SCOR Proceedings
Volume 52

Sopot, Poland
September 2016

EXECUTIVE COMMITTEE
SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH
September 2016 – September 2018

President:
Dr. Marie-Alexandrine Sicre
CNRS, LOCEAN
Tour 46-00, 5eme étage
4 place Jussieu
75252 Paris Cedex 05
FRANCE
E-mail: Marie-Alexandrine.Sicre@locean-ipsl.upmc.fr

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

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

Vice-Presidents:
Dr. Sergey Shapovalov
P.P. Shirshov Institute of Oceanology
36 Nakhimovsky ave
Moscow, 117997
RUSSIA
smshap@ocean.ru

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

Dr. Ilana Wainer
University of São Paulo
praca do Oceanografico 191
São Paulo, SP, 05508-120
BRAZIL
wainer@usp.br

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

Dr. Denise Smythe-Wright (IAPSO)
National Oceanography Centre
European Way
Southampton, Hampshire, SO14 3ZH
UNITED KINGDOM
dsw@noc.ac.uk

Dr. John Turner (IAMAS)
British Antarctic Survey
High Cross, Madingley Road
Cambridge, CB3 0ET
UNITED KINGDOM
jtu@bas.ac.uk

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

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

ISSN 0253-2808

INTERNATIONAL COUNCIL FOR SCIENCE

PROCEEDINGS
OF THE
SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

June 2017
Newark, DE USA

Support for SCOR activities (including international project offices and in-kind support) in 2016 came from the membership contributions of national SCOR committees and from the following organizations and agencies:

Agouron Institute
British Oceanographic Data Centre
Centre National de la Recherche Scientifique (France)
Institute for Marine and Antarctic Studies (IMAS) at the University of Tasmania
Institute of Oceanology, Polish Academy of Sciences
Intergovernmental Oceanographic Commission of UNESCO
International Geosphere-Biosphere Programme
National Aeronautics and Space Administration (USA)
National Science Foundation (USA), Division of Atmospheric and Geospace Sciences
National Science Foundation (USA), Division of Ocean Sciences
National Science Foundation (USA), Office of Polar Programs
Natural Environment Research Council (UK)
Urban Coast Institute (Monmouth University, New Jersey USA) and the Program for the Human Environment (The Rockefeller University, New York USA).

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SCOR
College of Earth, Ocean and Environment
003 Robinson Hall
University of Delaware
Newark, DE 19716 USA
Tel: +1-302-831-7011, Fax: +1-302-831-7012, Internet: secretariat@scor-int.org
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SCOR Proceedings, Volume 52
REPORT OF THE XXXIII SCOR GENERAL MEETING

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XXXIII SCOR GENERAL MEETING
Sopot, Poland
5-7 September 2016

1.0 OPENING

1.1 Opening Remarks and Administrative Arrangements

Peter Burkill opened the meeting by welcoming the participants (see Appendix 1), then introduced Janusz Pempkowiak, the chair of the Polish SCOR Committee and director of the Institute of Oceanology of the Polish Academy of Sciences (IOPAN), which hosted the meeting. Pempkowiak welcomed people and thanked SCOR for coming to Sopot. He noted that Prof. Pinski, the former chair of the Polish SCOR Committee had issued the invitation for the meeting. Pinski said it was an honor for the Polish SCOR Committee to host an annual SCOR meeting. The idea developed a few years ago, when Ed Urban was attending a meeting at the institute and also met with the Polish SCOR Committee. Pinski noted that the Polish ocean science committee are conducted good research. He stated that Gdansk was a Hansa city. The Polish SCOR Committee has a democratic structure for elections and is governed by an 8-person steering committee that meets twice each year. The committee is in charge of oceanographic journal *Oceanologia* and the heads of the sections organize conferences. IOPAN Deputy Director Pazdro provided information about the institute. IOPAN has 180 employees, including 30 professors. About 50 young scientists are doing Ph.D. studies at IOPAN. Their research vessel *Oceania* spends 250 days at sea in the European Arctic seas and the Baltic Sea.

Burkill gave an introduction to the meeting. Much of the discussion will be on working group proposals. We received 11 proposals for new groups. SCOR is evolving and two SCOR projects (IMBER and SOLAS) have become co-sponsored by Future Earth. ICSU has reviewed SCOR and we only recently received the review report. The SCOR Executive Committee will take responsibility for drafting the response. Burkill welcomed representatives of projects and partner organizations. He memorialized John Knauss (USA), Harry Elderfield (UK), Roland Schlich (France), and Czeslaw Druet (Poland). Pempkowiak added some memories about Druet, who organized IOPAN and the Polish SCOR Committee. Burkill asked for applause for the deceased scientists who had contributed to SCOR, to recognize their contributions.

Two special events were arranged by the local hosts: (1) an evening banquet for participants at the Solidarity Museum (see http://www.ecs.gda.pl/title,Jezyk,pid,2,lang,2.html) and (2) a special session on Polish marine science (see Appendix 2).

1.2 Approval of the Agenda

Additions or modifications to the agenda as distributed may be suggested prior to approval of the final version. No changes were requested.

1.3 Report of the President of SCOR

Peter Burkill reviewed his activities for SCOR since the SCOR Executive Committee Meeting in December 2015 in Goa, India. His most important activity was to work with the Executive Director, on a virtually daily basis through emails, and weekly to monthly phone calls. IIOE-2 has been a major responsibility for Burkill for the past year. He was involved in the report to the

G7 Council of Ministers, at the invitation of with IAPSO (Denise Smythe-Wright) and IUGG.[1] The report includes 8 chapters on topical societal issues. Another major task has been responding to the ICSU review of SCOR. The SCOR Executive Committee will produce a draft reply, which will be sent to national SCOR Committees for review. Implementation of the response will be done by next year's SCOR meeting. The concluding comments of the review were as follows:

"We conclude by commending the Officers and Secretariat of SCOR for the excellent work they do for the oceanographic community in terms of supporting scientists, founding working groups on important topics and initiating and developing major oceanographic projects. The recommendations we make are meant in the spirit of helping advance the work of SCOR and should not be taken in a negative way. SCOR is an organization with a proud history of leadership and achievement; we hope this report will help to make its future work even more valuable."

Burkill participated in the following meetings on behalf of SCOR:

Month	Country	City	Institution	Role / Talk	Funding
Jan 17-20	UK	Newcastle	University	Seminar: "*Research Challenges in the Indian Ocean*".	University
Jan 21	Malaysia	Penang	University	Video Seminar: *"SCOR & engaging with IIOE-2"*.	British Council
Mar 29	UK	London	IMAREST	IQOE Meeting attended	SCOR
Jun 5-10	France	Paris	France SCOR	Attend France SCOR meeting	SCOR
			IOC	Represent SCOR – Interventions	
			Belmont Forum	Informal Discussion on opportunities	
			ICSU	Discussion on ICSU-SCOR links*	
Jul 12 – Aug 4	India	Goa	NIO	Teaching and IIOE-2 links	NIO
Now	Poland	Sopot			SCOR
Sep 11-14	Russia	Moscow	PP Shirshov Institute of Oceanology	Keynote *"Russia and SCOR: past, present and future"* (with Ed Urban)	SCOR
Oct 21-27	South Korea	Busan	Pukyong National University	Keynote *"SCOR's new Research Initiatives in Ocean Systems"* to Int Assoc Mar Res Institutions (IAMRI)	SCOR
	South Korea	Yuosu		Invited Guest talk *"Introduction to SCOR and its Future Research"* Korean Oceanographic Society (Korean SCOR)	

1.4 Report of SCOR Executive Director

Ed Urban reported on his activities for SCOR since the 2015 SCOR meeting, and on the current condition of SCOR.

Finances: Most countries have paid their 2016 dues. SCOR maintains a healthy financial surplus to counteract any future shortfalls in dues income. SCOR finances should make it possible to

[1] http://www.icsu.org/news-centre/news/pdf/Report%20to%20G7%20SMins%20on%20FOSs.pdf

fund two new working groups, depending on outcome of discussions of the SCOR Finance Committee.
Working Groups: Most groups continue to make progress toward fulfilling their terms of reference on time, although a few groups have postponed activities. One of the three WGs approved at the 2015 SCOR meeting have met for the first time. The other two will meet soon after the SCOR meeting. Urban highlighted the recent release of the pre-publication paper from WG 146.[2]
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 is preparing its 2017 Intermediate Data Product. The IQOE Science Committee and GlobalHAB Scientific Steering Committee met for the first time in March 2016.
Outreach: SCOR hosted a booth at Ocean Sciences 2016 and the number of Twitter followers has almost doubled over past 9 months. The SCOR email list was increased by about 50% in the past month, using the new Constant Contact email management system. Ed Urban is co-convening a session at Fall AGU, focused on the Indo-Pacific region.
ICSU Review: The ICSU review of SCOR has been completed. The SCOR Executive Committee will involve national SCOR committees in some actions related to responding to the ICSU review.

Urban noted that the percentage of women involved in SCOR activities continued to increase, to about 37%; the percentage of developing country scientists stayed around the same, at about 23%.

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 2017 activities and dues for 2018. Members of the 2016 Finance Committee are Annalisa Griffa (Italy), Paul Myers (Canada), Johan Rodhe (Sweden), and Jing Zhang (Japan). The Committee's report is given in Section 8.3.

1.6 2016 Elections for SCOR Officers

The SCOR President and all three Vice-President positions were open for nominations for the 2016 elections. Wolfgang Fennel reported the outcomes of the election. Meeting participants congratulated with applause Marie-Alexandrine Sicre (France) as the new SCOR President, David Halpern (USA) as a new Vice-President, and Sun Song (China-Beijing) and Sergey Shapovalov (Russia) as re-appointed Vice-Presidents. The new officers started their terms at the end of the SCOR meeting.

