describe recent advances in data and understanding for each interface. Discussion groups and posters will enable a full exploration of the state of knowledge for each interface, identify areas of uncertainty, and consider possible future research. The programme is presently being finalised. This workshop has a limited number of places and is by invitation or application only.

3.5 Special sessions at international conferences featuring GEOTRACES findings

Several special sessions with relevance to GEOTRACES were featured or planned in major international conferences including the following:

2014 Asia Oceania Geosciences Society 11th Annual Meeting (AOGS 2014), 28 July to 1 August 2014, Sapporo, Hokkaido, Japan.

For further information: <http://www.asiaoceania.org/aogs2014/public.asp?page=home.htm>

*OS01: Trace elements and their isotopes in the ocean: GEOTRACES activities in Asia and Oceania
Convenors : Dr. Yoshiki Sohrin (Kyoto University, Japan), Dr. Tung-Yuan Ho (Academia Sinica, Taiwan), Dr. Pinghe Cai (Xiamen University, China), Prof. Man Sik Choi (Chungnam National University, Korea, South).

24th Earth Sciences meeting, 27-31 October 2014, Pau, France. For further information: <http://rst2014-pau.sciencesconf.org>

*Session 8.5: Advances in mercury biogeochemistry. Organizers: Jeroen Sonke (GET, Toulouse) and David Amouroux (LCABIE, IPREM, Pau).

*Session 8.7 : Biogeochemical cycling of contaminants in the Arctic. Organizers: Lars- Eric Heimbürger (GET, Toulouse, France) and Aurélien Dommergue (LGGE, Grenoble, France).

American Geophysical Union Fall 2014 Meeting, 15-19 December 2014, San Francisco, California, USA.
For further information: <http://fallmeeting.agu.org/2014/>

GEOTRACES sessions:

*Trace Element and Isotope Cycling in the Coastal Environment – 40 Years of Innovations. Conveners: Greg Cutter and Pete Sedwick

*Trace metals and isotopes in the Eastern Tropical South Pacific: Results of the 2013 U.S. GEOTRACES Zonal Transect and complimentary studies. Conveners: Jim Moffett, Chris German and Martin Frank

GEOTRACES-related sessions:

*Productivity Proxies: New Developments and Records. Conveners: Fatima Abrantes, Bob Anderson and Heather Stoll

*Biogeochemical cycling of silicon in coastal transition zones. Conveners: Claudia Ehlert, Patricia Grasse, Daniel J Conley and Mark A Brzezinski

*The Biogeochemical Cycling of Mercury in the Coastal and Open Ocean. Conveners: Robert P Mason and Arthur Russell Flegal

*Past Ocean Dynamics
Conveners: Joerg Albert Lippold, Luke Skinner and Sam Jaccard

ASLO 2015, Aquatic Sciences Meeting, 22-27 February 2015, Granada, Spain. For further information: <http://www.aslo.org/meetings/index.html>

*142 - Chemical Oceanography/GEOTRACES Convenor: Andrea Kochinsky, Jacobs University Bremen.

*037 - The Molecular Ecology of Metal-Microbe Interactions in the Ocean Environment. Conveners: Robert Strzepek, The Australian National University; Maite Maldonado, The University of British Columbia; and Yeala Shaked, The Hebrew University in Jerusalem.

*014 - Atmospheric Deposition Effects in Aquatic Ecosystems
Conveners: Francesc Peters, Institut de Ciències del Mar (CSIC), Barak Herut, National Institute of Oceanography, Adina Paytan, Institute of Marine Sciences, Cecile Guieu, Laboratoire d'océanographie de Villefranche, Ana M Aguilar-Islas, University of Alaska Fairbanks, Clifton Buck, Skidaway Institute of Oceanography and Simon Usher, University of Plymouth.

3rd International Symposium on the Effects of Climate Change on the World's Oceans, 23-27 March 2015, Santos, Brazil.
For further information: http://www.pices.int/meetings/international_symposia/2015/2015-Climate-Change/scope.aspx

*S3. Changing Ocean Chemistry: From Trace Elements and Isotopes to Radiochemistry and Organic Chemicals of Environmental Concern
Co-chairs: Angelica Peña (Institute of Ocean Sciences, Department of Fisheries and Oceans, Canada) and Geraldine Sarthou (LEMAR, IUEM, Brest, France)

12th International Conference on Mercury as a Global Pollutant, 14-19 June 2015, Jeju, Korea. For further information: <http://mercury2015.com/main/>

*17. Integrating marine observational studies and model development Conveners: Anne Laerke Soerensen & Lars-Eric Heimbürger

*Conference Workshop: GEOTRACES Intercalibration exercises for Hg species in seawater discussion forum Conveners: Lars-Eric Heimbürger

Forthcoming:

Goldschmidt 2015, 16-21 August 2015, Prague, Czech Republic. For further information: <http://goldschmidt.info/2015/index>

** Theme 2: Ocean Geochemistry. Present Conditions and Past Variation: fluxes, reservoirs and processes Co-ordinators: Geraldine Sarthou (Brest University, France) and Andrew Bowie (University of Tasmania). Team members: Katherine Barbeau (Scripps, USA), Kristen Buck (Univ South Florida, USA), Zanna Chase (Institute for Marine and Antarctic Studies, Austr), Rob Middag (Univ Otago, New Zealand), James Moffett (Univ. Southern Carolina, USA)

*02a: Trace Metals in the Ocean: Distributions, Isotopic Variation and Speciation. Session Conveners: Katherine Barbeau (UC San Diego, Scripps Institution of Oceanography, USA), Andrew Bowie (University of Tasmania), Kristen Buck (University of South Florida, College of Marine Science, USA), Rob Middag (Univ Otago, New Zealand), Christopher Pearce (National Oceanography Centre), Phil Pogge von Strandmann (Earth Sciences, University College London, UK), Géraldine Sarthou (LEMAR CNRS, Brest, France).

*02b: Radionuclides in the Ocean
Session Conveners: Bob Anderson (Lamont-Doherty Earth Observatory, USA), Ken Buesseler (Woods Hole Oceanographic Institution, USA), Pere Masque (Universitat Autònoma de Barcelona)

*02c: Past Changes in Ocean Biogeochemistry and Circulation and their Interaction with Climate
Session Conveners: Zanna Chase (Institute for Marine and Antarctic Studies, Australia), Martin Frank (GEOMAR Helmholtz centre for ocean research Kiel, Germany), Norbert Frank (University of Heidelberg, Germany), Katharina Pahnke (ICBM and MPI for Marine Microbiology, Germany), Laetitia Pichevin (University of Edinburgh, UK), Laura Robinson (University of Bristol, UK), Tina van de Flierdt (Imperial College London, UK), Kazuyo Tachikawa (Cerege, CNRS, France)

*02d: What are the unifying principles common to all three Oxygen Minimum Zones (OMZs)?
Session Conveners: Jim Moffett (Univ. Southern Carolina, USA), Aurélien Paulmier (LEGOS, France)

*02e: Air-Sea Exchange, the Biological Pump, and Ocean Acidification
Session Conveners: Steve Emerson (University of Washington, USA), Doug Wallace (Dalhousie University, Canada)

*02f: Biogeochemistry of Arctic and Antarctic sea ice systems
Session Conveners: Jun Nishioka (Univ. Hokkaido, Japan), Delphine Lannuzel (University of Tasmania, Australia)

*02g: Advances in marine N, P and Si biogeochemistry
Session Conveners: Damien Cardinal (University Pierre and Marie Curie, LOCEAN, Paris), Albert Colman (University of Chicago, USA), Masha Prokopenko (University of Southern California, USA), Christian März (Newcastle University, UK)

*02s: Goldschmidt 25th Anniversary
The 25th anniversary talk is an overview of the progress and breakthroughs made in this theme over the last 25

years. Invited speaker: Catherine Jeandel

22nd International Society for Environmental Biogeochemistry (ISEB) Symposium Dynamics of Biogeochemical Systems: Processes and Modeling, 28 September-2 October 2015, Piran, Slovenia.

For further information : <http://www.iseb22.ijs.si>

*Marine and coastal environments – Special session: GMOS and GEOTRACES

American Geophysical Union Fall 2015 Meeting, 14-18 December 2015, San Francisco, California, USA.

For further information: <http://osm.agu.org/2016/>

*GC067: Trace Metal Cycling in the Environment – 40 Years of Advancements Session ID#: 8771

Convenors: Priya Ganguli, Frank Black, Sergio Sanudo-Wilhelmy and Ed Boyle

*A035: Dust in High Latitudes: From its Origins to its Impacts Session ID#: 8015

Primary Convener: Santiago Gasso, GESTAR/NASA, Silver Spring, MD, United States Conveners: John Crusius, USGS Western Regional Offices Seattle, Seattle, WA, United States, Gisela Winckler, Lamont-Doherty Earth Observatory, Palisades, NY, United States and Paul A Ginoux, NOAA Princeton, Princeton, NJ, United States

*OS010: Exploring the Dust-Ocean Connection in a Changing Climate Session ID#: 8749

Primary Convener: Maurice Levasseur, Laval University, Quebec-Ocean, Quebec City, QC, Canada
Conveners: William L Miller, University of Georgia, Athens, GA, United States and Mitsuo Uematsu, University of Tokyo, Bunkyo-ku, Japan