[2]Buesseler, K., M. Dai, M. Aoyama, C. Benitez-Nelson, S. Charmasson, K. Higley, V. Maderich, P. Masqúe, D. Oughton, and J.N. Smith. 2017. Fukushima Daiichi–Derived Radionuclides in the Ocean: Transport, Fate, and Impacts. *Annu. Rev. Mar. Sci*. 2017.

2.0 WORKING GROUPS

2.1 Current Working Groups

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

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

Denise Smythe-Wright reported that WG 135 was extended at the 2015 SCOR meeting for another year to complete its second publication. The publication is still in process and SCOR will extend the life of the group until the publication is completed.

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

Corina Brussaard reported that the final workshop of the group was held on 30 August-4 September 2015 on Catalina Island, California, USA (see http://www.eforams.org/img_auth.php/e/ed/SCORWG138_Catalina_2nd_circular.pdf). No report was received for the SCOR meeting, but meeting participants decided to extend the life of the group until the group's work (primarily an ebook) is completed. The group's funding from SCOR has been completed, but Israeli sources have funded another meeting of the group.

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

Wajih Naqvi reported that the 2015 SCOR meeting extended the group for an additional year to complete on-going activities. The first is the *Frontiers in Marine Science - Marine Biogeochemistry*, Research Topic: Organic ligands - A key control on trace metal biogeochemistry in the ocean: http://journal.frontiersin.org/researchtopic/3981/organic-ligands---a-key-control-on-trace-metal-biogeochemistry-in-the-ocean> . It received 16 submissions of high-quality articles. This is the second special issue from WG 139. The first was published in 2015 in *Marine Chemistry* (issue 173). The group's intercalibration exercise, originally planned for 2016, had to be postponed due to technical issues with the ICP-MS that was to be used. However, as soon as the trace element concentration of the samples already collected is confirmed, samples will be sent to participating scientists to measure organic ligands for Fe, Zn, Cu, and other trace metals. This work will lead to at least one more research paper in the near future as a direct outcome of the SCOR WG 139.

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

Sergey Shapovalov reported that WG 140 held its final meeting in March 2016, an open meeting designed to attract early-career scientists. The focus of the meeting was to have a final discussion of the activities of the group, discuss the future activities of BEPSII (to be continued as a SOLAS/CLiC group), and discuss the final papers to be submitted to the Special Feature of *Elementa: Science of the Anthropocene* (see https://home.elementascience.org/special-features/biogeochemical-exchange-processes-at-sea-ice-interfaces-bepsii/). Eleven papers have been published online in this Special Feature so far. Meeting participants approved disbanding

the group.

2.1.5 WG 141 on Sea-Surface Microlayers

Peter Burkill reported that the Schmidt Ocean Institute has approved approximately one month of ship time in October/November 2016 for a cruise of the R/V *Falkor* by a team representing the working group.[3] 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-surface microlayer on air-sea interactions. A modest amount of SCOR funding was allocated for updating of the group's Best Practices Manual after the cruise. It will be necessary to ensure that the manual will be updated wherever it is posted. A special feature in the journal *Elementa: Science of the Anthropocene*, has been opened by the group (see https://home.elementascience.org/special-features/the-sea-surface-microlayer/).

In relation to the group's terms of reference:

TOR 1. Review sampling techniques and provide best practice sampling protocols. Such protocols will support new scientists entering the field of SML research to produce reliable and comparable data among different research groups/oceanic regions. The best practice sampling document will be made freely available online. – Completed - see (http://www.scor-int.org/Publications/SCOR_GuideSeaSurface_2014.pdf). Even though the TOR is complete members of the group will update the guide if any major improvements in SML sampling are made, for example, after the *Falkor* cruise.

TOR 2. Create a consensus definition of the SML in terms of physical, chemical and biological perspectives for a better understanding within the ocean science community, and discuss the SML's role in a changing ocean. This will be delivered as an opinion/position paper in a peer-reviewed journal and will support future international projects concerning the SML and ocean change. - A final draft of the paper is now complete and is being reviewed by the members of the group.

TOR 3. Initiate sessions on SML research during major meetings (e.g., Ocean Sciences Meetings), to increase the awareness of the importance of the SML within the general ocean science community. – Completed. The open session "Linking the Ocean with the Atmosphere - Exploring the Importance of the Ocean-Atmosphere Interface and Near Surface Waters in Global Scale Processes" at the 2016 Ocean Sciences Meeting in New Orleans was a great success. The session brought together ideas and results from field observations, laboratory experiments and models.

TOR 4. Summarize and publish the latest advances in microlayer research in a special issue of a peer-reviewed journal, including consolidation of existing sea surface microlayer datasets among different disciplines (chemistry, biology, atmospheric, physics). The publication will promote new research ideas and projects at an interdisciplinary level. - The SML special issue will be in the journal *Elementa: Science of the Anthropocene* and will open for submissions on the 1 September 2016.

[3] https://schmidtocean.org/cruise/study-of-the-sea-surface-microlayer/

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

Peter Burkill reported that the group has discussed oxygen, nitrate, and pH sensors. In relation to oxygen sensors, the group will produce a technical report and an article in *Eos* as its final products. The group plans to hold its 4th and final WG meeting in conjunction with an Argo Science Team Meeting or Argo Data Management Team Meeting in 2017. This meeting will be used to combine all information available by then on the use of biogeochemical sensors on floats and gliders. It will decide on the form and content of the final product and will assign writing tasks on responsibilities to group member for specific parts of the final document. SCOR approved funding for a 2017 meeting of the group.

2.1.7 WG 143 on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4

John Turner reported that the main activity of the group in the past year has been to prepare for another round of sample analysis and intercomparisons. Standard nitrous oxide and methane samples have been sent to laboratories around the world for analysis. A 10-day expedition to the Baltic Sea in October 2016 will be used to compare underway equilibrator systems for dissolved nitrous oxide analysis and to conduct another round of discrete sample collection. Efforts in 2017 will focus on report writing. Two documents will be produced. The first will be a technical report concerning the production of the gas standards for methane and nitrous oxide. The intended audience is any user of the gas standards or anyone seeking to reproduce the method. The second document will be a manuscript for the scientific literature in which the group outlines the inter-comparison and distribution of gas standards.

2.1.8 WG 144 on Microbial Community Responses to Ocean Deoxygenation

Ed Urban reported that WG 144 on Microbial Community Responses to Ocean Deoxygenation, is in its third year. It has a white paper underway on methods to study oxygen minimum zones and is planning a symposium on OMZ microbial ecology and biogeochemistry to be held in Goa, India, at the National Institute of Oceanography during 2–5 December 2016, which will fulfill TOR #4 and which will result in a special issue of a peer-reviewed journal. It will not be possible to fulfill TOR #3, a training event in Chile, due to lack of funds. The group has submitted a proposal to the Schmidt Ocean Institute to request ship time. If funded, the cruise will require additional funding independent of SCOR.

The status of fulfilment of the terms of reference follows.

TOR 1. Convene a practical workshop in Saanich Inlet, a seasonally anoxic fjord off the coast of Vancouver Island, British Columbia, Canada, to ground truth common standards for process rate and molecular measurements and identify model ecosystems for future cross-scale comparative analyses. - Completed. Report of workshop being prepared

TOR 2. Convene a meeting at the Leibniz Institute for Baltic Sea Research in Warnemünde, Germany to codify standards of best practice, and compose a white paper describing said standards and opportunities. - Completed. White paper on best practices underway.

TOR 3. Sponsor a workshop at the marine lab of the University of Concepcion, Chile, to disseminate the best practices described in the white paper, and to provide hands-on experience to international participants, and local students and scientists, with those practices. - Postponed to January 2018. A workshop will be held in conjunction with ECODIM in Concepcion, Chile. Students of the ECODIM course will participate in a hands-on workshop applying the best practice methods described in the Warnemünde white paper. The Concepcion research vessel will be used for day trips to collect samples and will perform the incubations and some analysis at the Concepcion lab.

TOR 4. Convene a meeting at the National Institute of Oceanography in Goa, India, engaging local students and scientists in the project. The goal of this meeting is to compile a peer-reviewed monograph, which will be published as an electronic book in an open-access journal such as *Frontiers* or *PLoS* to ensure both visibility and long-term access. - Symposium on OMZ microbial ecology and biogeochemistry will be held in Goa, India, at the National Institute of Oceanography during 2–5 December 2016.[4] The attendees will include all WG 144 members, and a total of about 30 invited U.S. and European scientists plus 10-15 Indian scientists. The outcome of the meeting will be a journal issue, along the lines of a Special Topics in *Frontiers in Marine Science*.

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

Wajih Naqvi reported that the group met in conjunction with the Ocean Sciences Meeting in New Orleans, Louisiana, USA in February 2016, and held a Town Hall at Ocean Sciences to solicit input about what scientists in the community would like in terms of chemical speciation software. Ed Urban reported that these events were well attended. A SurveyMonkey questionnaire was distributed to seek additional input (see https://www.surveymonkey.com/r/SGDQQG6). The group has published its first paper in a special section of *Frontiers in Marine Science* (see http://journal.frontiersin.org/article/10.3389/fmars.2016.00139/full). A WG 145 website has been set up, hosted at Otago University (see http://neon.otago.ac.nz/research/scor145/). The next meeting is planned in conjunction with the 2018 Ocean Sciences meeting. Funding was approved for the next working group meeting.

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

Denise Smythe-Wright reported that WG 146 held its second meeting in Xiamen, China in June to assess the status of its terms of reference and products. The group also conducted a three-day Training Course on Marine Radiochemistry and one day of public outreach activities. Four e-lectures that will be made widely available as *Limnology & Oceanography* e-lectures. Also discussed was the group's efforts to create a database of radionuclides in the ocean, and communication and outreach efforts, including the major review paper that has recently been published online.[5] SCOR approved regular funding for the group's 2017 meeting. They may also

[4]http://www.scor-int.org/Working_Groups/WG%20144%20Symposium%20Flyer.pdf

[5]Buesseler, K., M. Dai, M. Aoyama, C. Benitez-Nelson, S. Charmasson, K. Higley, V. Maderich, P. Masqúe, D. Oughton, and J.N. Smith. 2017. Fukushima Daiichi–Derived Radionuclides in the Ocean: Transport, Fate, and Impacts. *Annual Reviews in Marine Science* 2017. 9:1.1–.31. http://www.annualreviews.org/doi/abs/10.1146/annurev-marine-010816-060733

apply for additional funding for Associate Members from developing countries to attend the meeting, and for early-career scientists to attend any training activities associated with the meeting. The group will organize a one-day "Training Course on Marine Radioactivity" at the 2017 Goldschmidt Conference in Paris, France.

2.1.11 WG 147: Towards comparability of global oceanic nutrient data (COMPONUT)
Wajih Naqvi reported that WG 147 will have its second annual meeting in September 2016 in Qingdao, China, having had a 'poster cluster' accepted as part of the annual CLIVAR science meeting. In order to promote the wider global use of reference materials (ToR 4 of WG 147), WG147 has arranged the provision of low-cost nutrient reference materials by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). To provide training in analytical protocols and best practices (ToR 4 of WG 147), the group has agreed with NIOZ (The Netherlands), to be the host laboratory for a training course for scientists from developing countries to be held in November 2017. The tutors from WG 147 will also continue with a workshop relating to silicate analysis so as to make recommendations to the world's nutrient scientists about improving the quality of their analysis for this often difficult parameter. The training module will be supported by extra funding provided from a grant from SCOR. Funding was approved for the group's 2017 meeting.

2.1.12 WG 148 on International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)
Ilana Wainer reported that the group will meet for the first time in Tokyo, Japan during 3-7 October 2016, in conjunction with the 5th XBT Science Workshop. The first element of IQuOD to be delivered will be data streams for iMeta and uncertainty estimates to be served as part of the World Ocean Database, using their standard data formats (NetCDF and ASCII). The aim is to deliver these before the meeting in October 2016. The first full IQuOD database, with automated QC flags applied, will be released in late 2017. Ed Urban noted that there is a related group working under the International Oceanographic Data and Information Exchange (IODE). WG 148 will focus on the more technical aspects of the IQuOD tasks. Funding was approved for a 2017 meeting of the group.

2.1.13 WG 149 on Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?
Patricia Miloslavich reported that WG 149 held an opportunistic meeting in conjunction with the 4th Symposium on The Ocean in a High-CO_2 World in Hobart, Australia, in May 2016, followed by the first full meeting in conjunction with a Gordon Research Conference in July 2016, on Ocean Global Change Biology (see http://www.grc.org/programs.aspx?id=15856). The terms of reference were re-arranged on the advice of SCOR. Funding was approved for a 2017 meeting of the group.

2.1.14 WG 150 on Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)
Wolfgang Fennel reported that the first workshop will be held on the 12-14 September 2016 at the National Oceanography Centre, Southampton, UK. The group's website will be hosted by the National Oceanography Centre, UK. Until then, an open discussion forum and mock website is

available at https://tomcatscor.wordpress.com/. In the coming year, the group will (1) publish a review on the use of optical instruments to estimate carbon export; (2) make an active effort to start inter-calibrating the different devices in different oceanic settings; and (3) together with the IT team at NOCS and the BODC, start building the Web site and data repository. Funding was approved for a 2017 meeting of the group.

2.2 Working Group Proposals

Ed Urban introduced the discussion of working group proposals by showing the chart of how the working group proposals were ranked by national committees, as ranked "must fund", "may fund", and "do not fund". In order of preference by national SCOR committees, the ranking was as follows: FeMIP, ECVice, NexT SGD, cOCtEAU, EBUE, Carbon, DEMASCO, Extremes, JOS, Coral, and IBDI. FeMIP had the most "must funds", 8, and no "do not funds". The other proposals had 5 or fewer "must fund" rankings. Because of the shortness of time for discussion, Peter Burkill suggested the procedure of only one round of discussion, after short presentations by the Executive Committee reporters.

Following the discussions, it was obvious that FeMIP would be funded. The proposals in the "may fund" category included ECVice, NEXT SGD, and EBUE. DEMASCO, cOCTEAU, Carbon, EXTREMES, JOS, Coral, and IBDI were ranked as "do not fund".

There were discussion about whether or not a second working group should be funded and it was decided to do so, if a second proposal was decided to meet the SCOR standards. After much discussion, it was decided to fund ECV-Ice as the second proposal. The following sections summarize the discussions on individual proposals.

2.2.1 Atmosphere-waves-current interactions and oceanic extremes (EXTREMES)

Sergey Shapovalov summarized the proposal. The membership is well balanced. In terms of capacity building, the group would hold one of its meetings in China and would allow students from developing countries attending a course at the host institution to interact with the working group in some capacity–building activities in conjunction with the meeting. SCOR national committees generally thought the group was timely and a priority for SCOR, but opinion was mixed regarding whether SCOR would be a good mechanism for the proposed work and whether the terms of reference were appropriate.

The German SCOR Committee ranked the proposal as a "do not fund", unless the focus of the proposal could be clarified. The Dutch SCOR thought the proposal was mainly technical and operational, with inadequate capacity building plans and superficial terms of reference. The Japanese SCOR Committee thought that the proposal was not well organized. The terms of reference are too broad and they miss out on membership expertise. The Japanese SCOR committee ranked the proposal between "may fund" and "do not fund". It noted that atmospheric scientists would need to be added to fulfill the terms of reference and there was no mention of coupled models already used. The Polish SCOR Committee agreed with the German committee that the proposal should focus on theory. IABO thought the proposal was high priority, but was very technical and not well organized, with poor capacity building activities described. The Italian SCOR Committee agreed that the timeliness of the proposal was good, but the terms of

reference were not clear and the proposal contained inadequate capacity building plans. This would not be the best use of a working group mechanism. IAPSO ranked the proposal as a "may fund", as it was the closest proposal to IAPSO's core interests. However, it was by no means novel, the terms of reference were not clear, and the membership needs improvement. Many of the terms of reference were more suitable to a research proposal and IAPSO was unsure whether they were achievable in a working group process. The membership is U.S. and European focused. The UK SCOR committee ranked the proposal as a "do not fund", although the science is timely. The Australian SCOR committee did not think the proposal was suitable for SCOR and ranked the proposal as "do not fund". This is a mature field that does not need a working group and the papers would be published even without a group. The terms of reference were very generic and the membership out of balance. The South African SCOR Committee thought the topic was exciting, but not a priority for South Africa. The proposal was not well written and was not clear. The China-Beijing SCOR Committee thought the physics included in the proposal is important, but they ranked the proposal as "may fund".

Peter Burkill noted that this proposal was toward the bottom end of the chart prepared from national inputs before the meeting, and the discussion at the meeting did not change the ranking. This topic is not mainstream SCOR territory, because it is more operational; perhaps IOC would be interested because of the operational nature. David Halpern suggested an IAPSO session on this topic. Denise Smythe-Wright replied that there are sessions at the IAPSO-IAMSA-IAGA assembly already including "freak waves."

The decision of the meeting was to not fund this proposal.

2.2.2 Climate-Change Impacts of Ocean Carbon Chemistry/Synergism with Other Stressors: How can Seamount Deep-Sea Coral Ecosystems respond to ASH/CSH Shoaling/Ocean Acidification? (IBDIOCC)

Denise Smythe-Wright presented a summary of the proposal and the comments from national SCOR committees. This was a proposal resubmitted from last year. It was revised to remove the deep-sea mining focus. The proposal is focused on threats to biodiversity on seamounts, including physical threats (mining) and chemical threats (ocean acidification). The membership is worldwide, but has a below average percentage of female members and members from developing countries. The proposal is not well written and 11 national SCOR committees ranked it as "do not fund".

IABO would have liked to recommend this proposal, as it would use novel methods and area of study, but the proposal was hard to read and has many mistakes. The membership is biased. The Korean SCOR Committee found the terms of reference and goals to be disjointed. The proposal would need to be re-written before it could be funded; the re-write from last year was not well done. The Canadian SCOR Committee liked the focus on seamounts, but also found the proposal to be poorly written, without adequate detail. Each of the terms of reference would be difficult to answer and each could merit its own working group; TOR #4 was considered to be the strongest part of the proposal. The summer course proposed was appreciated.

The decision of the meeting was to not fund this proposal.

2.2.3 Iron Model Intercomparison Project (FeMIP)

Colin Devey provided a brief presentation about the proposal and a summary of the comments from national SCOR committees. The committees expressed that the proposal was well written and the gender balance good. However, there are only two members from developing countries and the Full Membership is too Northern Hemisphere-dominated. There were no Associate Members from developing countries. The capacity building activities were not well developed. The timeliness of the proposal is ok and it builds on several past and existing working groups. The science priority level is OK. The terms of reference link models, experiments, and observations.