2016 Ocean Sciences Meeting, 21-26 February 2016, New Orleans, Louisiana, USA. For further information :

<http://osm.agu.org/2016/>

*CT001: Atmospheric deposition and ocean biogeochemistry Session ID#: 9243

Primary Chair: Ana M Aguilar-Islas, University of Alaska Fairbanks, Fairbanks, AK, United States
Chairs: Clifton S Buck, Skidaway Institute of Oceanography, Savannah, GA, United States and Meredith Galanter Hastings, Brown Univ-Geological Sciences, Providence, RI, United States

*CT002: Integrating approaches to understanding the distribution and transfer of trace elements in the upper water column

Session ID#: 8750

Primary Chair: Rachel Shelley, LEMAR/UBO, Brest, France

Chairs: Peter L Morton, Florida State University, Department of Earth, Ocean, and Atmospheric Science, Tallahassee, FL, United States and Sunil Kumar Singh, Physical Research Laboratory, Ahmedabad, India

*CT003: Kinetics: the force driving trace metal distributions in marine waters Session ID#: 9486

Primary Chair: Christian Schlosser, GEOMAR Helmholtz Centre for Ocean Research Kiel, Chemical Oceanography, Kiel, Germany

Chairs: Eric P. Achterberg, GEOMAR Helmholtz Centre for Ocean Research Kiel, Chemical Oceanography, Kiel, Germany, Christoph D Voelker, Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven, Bremerhaven, Germany and Alessandro Tagliabue, University of Liverpool, Earth, Ocean and Ecological Sciences, Liverpool, United Kingdom

*CT008: The role of particles in the cycling of trace elements and their isotopes in the ocean

Session ID#: 7493

Primary Chair: Hélène Planquette, LEMAR, CNRS, Plouzané, France

Chairs: Phoebe J Lam, University of California Santa Cruz, Department of Ocean Sciences, Santa Cruz, CA, United States and Benjamin S. Twining, Bigelow Lab for Ocean Sciences, East Boothbay, ME, United States

*CT009: Trace Elements and Isotopes at the Interfaces of the Atlantic Ocean Session ID#: 9208

Primary Chair: Geraldine Sarthou, LEMAR UMR 6539 CNRS UBO IRD IFREMER, IUEM, Plouzané, France
 Chairs: Edward A Boyle, Massachusetts Institute of Technology, Earth Atmospheric and Planetary Sciences, Cambridge, MA, United States, Gideon Mark Henderson, University of Oxford, Earth Sciences, Oxford, United Kingdom and Micha J.A. Rijkenberg, Royal Netherlands Institute for Sea Research, Den Burg, Netherlands

*CT010: Trace Metal Bioavailability and Metal-Microorganism Interactions Session ID#: 8373

Primary Chair: Julia M Gauglitz, Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry, Woods Hole, MA, United States

Chairs: Randelle Bundy, Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry, Woods Hole, MA, United States and Jill N Sutton, IUEM/UBO, Technopôle Brest-Iroise, Place Nicolas Copernic, Plouzané, France

*CT011: Trace metal speciation in seawater: measurements, modelling and impact on marine biogeochemistry Session ID#: 9231

Primary Chair: David R Turner, University of Gothenburg, Gothenburg, Sweden

Chairs: Stan MG van den Berg, University of Liverpool, Liverpool, L69, United Kingdom, Sylvia Gertrud Sander, University of Otago, Dunedin, New Zealand and Kristen N Buck, University of South Florida Tampa, Tampa, FL, United States

GEOTRACES Tutorial:

*T014: What Controls the Distribution of Dissolved Iron in the Ocean? Session ID#: 9303

Primary Chair: Alessandro Tagliabue, University of Liverpool, Liverpool, L69, United Kingdom

3.6 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 programme 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 1018 intelligent rosette system	12 x 10-L Teflon-lined Niskin-1010X	6000 m; 6 mm Dynex rope

Australia	2nd system (complete)	Polyurethane powder-coated aluminium autonomous Seabird rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	12 x 12-L Teflon-lined OTE external- spring Niskin- style bottles	1750 m 9mm Dyneema rope or 200 m 6 mm Dyneema rope with coupling to 6000 m CTD wire
Brazil	Complete	GEOTRACES WATER SAMPLER - 24-bottle sampler for use with modern 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
Israel	Complete	Powder coated aluminium, SeaBird Rosette	12 X 12-L Niskin; 8 X 12-L GO-Flo (Teflon coated)	2000 m, steel conducting cable
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
Poland	Complete	Powder coated aluminum, SeaBird Rosette	8x 10L GoFlo	3000m, steel conducting cable
Poland	Complete	Single bottle	10l G-FLO X	300m Kevlar
			Teflon coated	
Poland	Complete	Teflon pump on-line	Surface water pump	1.5m fixed
Poland	In development	Pump CTD	Teflon hose 10mm	Up to 200m
South Africa	Complete	Powder coated aluminium, titanium housing/fittings	24 X 12-liter GO-Flo	6500 m; Kevlar cable
UK	Complete	2 x Titanium frame, Ti pressure housings	24 10-L OTE 24 10-L OTE	2 x 8000m conducting Kevlar
USA - CLIVAR	Complete	Powder coated aluminium	12 X 12-L GO-Flo	1500 m; conducting Kevlar
USA - GEOTRACE S	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. Plans for coming years