The Japanese SCOR Committee strongly supported the proposal due to its timeliness. We need reliable representation of iron in global models and the group would be able to take advantage of the large amount of new data from the GEOTRACES project. The group would be good for improving tools for predicting climate change. The Japanese SCOR Committee had two issues with the proposal: (1) specification of the policies for openness of data produced through the group, and (2) the lack of an Asian scientist on the group. The Dutch SCOR Committee noted that the proposal is well written. However, the capacity building was weak and the membership was not well balanced (biased towards modelers). The Dutch SCOR Committee ranked the proposal as "may fund" because this could be viewed as a follow-up proposal. The deliverables are not very strong. The Italian SCOR Committee felt that the proposal was very good and timely, and it was their top-ranked proposal. The group will provide tools to evaluate model outputs. However, the capacity building and membership need to be improved. Still, the Italian SCOR Committee ranked the proposal as "must fund". IABO noted that the proposal terms of reference were not multidisciplinary, in the sense that phytoplankton are missing, and did not match the proposed members. The inclusion of developing country scientists in the membership was too low. However, IABO ranked the proposal as "must fund". The U.S. SCOR Committee ranked the proposal as "may fund". The proposal is good in the sense that it brings modelers and experimentalists together. But, the U.S. SCOR Committee felt that other proposals were better. The Canadian SCOR Committee noted that the proposed membership is diverse and a SCOR working group would be a good means to get these people together because they might not otherwise attend the same meetings. The Canadian SCOR Committee ranked this as their top proposal. The UK SCOR Committee ranked the proposal as "must fund", for reasons already noted by other national committees. IAPSO ranked the proposal as "must fund". A biologist from a developing country could be added. We do not really understand how best to represent iron in ocean models and pulling the community together is relevant and a good focus for a SCOR working group. The Korean SCOR Committee liked the proposal and offered to support a female Korean modeler as an Associate Member. The Australian SCOR Committee was in favor of approving the proposal, reiterating the comments of the Canadian SCOR Committee. However, the membership and capacity building deficiencies could and should be addressed. An observational scientist could be added. This would be a diverse group that otherwise would not meet. The China-Beijing SCOR Committee expressed that the proposal is very good and all the members have good expertise. They ranked it as "may fund".

Peter Burkill summarized that this is a very strong proposal with a good science focus. Good rationale is identified and the terms of reference are good. The capacity building weakness

should be addressed and the membership should balance modelers and observationalists. It was decided to fund the proposal.

2.2.4 Measuring Essential Climate Variables in Sea Ice (ECVice)

John Turner summarized the proposal for this new working group. National SCOR committees were mostly favorable about the group and believed that it is timely and high priority. The overlap with SCOR WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) has both positive and negative implications.

In terms of membership, the gender balance was 5 male and 5 female Full Members. However, the group has a definite Northern Hemisphere emphasis and only one developing country member among the Full and Associate Members. There is a good inclusion of early-career scientists.

Some national SCOR committees believed the proposed capacity-building activities were not as extensive as they should be, although they appreciated the idea of the proposed international summer school in Svalbard.

The Brazilian SCOR Committee noted that sea-ice has no hemispheric identity. Southern Hemisphere countries (e.g., Brazil and India) have strong programs on sea ice, yet scientists from such countries are not listed in the proposed membership. The Australian SCOR Committee noted that they also have a lot of sea-ice research activity, but are willing to concede this as an Arctic group and that the results may or may not be relevant to the Southern Hemisphere. The Australian SCOR Committee believed that the group should be funded. The U.S. SCOR Committee was concerned that WG 140 already is supposed to be handling sea-ice biogeochemistry. If funded, the group should include satellite observations. The Russian SCOR Committee felt that the title of the proposal was inappropriate because it is not clear that any GCOS variables will be measured in sea ice. The Dutch SCOR Committee also noted the overlap with the tasks of WG 140, although the proposal is well written and presents a clear scientific topic. However, the terms of reference need to be strengthened to describe actions, not only intentions. The training of young scientists could be more explicit as a deliverable. The Dutch SCOR Committee ranked this as a "may fund". The Italian SCOR Committee also ranked this as a "may fund", as they found statements of "we hope" to be too vague. The proposal was timely, but not the most important topic to bring forward. The Italian Committee wondered about some of the tasks that were proposed. The Canadian SCOR Committee ranked the proposal as "must fund" and thought the proposal was well written and timely, although the terms of reference were broad. They were not concerned that the group would be a follow-up to WG 140. The Canadian SCOR Committee wanted to know if Canadian communities such as the Inuit would be eligible for capacity building support. Maciej Telszewski noted that sea ice as an Essential Ocean Variable needs several parameters to classify it. The focus on the Arctic is not a problem, although the focus on the Arctic is not specified, which makes the proposal weaker. The UK SCOR Committee and IAPSO agreed that the Arctic focus would be ok and would rank the proposal higher if it had been obvious through the membership that the Antarctic would be included. The Finnish SCOR Committee also ranked the proposal as a "must fund." Finland is familiar with sea ice and it is good to have a SCOR working group on this topic. They rated the proposal as "must fund". Arctic ice is decreasing and we don't know how this will change the

climate system. There is a lack of common measurements and standards, so we can't compare the results. It was noted that WG 140 was supposed to do the kind of work proposed, but did not achieve it.

Peter Burkill summarized that this is not a perfect proposal for a variety of reasons: the lack of inclusion of the Antarctic, the risk to the group's work if the related research is not funded by other sources, etc. SCOR does not fund research and it is unknown whether the research on which the proposal is based will be funded. However, many national SCOR committees ranked this as a "must fund'. After discussion of all the proposals, it was decided to fund this as one of the two new working groups.

2.2.5 Building a coral reef marine biodiversity observation network (CoralMBON)

Patricia Miloslavich presented the proposal and a summary of comments from national SCOR committees. The proposal included good outreach to policymakers and good capacity building activities, and the topic is timely and relevant to society. The activity would improve global coordination on the topic and the proposed chair is from a developing country. However, the scientific content is not strong enough. Some of the terms of reference are outside SCOR's remit and are too general. There are already international coordination efforts, so it is not clear that a SCOR working group is needed. Only two national SCOR Committees rated the proposal as a "must fund".

The Italian SCOR Committee rated the proposal as "must fund" because the topic is important, even though the proposal is mostly about policy and not about new science. Such an activity could draw together scientists and policymakers. The China-Beijing SCOR Committee also rated the proposal as "must fund" because of the vulnerability of coral reefs due to climate change. The Dutch SCOR Committee rated the proposal as "do not fund", because it is not strong enough scientifically, but also suggested that there be another mode of SCOR funding of activities like this that have significant capacity-building potential. The Japanese SCOR Committee ranked the proposal as "may fund" because understanding coral reef diversity change is very important and multiple stressors is a major issue. However, the terms of reference would need to be improved to make a fundable proposal, and it would be helpful to include a link to higher trophic levels and to include some developing country members from Asia. IAPSO agreed that the proposal is too policy-oriented, but it is well written and the terms of reference are commendable. The work could be done by some mechanism other than a SCOR working group. Perhaps another organization might fund it or SCOR could use another funding approach, as suggested by the Dutch SCOR Committee. The UK SCOR Committee did not think that this is a good topic for a SCOR working group. The German SCOR Committee did not think the proposal was scientific enough to merit a "must fund", but the topic is important enough to rank a "may fund". It is important not to try to re-rewrite the proposal to suit SCOR, but maybe not suit the proponents. The U.S. SCOR Committee ranked the proposal as a "do not fund" because it is not timely in terms of being a topic that no one else is handling. (The Global Coral Reef Monitoring Network has been meeting since 1998.) It is not clear what impact a SCOR working group would have. The Australian SCOR Committee agreed that there is not enough science in the proposal and a lot of activity is already going on. Coral reefs are being extensively monitored.

Peter Burkill summarized that the consensus is to not fund this group, reflecting the written comments received from national SCOR committees before the meeting. Various national SCOR committees made suggestions about how such a group might be funded outside SCOR, perhaps through Future Earth.

The decision of the meeting was to not fund this proposal.

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

Wajih Naqvi presented the proposal and summarized the written comments from national SCOR committees. This is a revised proposal from a previous year and most national committees agreed that the revisions were appropriate. The issue is timely, although there was some question about whether a SCOR working group is a good way to approach this topic. National committees considered the proposed Full Membership to be well balanced in terms of gender, developing country and early-career scientist participation, and geography. However, there may be some key persons missing and not enough expertise on nutrients. Perhaps some other organization (e.g., IOC, IAEA, Future Coasts) should take the lead. The terms of reference need better development. The proposal needs more detail about how the best practices manual will be published and the best practices implemented. A roadmap for model development should be added.

The Korean SCOR Committee rated the proposal as "must fund" because the group would improve our understanding of submarine groundwater discharges significantly and could improve biogeochemical modeling. The topic is timely. The Australian SCOR Committee rated the proposal as "may fund", with reservations. The topic is important, but not the highest priority, compared with some of the other proposals. The terms of reference are not very well developed and the deliverables rather limited for a SCOR working group. The membership is good. The U.S. SCOR Committee rated the proposal as "must fund". It is well written and has an excellent chance to advance the field. The terms of reference are very appropriate and the deliverables are feasible. Creating a database would be a break-through, although the database would need to be continued and the proponents acknowledge that they would need to find funds to maintain it. The Polish SCOR Committee was in favor of funding the proposal. The proposal is well balanced, the topic is timely, and we need to advance our knowledge on this topic. The synthesis through a model is a new way forward. This working group taking a global approach could do a good job in developing this field. The South African SCOR committee agreed that the balanced of the proposed membership is good, but it is not clear how the objectives would be achieved because the terms of reference are too vague. IAPSO was strongly against the proposal because they believed that the group's activities would overlap those of the IAPSO Groundwater Commission that was disbanded in 2013. The topic is broad and unfocused. Getting datasets together is a good idea, but it is not clear how to this could be accomplished. David Halpern (USA) asked why the IAPSO Groundwater Commission was disbanded, and he suggested that a working group might be a good way forward at this time. Denise Smythe-Wright (IAPSO President) replied that this commission within IAPSO was never able to resolve the scientific issues on which it was focused. Halpern responded that this would be a good argument for an activity conducted by a new group of scientists.