Field Programme

The completion of the GEOTRACES research Arctic programme (4 cruises in 2015 and 1 more planned for 2016) will be one important target of the field programme for the coming reporting year. In addition, other cruises are already planned in the Atlantic Ocean (Germany, Netherlands), Pacific Ocean (Japan and Germany) and Southern Ocean (Australia).

Next Intermediate Data Product

GEOTRACES plans to release **the second Intermediate Data Product at Goldschmidt 2017** (13-18 August 2017, Paris, France). Thus, preparing the next Intermediate Data Product will be the top priority for the GEOTRACES community. A procedure and clear timeline for data submission and review will be established and communicated in order to ensure the timely release of the next IDP.

GEOTRACES synthesis of results strategy

GEOTRACES plans to launch a three-pronged synthesis initiative. The first component focuses on sources and sinks of TEIs at ocean boundaries, starting with the workshop “[The biological and climatic impacts of ocean trace-element chemistry](#)” (7-8 December 2015, Royal Society in London, UK, see « GEOTRACES Workshops » above).

The second component focuses on internal cycling of TEIs within the ocean. This will be organised by U.S. GEOTRACES, in collaboration with the Ocean Carbon and Biogeochemistry Programme (OCB) in mid-2016.

The third component will be centered on geochemical tracers used as paleoceanographic proxies with a workshop planned for 2017. GEOTRACES is exploring a partnership with the Past Global Changes project (PAGES) in hosting this workshop.

The first two workshops will use the wealth of data in the 2014 Intermediate Data Product (IDP2014) and demonstrate to the broader oceanographic community the usefulness of the IDP2014. The 2017 workshop will have access to the first and second IDPs, as well as to the results of the 2015 and 2016 workshops.

Together, these workshops cover the main scientific goals of GEOTRACES and are designed to respond to the expectation that GEOTRACES results benefit other oceanographic disciplines.

Acknowledgements

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Written and compiled by:

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Catherine Jeandel (GEOTRACES IPO Science Director)

Elena Masferrer Dodas (GEOTRACES IPO Executive Officer) June 2015

APPENDIX 10

2014 Audited SCOR Income and Expenses Statement

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH, INC.
STATEMENT OF ACTIVITIES
YEAR ENDED DECEMBER 31, 2014

UNRESTRICTED NET ASSETS

SUPPORT AND REVENUE

Grant and contract revenue	\$ 909,948
Membership dues	339,208
Meeting registration fees and miscellaneous income	785

TOTAL SUPPORT AND REVENUE	<u>1,249,941</u>
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EXPENSES

PROGRAM SERVICES

Scientific programs	782,966
Travel and subsistence programs	103,977
Other conferences and meetings	68,454

TOTAL PROGRAM SERVICE EXPENSES	955,397
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SUPPORT SERVICES

Management and general	<u>270,778</u>
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TOTAL EXPENSES	<u>1,226,175</u>
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CHANGE IN UNRESTRICTED NET ASSETS	23,766
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UNRESTRICTED NET ASSETS, beginning of year	<u>212,062</u>
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UNRESTRICTED NET ASSETS, end of year	<u><u>\$ 235,828</u></u>
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APPENDIX 11

SCOR-Related Meetings (2015-2017)

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	Warnemunde, 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

2016		
19-21 February	IMBER Scientific Steering Committee Meeting	New Orleans, Louisiana, USA
21 February	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	New Orleans, Louisiana, USA
24 February	WG 141 on Sea-Surface Microlayers	New Orleans, Louisiana, USA

27 February	WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders	New Orleans, Louisiana, USA
8-10 March	GlobalHAB Scientific Steering Committee	Oban, Scotland, UK
16-18 March	WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII)	Paris, France
29-31 March	IQOE Science Committee	London, UK
12-14 May	SOOS Scientific Steering Committee	La Jolla, California, USA
5-7 June	WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5)	Qingdao, China
5-7 September	SCOR General Meeting	Sopot, Poland
12-16 September	GEOTRACES Data Management Committee and Scientific Steering Committee	Toulouse, France
September	WG 147 on Towards comparability of global oceanic nutrient data (COMPONUT)	Quindao, China
2017		
August	WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5)	France