The UK SCOR Committee noted that the proposal was improved compared to last year, but they agreed with the Australian SCOR Committee that the topic was not the highest priority compared to other proposals and not necessarily within SCOR's interests. Henrik Enevoldsen (IOC) noted that nutrient input management is an important topic and that IOC has a large project addressing part of this topic, but not to the level of detail proposed for this working group. The working group would complement IOC activities. IOC is strongly supportive of this proposal, but the proposed membership could be improved. The Canadian SCOR Committee is very supportive of the proposal, but largely agrees with earlier comments. A potential concern that has not yet been mentioned is whether it would be possible to extrapolate from local scale to global within the time frame of the working group, In any case, the proposal is timely and innovative. IABO ranked the proposal as "do not fund" because it is not evident that this group would pursue new ideas compared to SCOR WG 112 on Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes. The German SCOR Committee ranked the proposal as "may fund". The topic is valid and timely, but there are concerns, particularly related to the lack of detail about what the group would do. The Dutch SCOR Committee agreed with previous comments that the proposal was improved compared to last year's version. However, the terms of reference could be developed better. The participation of early-career scientists is good. The Dutch Committee ranked the proposal as "must fund".

Ed Urban added that WG 112 focused largely on intercalibration of measurements of submarine groundwater discharges, thus the overlap with the current proposal is small. The proposal was submitted because of analyses and papers published in the past year or two estimating that groundwater discharge may equal river inputs.

Peter Burkill summarized that the proposal is potentially fundable, but would need some improvements. It is timely, with moderate priority, and the topic is complementary to other initiatives. The terms of reference are satisfactory overall, but could be looked improved. The proposal is ranked at the high "may fund" level.

The decision of the meeting was to not fund this proposal.

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

Patricia Miloslavich presented the proposal and summarized the review comments from national SCOR committees. Most national committees ranked this proposal as "may fund", with only two "must funds". The strengths of the proposal were that it is very timely, it includes the use of satellite technology, the membership is well balanced, and the activities are scientifically interesting. The weaknesses of the proposal are that the capacity building is very limited, the terms of reference are not appropriate and the expertise does not fit them, the proposal is mostly about salt marches (not balanced with mangroves), the focus on science is limited, and the focus is entirely on physical aspects. The proponents should consider combining or connecting with other on-going initiatives.

The Dutch SCOR Committee found the proposal timely and scientifically interesting, but the most interesting focus would be on mangroves and that aspect of the proposal was weakest. The proposal is not very strong scientifically. The gender balance needs improvement. Why don't

they do a special issue as a deliverable? The Dutch SCOR Committee ranked the proposal in the lower end of the "may fund' category. The Australian SCOR Committee was uncertain how the group would advance the field and thus ranked the proposal as "do not fund". The value of wetlands is well accepted, and the proposal overlaps with the Eastern Boundary Upwelling Ecosystems proposal. The German SCOR Committee commented that the terms of reference could/should partly be done before conducting TOR #1 (review) to have a better focus for the working group proposal. There are not really many science goals in the proposal. Documenting the key gaps in understanding could be an important task of such a group. IAPSO found that this well-written proposal describes more of a research project than a SCOR working group activity. The described papers can be written without creation of a working group.

Peter Burkill summarized that the proposal falls in the low "may fund" category. There are important elements in the proposal and it is very timely, but there is not enough science included. The proposal was not accepted for funding.

2.2.8 Towards strategic observatories for regional ocean-atmosphere interactions in the Eastern Boundary Upwelling Systems (cOCtEAU)

Ilana Wainer presented the proposal and a summary of comments from national SCOR committees. The positive aspects of the proposal were the gender and geographic balances of the proposed membership, with four members from developing countries. The proposal includes a lot of capacity-building activities and many links to other projects (e.g., CLIVAR, IMBER, SOLAS, GO_2NE, SCOR WG 144). This is an important topic and a priority for SCOR, A SCOR working group is an appropriate mechanism to address this topic. The terms of reference are appropriate, although there were not enough specifics on how the terms of reference would be achieved. The most important concern is the overlap with the proposal on Eastern Boundary Upwelling Ecosystems (EBUE).

The Japanese SCOR Committee found the proposal idea to be timely, but the proposal is not well organized and should be combined with the EBUE proposal. Other experts representing other disciplines should be included, such as experts on El Niños/La Niñas. The Japanese SCOR Committee rated the proposal as "may fund". Maciej Telszewski (IOCCP) noted that there is no real action description. There is another meeting being organized in Miami next February to come up with key topics that need to be handled (50 scientists will attend) and this looks very similar to the terms of reference in this proposal. The South African SCOR Committee appreciated this topic and supported the proposal because of the importance of Benguela Current upwelling system to South Africa, but noted the overlap with the EBUE proposal, which the committee preferred. The Australian SCOR Committee ranked the proposal as "do not fund". The topic is important but it was not clear that the proposed terms of reference would justify a SCOR working group. There is too much emphasis on reviewing knowledge and writing review papers. Wajih Naqvi noted the symposium on upwelling that was held in the Canary Islands and supported by SCOR projects (International Symposium - 'Eastern boundary upwelling ecosystems: integrative and comparative approaches' (2-6 June 2008, Canary Islands, Spain).[6] The U.S. SCOR Committee added that terms of reference are rather vague and would lead to no real breakthrough deliverable. The committee did think the topic is timely for SCOR. The Canadian SCOR Committee thought it would be useful to recommend observation systems, but it

[6] https://c666188.ssl.cf2.rackcdn.com/Images/Abstractsbook_final.pdf

is not clear how the recommendations would be implemented. The Italian SCOR Committee thought that this is a fundamental topic that is relevant to SCOR. But the proposal is not high enough quality to be funded and overlaps with the EBUE proposal. The German SCOR Committee ranked the proposal as "must fund" because of the strong track record of the proposed working group members and the quality of the capacity-building plans. The topic is timely. The only concern is that this group and the EBUE group proposed two different projects with virtually no overlap in membership. Who are the real experts? The Dutch SCOR Committee believes that the topic is timely and the proposal has merit, but not enough to be funded.

Peter Burkill summarized that there was a feeling that the topic is timely, but there is a conflict with the EBUE proposal. We cannot force the two proposals together. The proposal was ranked in the middle of the "may fund" category.

Ilana Wainer asked how SCOR can help fund proposals from developing countries that take the initiative to submit proposals. Peter Burkill stressed the importance of proponents submitting draft proposals to the SCOR Secretariat well before the deadline, so they can get feedback that could improve the proposal.

The decision of the meeting was to not fund this proposal.

2.2.9 Towards the science-based jellyfish observing system (JOS)

Sun Song presented the proposal and comments from national SCOR Committees. National committees thought the topic of jellyfish observations are important, but few nations thought the proposal was a priority for SCOR. The Dutch SCOR Committee stated that the proposal is timely and a SCOR working group could be a good mechanism to approach the topic, but the proposal is rather weak and should have an improved description of the state of the science, as well as what measurements are needed for modelling and prediction. The rated the proposal as a "do not fund". IAPSO believes that the proposal is premature because the new technology (measurements) is still being tested. The Korean SCOR Committee stated that other international efforts underway will probably have a greater impact than would a SCOR working group. The Italian SCOR Committee thought this is a timely topic, but very specific and probably premature. They rated the proposal as "may fund". The French SCOR Committee rated the proposal as "do not fund" and found it to be lacking in physical oceanography. The UK SCOR Committee agreed that physical oceanography is lacking.

Peter Burkill summarized that the consensus that the proposal should not be funded.

2.2.10 Eastern Boundary Upwelling Ecosystems (EBUE): inter-comparisons, variability and forecasting responses to climate and global change

Wolfgang Fennel presented the proposal and shared comments from national SCOR committees. National committees appreciated the importance of the topic, but suggested that the proposal could be improved by increasing the number of female Full Members, increasing the number of non-biologists proposed for membership, including a climate modeler, and reducing the number of terms of reference and making them more specific.

The Japanese SCOR Committee rated the proposal as "must fund", if the membership were modified. The Dutch SCOR committee thought the proposal was well written, but objectives need to be better focused. The terms of reference should be grouped (e.g., #1-5); TORs #9 and 10 are not really appropriate. The proposed membership is good, although misses some specific specialists. The committee ranked the proposal as "do not fund". The South African SCOR Committee rated the proposal as "must fund", although noted that the proposal is fisheries dominated. The Australian SCOR Committee did not think the proposal was suitable for funding in its present form because the terms of reference are not focused. Wajih Naqvi noted that the proposed membership of the committee is very good. The U.S. SCOR Committee rated the proposal "must fund" because it is focused on fisheries. The group will look at similarities and differences in various upwelling systems to come up with generic statements to allow improved modelling (upwelling is poorly represented in models). What is missing is that cloud cover is important but not included; involvement of CLIVAR could help with this. The proposed membership represents a strong group of scientists. Antonio Caltabiano and Ilana Wainer noted there are members that are linked to atmospheric modeling. PICES rated this group as "must fund" because of the fisheries relevance, and would be willing to fund the participation of an Associate Member. IAPSO ranked this proposal as "do not fund", but might wish to upgrade its ranking. Wolfgang Fennel stated that the terms of reference are not exciting and should be much better for the proposal to be approved.

Peter Burkill summarized that the proposal seems to be high in the "may fund" category. The terms of reference must be fine-tuned, although the membership is good. The decision of the meeting was to not fund this proposal.

2.2.11 Carbon Hot Spot: Drivers and Sensitivities of Large Carbon Uptake in Western Boundary Currents

Denise Smythe-Wright summarized the proposal and comments from national SCOR committees. The proposal only included two Associate Members, which some national committees felt was a negative aspect. The capacity building was poorly developed. Many committees were positive about the proposal's subject matter, but it seemed to be very research oriented. There were no biologists in the membership and no members from Europe. The German SCOR Committee felt that the terms of reference were very weak and that a working group was not a good mechanism to accomplish the proposed work. The Dutch SCOR committee asked whether the motivation on which this working group is based is correct. The added value from a SCOR working group is not clear and the terms of reference are not reflected in the deliverables.

Peter Burkill summarized that this is low in the "may fund" category. The decision of the meeting was to not fund this proposal.

3.0 LARGE-SCALE SCIENTIFIC PROGRAMS

SCOR currently sponsors five large-scale research projects; four of them are co-sponsored by other organizations. Each project has its own scientific steering committee (SSC) to manage the project. 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 IMBER, SOLAS, and GEOTRACES, but is providing SCOR support for IQOE and IIOE-2 until they are self-supporting.

3.1 SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research,

Peter Burkill presented PowerPoint slides provided by IMBER. IMBER has been in transition for the past several years, from having IGBP as a co-sponsor to having Future Earth as a co-sponsor, and in transition from the first to second phase of IMBER. The IMBER Science Plan/Implementation Strategy (SPIS) has been reviewed and reviewers' comments are being considered by IMBER. The new SPIS includes three Grand Challenges and four Innovation Challenges.

IMBER held its 5th CLIMECO Summer School in Natal, Brazil on 10-17 August 2016; 65 students from 27 countries participated. The 5th Imbizo open science meeting will be held in Woods Hole, Massachusetts, USA on 2-6 October 2017. The overall theme will be "Marine biosphere research for a sustainable ocean: Linking ecosystems, future states and resource management." The three concurrent workshops will be on

1. Metabolic diversity and adaptation/evolution (Innovation challenge 1)
2. Developing scenarios and projections of future marine and human systems (Grand Challenge 2)
3. Integrating human behavior into ecosystem models (Grand Challenge 3)

Progress on other IMBER activities includes the following:

- IMBER Report No. 9 on *IMBER Capacity Building – Legacy and Perspectives* was published in 2016. The report recommends that capacity building be a component of all IMBER activities, that IMBER include early-career scientists on its Scientific Steering Committee, that IMBER capacity building seek to build capabilities for interdisciplinary science, and that IMBER seek better capacity-building linkages with other national, regional, and international initiatives.
- The IMBER regional group on Ecosystem Studies of Subarctic and Arctic Seas (ESSAS) has been involved in a project called Resilience and Adaptive Capacity of Arctic Marine Systems under a Changing Climate (RACArctic), funded by the Belmont Forum.
- Tarling et al. (2016)[7] was published by scientists involved in the IMBER Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) project, regarding how ocean acidification will affect polar pelagic food webs.

[7]Tarling et aI. 2016 Effects of acute ocean acidification on spatially-diverse polar pelagic foodwebs: insights from on-deck microcosms. *Deep-Sea Research II* DOI 10.1016/j.dsr2.2016.02.008

- The Climate Impacts on Oceanic Top Predators (CLIOTOP) project held a symposium in San Sebastian, Spain on 14-18 September 2015, on the "Future of oceanic animals in a changing ocean."
- The Eastern Indian Ocean Upwelling Research Initiative (EIOURI) has been established (see http://www-masu.s2.weblife.me/EIOURI/).
- The IMBER Human Dimensions Working Group has developed the I(MBER)-ADApT decision support tool I-ADApT, which was published by Bundy et al. (2015)[8] and is now being tested with an increasing number of case studies.
- IMBER cooperates with SOLAS on ocean carbon cycle activities, with Future Earth Coast on continental margin activities, and with CLIVAR on activities related to upwelling regions.

Funding for the IMBER International Project Office has been extended to 2020 and Gro van der Meeren has been appointed as the new IMBER Executive Officer.

Burkill noted that IMBER has a large Scientific Steering Committee because of the many different topics they need to handle, including societal aspects. They have good representation of female scientists on the SSC and in their committees. Capacity building is taken very seriously. They signed an MoU with Future Earth. IMBER has proposed that the definition of their acronym be changed to "Integrated Marine Biosphere Research". They have launched a new Web site and may adopt a new logo.

3.2 GEOTRACES

Wajih Naqvi introduced Jing Zhang (former member of the GEOTRACES SSC and a Nominate Member from Japan), who presented PowerPoint slides prepared by the GEOTRACES IPO. GEOTRACES continues its systematic exploration of the chemistry of the ocean. Eighty-six GEOTRACES cruises have been conducted (including 11 International Polar Year cruises) with 946 section stations completed and about 703 peer-reviewed papers published, with 8 special issues and three more in preparation. About 24 GEOTRACES Process Studies have been completed.

The major GEOTRACES activities for the past year have been (1) four cruises in the Arctic Ocean region, (2) preparation for the 2017 Intermediate Data Product, and (3) mid-project synthesis activities. Planning is underway for cruises in the Pacific and Indian oceans, and in the Siberian seas. The 2017 Intermediate Data Product will be released at the 2017 Goldschmidt Meeting on 13-18 August 2017, in Paris, France. GEOTRACES held two synthesis meetings in the United Kingdom in December 2015,[9] sponsored by the Royal Society, and another synthesis meeting in the United States was held in August 2016.[10] GEOTRACES is discussing with the

[8]Bundy, A., R. Chuenpagdee, S.R. Cooley, O. Defeo, B. Glaeser, P. Guillotreau, M. Isaacs, M. Mitsutaku, and R.I. Perry. 2016. A decision support tool for response to global change in marine systems: the IMBER-ADApT Framework. *Fish and Fisheries* 17(4):1183-1193, DOI: 10.1111/faf.12110

[9]Discussion meeting issue 'Biological and climatic impacts of ocean trace element chemistry' organised and edited by Gideon Henderson, Ed Boyle, Maeve Lohan, Micha Rijkenberg and Géraldine Sarthou, 28 November 2016; volume 374, issue 2081. http://rsta.royalsocietypublishing.org/content/374/2081

[10]http://web.whoi.edu/geotraces-synthesis/

Past Global Changes (PAGES) program a possible joint workshop in 2018.

GEOTRACES regularly has outreach at major international scientific meetings. Elena Masferrer-Dodas, the GEOTRACES Executive Officer, organized the SCOR Booth at Ocean Sciences 2016 and created a video loop with contributions from SCOR projects and working groups. Many GEOTRACES SSC members and scientists took turns staffing the booth. GEOTRACES organized a Town Hall session at Ocean Sciences on the topic of "Strengthen your science using GEOTRACES data", based on data from the 2014 GEOTRACES Intermediate Data Project. GEOTRACES also organized a workshop on "Exploring GEOTRACES data with ODV" at the 2016 Goldschmidt Conference. There has also been outreach beyond the ocean chemistry community, for example, through an article in the magazine of the International Union of Pure and Applied Chemistry.[11] The GEOTRACES Outreach Web page is at http://www.geotraces.org/outreach.

Examples of scientific output from GEOTRACES cruises were presented:

- Decoupling between dissolved zinc and silicon in the North Atlantic Ocean driven by mixing of end-members (Roshan, S., and J. Wu. 2015. Water mass mixing: The dominant control on the zinc distribution in the North Atlantic Ocean. *Global Biogeochemical Cycles* 29(7):1060–1074. doi:10.1002/2014GB005026)
- Changing the cadmium:phosphorus paradigm? (Quay, P., J. Cullen, W. Landing, and P. Morton. 2015. Processes controlling the distributions of Cd and PO_4 in the ocean. *Global Biogeochemical Cycles* 29(6):830–841. doi:10.1002/2014GB004998)
- Large fluxes of dissolved aluminium exported from the coast to the ocean (Ren, J.-L., J.-L. Xuan, Z.-W. Wang, D. Huang, and J. Zhang. 2015. Cross-shelf transport of terrestrial Al enhanced by the transition of northeasterly to southwesterly monsoon wind over the East China Sea. *Journal of Geophysical Research: Oceans* 120(7):5054–5073. doi:10.1002/2014JC010655)
- Multiple controls on the dissolved aluminium fate in the western Atlantic Ocean (Middag, R., M.M.P. van Hulten, H.M. Van Aken, M.J.A. Rijkenberg, L.J.A. Gerringa, P. Laan, and H.J.W. de Baar. 2015. Dissolved aluminium in the ocean conveyor of the West Atlantic Ocean: Effects of the biological cycle, scavenging, sediment resuspension and hydrography. *Marine Chemistry*. doi:10.1016/j.marchem.2015.02.015)

Corina Brussaard asked how SCOR is acknowledged in GEOTRACES publication. Ed Urban answered that it is SCOR policy that if SCOR funding is used for project activities, any resulting publications should acknowledge SCOR. However, many national activities are funded by national funding, so SCOR is not necessarily acknowledged in publications from these activities. Most acknowledgements to SCOR would be in synthesis reports and publications that result from meetings sponsored by international GEOTRACES (i.e., SCOR). Brussaard suggested that SCOR develop a standard sentence that could be used to acknowledge SCOR support of project workshops. Urban will take this up in his next meeting with GEOTRACES.

[11]Turner, D., and E. Urban. 2016. GEOTRACES: High-Quality Marine Analytical Chemistry on a Global Scale. *Chemistry International* 38(1):16–17. https://www.degruyter.com/view/j/ci.2016.38.issue-1/ci-2016-0108/ci-2016-0108.xml.

Peter Burkill noted that it is important for the various projects working on iron (i.e., GEOTRACES, SOLAS, and IMBER) to cooperate.

3.3 Surface Ocean – Lower Atmosphere Study (SOLAS)

John Turner, the SCOR Executive Committee Reporter for SOLAS, presented PowerPoint slides prepared by the SOLAS IPO. SOLAS reaches more than 2,400 scientists in the community. Six open science conferences have been held, with more than 1,250 participants. Six SOLAS Summer Schools have trained more than 420 young scientists.

The IPO is currently staffed by two people, although the funding is ending for the second person. Ed Urban added that more funding is needed for the second person, and encouraged national SCOR committees to consider how to provide national funding for the SOLAS IPO. Otherwise, SOLAS will need to reduce its activities, such as open science conferences and summer schools. The IPO will be hosted until December 2020 at GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany.

SOLAS is awaiting approval of the response to review of its Phase II Science Plan from co-sponsors.[12] The SOLAS Implementation Plan is being developed and will be a "living document" on the SOLAS Web site, which will be updated regularly.[13]

SOLAS is funding two important workshops in June and October 2016. The first workshop was a SOLAS/ESA workshop on concurrent remote-sensing inversions of ocean and atmosphere, which took place at the ESA facilities in Frascati, Italy on 13-15 June. A second workshop will take place in Brussels, Belgium in late October on "SOLAS and Society". This workshop is closely linked to the goals of Future Earth. SOLAS presented a banner at the SCOR Booth at the 2016 Ocean Sciences Meeting and helped staff the booth. SOLAS scientists participated in the GESAMP working group inception meeting on `Marine Geoengineering` in London, UK, on 23-24 May 2016. SOLAS scientists also participated in the meeting on Air-sea Gas Flux; Progress and Future Prospects convened by the Oceanflux Evolution project and ESA, in Brest, France on 6-9 September 2016, and the Global Ocean Oxygen Network (GO_2NE) meeting in Paris, France, on 7-9 September 2016. The SOLAS SSC meeting and SOLAS Asia Symposium days will be held in Qingdao, China on 24-28 October 2016. The aim of the symposium is to foster the exchange of ideas and knowledge among Asian scientists as well as the communication with the international community and to promote collaborations within Asian countries for SOLAS research and activities over the next decade.

Planned is underway for several meetings to be held in 2017 and 2018:

- SOLAS is also involved in an Ocean Acidification workshop to take place in Dakar, Senegal (West Africa) on 12-20 February 2017.
- Workshop convened by SOLAS, CliC and the BEPSII project in San Diego, California, USA on 3-5 April 2017 to promote studies of sea-ice biogeochemistry.

[12] http://www.solas-int.org/about/solas.html
[13] http://www.solas-int.org/activities/implementation.html

- Meeting convened by SOLAS and WCRP in Cargese, France on 15-19 May 2017 on the topic of the role of the air-sea interface in fluxes of mass and energy.
- Plans are developing to organize another SOLAS Summer School in Cargese, France on 23 July-3 August 2018. A proposal to secure the venue will be submitted shortly. An organizing committee was established in early summer 2016 and includes SOLAS Summer School alumni from the first school and current/past SSC members. The school is planned to bring together around 75 students and 20 lecturers.

SOLAS has a long-standing cooperation with the European Space Agency (ESA). SOLAS provided a document entitled "Earth Observation and SOLAS Science Priorities" to ESA in 2016, which consists of a summary of the conference "Earth Observation for Ocean-Atmosphere Interactions Science 2014" and SOLAS Science Priorities. This document will be a base for future collaboration between SOLAS and ESA. Another step in the continuation of the collaboration was the SOLAS/ESA workshop in June 2016 on 'Concurrent remote-sensing inversions of ocean & atmosphere'.

SOLAS is now a core project of Future Earth (IGBP came to an end last year). A Memorandum of Understanding was signed between SOLAS and Future Earth in September 2015. SOLAS is involved in establishing the Knowledge Action Network (KAN) on Oceans and the preparation of the Belmont Forum call for proposals, by involvement in the development team. Three topics where SOLAS involvement could be beneficial include the following:

(1) Extreme events in Eastern Boundary Upwelling Systems
(2) Changes in the Arctic: Threat or opportunity?
(3) Atmospheric chemistry services / Volcanic emissions

Finally, SOLAS is contributing to Future Earth through the SOLAS & Society workshop planned for October 2016.

3.4 SCOR/POGO International Quiet Ocean Experiment (IQOE)

Ed Urban made the presentation on behalf of IQOE. The project was developed because human activities increase ambient ocean noise, at frequency ranges that overlap the full range of animal uses of sound in the ocean. Ocean noise at frequencies of 20-80 Hz has increased over the past four decades by 10 dB in the northeast Pacific Ocean, although current trends are leveling or decreasing in this area, but increasing in the Indian Ocean. Few studies address large enough spatial and time scales to quantify sound in the ocean or its effects on marine organisms. Does this increase in human-made ocean noise adversely affect marine life? Can human-made noise be managed to minimize impact? There is high uncertainty in available knowledge, future trends, and significance of effects. This high uncertainty, combined with potentially serious consequences, have led to a precautionary approaches within legislation. IQOE will address four fundamental questions:

1. How have human activities added to the global ocean soundscape (compared with historical data)?
2. What are the current levels and distribution of man-made sound in the ocean?

3. What are the trends in man-made sound levels across the global ocean?
4. What are the current/potential effects of anthropogenic sound on important marine animal populations?

IQOE's Science Committee was formed in early 2016 and met for the first time in London, UK in March 2016. The meeting was attended by representatives from several stakeholder groups and the Science Committee agreed to develop six working groups, on (1) Standards and Intercalibration, (2) Data Management and Data Access, (3) Arctic Acoustic Environment, (4) Acoustic Measurement of Biodiversity on Coral Reefs, (5) Acoustic Location of Spawning Aggregations of Fish, and (6) Stakeholder Relations. A Web site has been set up for the project, at www.iqoe.org. The project is envisioned as a 10-year activity, including a "Year of the Quiet Ocean", a period of extensive acoustical and biological observations related to project goals.

Colin Devey noted that most research vessels operate multi-beam sonar routinely to observe bottom bathymetry, which creates a conflict between basic science needs and impacts on sea animals. Corina Brussaard asked whether SCOR should make the scientific community more aware of this issue. Erik Pihl from Future Earth noted that it is not clear whether higher frequencies have significant impacts on populations. Peter Burkill asked whether IQOE is talking to GOOS about acoustics as essential oceanic variable. Ed Urban responded that a POGO working group is taking on this task, among others.

SCOR approved 2017 support from SCOR for IQOE, to be matched by funds from the Monmouth University/Rockefeller University partnership.

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

Peter Burkill, one of three co-chairs of the IIOE-2 Steering Committee, made a presentation about the project. The symposium held in Goa, India in December 2015 in conjunction with the SCOR annual meeting, concluded with the official launch and first cruise of the project. About half of the participants in this cruise were from beyond India and were largely early-career scientists. Many cruises are planned for the coming 5 years from participating countries. The three co-sponsoring organizations—SCOR, the Intergovernmental Oceanographic Commission of UNESCO, and Indian Ocean Global Ocean Observing System—issued a call for nominations of chairs of 6 Science Theme teams and 7 working groups and the organizations are in the process of selecting chairs. A call was also put out for members of these groups. A Joint Project Office has been set up, with offices in Perth, Australia and Hyderabad, India. An endorsement process has been developed to increase coordination among individual research projects and cruises in the Indian Ocean. The Indian National Centre for Ocean Information Services (INCOIS) set up a Web site for the project at www.iioe-2.incois.gov.in. Several countries have formed national committees and the number is still growing. Each national committee will be represented on the IIOE-2 Steering Committee and they will meet once each year. The first meeting will be in February 2017, in Perth, Australia. An informal publication has been created for the project, *the Indian Ocean Bubble-2*, to which participants can submit articles about ongoing work and ideas for new initiatives. This newsletter is hosted by India.

Annalisa Griffa noted that, in Italy, modelers are greatly interested in being involved in the project. Italian scientists are trying to organize a national committee. They are wondering how they can best obtain data. Peter Burkill replied that the Italian chair or other link person should communicate with the IIOE-2 Joint Project Office. National representatives can attend annual IIOE-2 Steering Committee meetings at their own expense. Corina Brussaard suggested that it would be good to consider having a separate IIOE-2 modelling working group and to have this group involved in planning of sampling activities.

Antonio Caltabiano commented that CLIVAR is not visible enough on the IIOE-2 Web site, but is active in Indian Ocean and was involved in creating the Science and Implementation plans (CLIVAR is a key partner through IOC). Peter Burkill agreed to bring up this issue with IOC.

SCOR approved rolling over $5,000 and provided an additional $25,000 in 2017, to help fund the first meeting of the IIOE-2 Steering Committee and other activities.

4.0 INFRASTRUCTURAL ACTIVITIES

4.1 IOC/SCOR International Ocean Carbon Coordination Project

Maciej Telszewski, the IOCCP Executive Officer based in Sopot, reported on IOCCP progress. Since 1960, IOC and SCOR have funded some kind of joint panel on ocean carbon and climate systems. In 2005, IOCCP was approved by IOC and SCOR as a standing project. IOCCP leads the Biogeochemistry (BGC) Panel of the Global Ocean Observing System. In 2015, IOCCP also became the AtlantOS Biogeochemistry Panel. IOCCP is planning to update its terms of reference to reflect its increasing role in relation to ocean biogeochemistry. The GOOS BGC Panel is developing the concept of biogeochemical essential ocean variables for GOOS. Besides scientific curiosity, societal needs and sustainable development goals are "top-down" stimuli for observing system development. There is more emphasis on developing "fit-for-purpose" observing systems and on training for new operators of observing system elements.

IOCCP is still contributing to activities related to ocean carbon data management. In January 2016, the GLobal Ocean Data Analysis Project version 2 (GLODAPv2) was released. Over the past few years, IOCCP was heavily involved in compiling this new interior ocean data synthesis product. The Surface Ocean CO_2 Atlas (SOCAT) is an activity coordinated by IOCCP on behalf of the international ocean carbon science community. Its goal is to improve access to surface water CO_2 measurements by regular releases of quality controlled and documented data products on fugacity of carbon dioxide (fCO_2) for the global oceans and coastal seas. Data submission for version 4 closed at the end of January 2016 (1,171 new and updated datasets submitted), the QC process is underway, and the release was scheduled for June 2016. The data submission, QC, and release of subsequent versions will become an annual activity. IOCCP is discussing is whether they should change their acronym or the definition of the acronym to reflect their broader role.

4.2 SCAR/SCOR Southern Ocean Observing System (SOOS)

Ilana Wainer introduced Anna Wåhlin, who made the SOOS presentation. Wåhlin began her presentation by reminding meeting participants why SOOS is needed. The Southern Ocean is

central to the Earth's metabolism. It is a major region of deep ocean water mass formation and arguably takes up ~50% of global anthropogenic carbon production. The Southern Ocean is changing. Antarctic ice sheets are showing significant change, many nearing potential "tipping points" in terms of large portions of the ice sheets breaking off. Marine ecosystems are exhibiting change also, such as dramatic changes in penguin populations, likely as a response to regional changes in the physical system. An observing system is needed to help document changes and to predict the speed and direction of future changes. SOOS has recognized that future observations will need to increasingly use remote sensing and automated in situ sensing, instead of relying on icebreakers. SOOS was launched in 2011 with the mission to facilitate the collection and delivery of essential observations on dynamics and change of Southern Ocean systems to all international stakeholders, through design, advocacy, and implementation of cost-effective observing and data delivery systems.

The SOOS IPO (http://soos.aq/about-us/ipo) is currently staffed by two personnel; an Executive Officer (Dr. Louise Newman) and a Data Officer (Dr. Phillippa Bricher). The role of the Executive Officer is support and facilitation of SOOS implementation. Implementation of SOOS will be carried out by a combination of SOOS working groups and task teams, and through strategic partnerships with external programs and initiatives. Regional and Capability Working groups are being set up. Capability working groups include Southern Ocean FLUX, Censusing Animal Populations from Space, POGO Working Group Observations Under Ice, and Ecosystem Essential Ocean Variables. Regional working groups are Weddell Sea, Indian Sector, Ross Sea, Amundsen Sea, and West Antarctic Peninsula.

In 2015/2016, SCAR and SCOR facilitated an international review of SOOS progress and the new 5-Year Implementation Plan. SOOS has provided a response to the review comments, and has made significant changes to the 5-Year Implementation Plan as a result of the review. SOOS is waiting for the final approval by sponsors. A major product of SOOS, SCOR, and SCAR was the Constable et al. (2016) paper.[14] SOOS is in the process of developing regional and capability working groups to implement SOOS, for example, a working group to drive observations under ice and another group focused on observations on the West Antarctic Peninsula. The Southern Ocean Satellite Data Task Team has led a community report that has been accepted by the journal *Antarctic Science*. The SOOS IPO has two more years of funding from Australia. The Australian hosts will most likely like to see more international involvement in IPO funding to match Australian funding. The IPO has prepared a database of all moorings in the Southern Ocean (ocean and glaciers). Looking ahead, SOOS will be looking for more funding for a database of field projects and moorings. Governance and data management have been funded, but it would be good to have one person more for communication.

Peter Burkill asked about linking to other groups. Wåhlin replied that SOOS is trying to create linkages with other relevant projects, for example with CLIVAR. The link with the

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

CLIVAR/CliC/SCAR Southern Ocean Region Panel and CLIVAR/IOC-GOOS Indian Ocean Region Panel could be better. SOOS is looking for a specific person to serve as a liaison with CLIVAR and they have somebody in mind, but person has not yet agreed.

4.3 IAPWS/SCOR/IAPSO Joint Committee on Seawater

Denise Smythe-Wright presented on the status of the Joint Committee on Seawater (JCS). The JCS is a group that resulted from SCOR/IAPSO Working Group 127 on Thermodynamics and Equation of State of Seawater, which developed a new equation of state of seawater (TEOS-10), which has been widely accepted. The group holds opportunistic meetings, particularly in conjunction with annual meetings of the International Association for the Properties of Water and Steam (IAPWS). The number of downloads from the TEOS-10 Web site is large, with 1,500-2000 views per month, with many unique user views since October 2010.

Ed Urban noted that the members of this group mostly fund their own travel to meetings. SCOR mainly contributes to the travel of the co-chairs. Paul Myers asked about teaching material based on TEOS-10. Denise replied that there are PDFs available on-line (e.g., see http://www.teos-10.org/pubs/TEOS-10_Primer.pdf).

SCOR approved US$5,000 for travel expenses for the group for 2017.

4.4 GlobalHAB

Elisa Berdalet, the chair of GlobalHAB, made a presentation about the activity. GlobalHAB is an international project designed to "improve understanding, prediction, management and mitigation of HABs in aquatic ecosystems." It follows on from the Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) project, which ran from 1998 to 2013. GlobalHAB will pick up some of the topics leftover from GEOHAB (e.g., benthic HABs), plus develop some new areas of interest, including cyanobacterial blooms, human health, and interactions of fish farming with HABs. The GlobalHAB SSC will produce summaries for policymakers related to important aspects of HABs. GlobalHAB is seeking funding to carry out its work. The GlobalHAB SSC met for the first time in March 2016 in Oban, Scotland.

Sun Song asked whether there has been any assessment of the economic impact of HABs. Berdalet answered that improving such assessments is a specific goal of GlobalHAB. There was a follow-up question about the GlobalHAB aquaculture project. Berdalet responded that the idea is to see how HAB toxins affect aquaculture and how physics (water movement) are affecting toxin transport. Also, to investigate how nutrient enrichment from aquaculture facilities may induce HABs and lead to changes in food web structures.

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

Ed Urban presented an update on the outcomes of this workshop. SCOR sponsored a meeting of 12 marine scientists in September 2014 to develop a high-profile paper on research priorities related to seafloor ecosystem functions and their role in global processes. The workshop participants are preparing a paper for submission to *Nature Geosciences*.

5.0 CAPACITY-BUILDING ACTIVITIES

5.1 SCOR Committee on Capacity Building

Venu Ittekkot, chair of the SCOR Committee on Capacity Building, noted that a new committee would be in place soon. He also noted that more detail on the capacity-building activities of working groups was added to the call for proposals in 2016. The committee developed advice for capacity-building aspects of the working groups approved in 2015. Some actions that could be recommended to all groups includes the following:

- Consider organizing mentoring events in conjunction with larger meeting events
- Include members from the Asia-Pacific region
- Consider linking up with the IIOE-2 early-career activity
- Consider scheduling at least one meeting with an attached training session in a developing country
- Make better use of International Oceanographic Data and Information Exchange (IODE) centers in China, India etc.
- Integrate capacity-building activities better with other working group activities
- Include developing country participants from the beginning

SCOR approved US$10,000 for activities of the SCOR Committee on Capacity Building for 2017.

5.2 SCOR Visiting Scholars

SCOR has sent 19 Visiting Scholars to 13 different countries in the first 8 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. A survey of the 16 Visiting Scholars who served in 2009-2015 showed that they appreciated the opportunities provided by the program and also have suggestions for improvements.

SCOR approved three Visiting Scholars in 2016, two of which are serving in the Indian Ocean region and are a contribution from SCOR to the IIOE-2. New sources of funding should be sought to help fund the Visiting Scholar program (e.g., British Council, and funding from national SCOR committees). National SCOR committees could help identify funding sources in their countries that could contribute to the Visiting Scholar program and other SCOR capacity-building activities. Ilana Wainer asked if a country can then keep that funding for only their citizens. This would makes it easier to convince government to contribute. Peter Burkill answered yes, that is how some funding, for example, from the British Council, already operates.

A question was asked about whether there are separate activities for early-career scientists from developed countries. Ed Urban answered that SCOR's funding from NSF funding can only be used to benefit developing country scientists and institutions. However, within SCOR research projects there are activities—for example, summer schools—that include early-career scientists from both developed and developing countries. Peter Burkill added that SCOR also encourages the involvement of early-career scientists in SCOR events. This is an indirect way of promoting early-

career scientists.

A suggestion was made that early-career scientists (including beginning tenure-track faculty) be included in national SCOR committees. If several countries involved in SCOR could do this, the early-career scientists could meet electronically for cooperative planning. It was also suggested that early-career scientists could be asked to co-chair national oceanography meetings. Peter Burkill added that this is an important issue. The early-career session at the Goa symposium developed an idea that will be on the Web soon, in terms of convening a meeting of early-career scientists (from both developing and developed countries) interested in the Indian Ocean. Burkill suggested that national SCOR committees try to find funding for a few travel grants to such a meeting. Someone noted that national SCOR committees sometimes experience problems just to get SCOR dues paid. National funding might be more available if funding agencies can see more benefit from their long-term investment. Venu Ittekkot mentioned that Germany has included early-career scientist initiatives within and between projects; senior scientists can aid by lobbying funding agencies at national level to set apart funding for capacity building. Hal Batchelder added that ICES and PICES would love to get more applications for their capacity-building events. Another comment was that the European Union has a means via the BONUS program (Baltic nations) for funding projects and it should have a very strong capacity-building program. Early-career scientists within Baltic nations have chances to meet during special meetings. The EU will try to have this initiative continue during the next EU funding term. An action for all national SCOR committees is to consider how to bring forward early-career scientists within the different national committees.

5.3 POGO-SCOR Visiting Fellowships for Oceanographic Observations

Ed Urban provided an update on this program. SCOR has co-funded this program with POGO since 2001. The program has funded about 150 fellows so far, including five fellowships awarded in 2016. A SurveyMonkey questionnaire was used in the past year to gather feedback about the program, and the results will be used to continue to improve the program. SCOR provided access to the SurveyMonkey and Ed Urban programmed the survey.

5.4 NSF Travel Support for Developing Country Scientists

Ed Urban provided an update on the SCOR travel grant program. 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 approved several batches of requests since the 2015 SCOR meeting and additional requests will be considered before the SCOR meeting in Poland.

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1 Intergovernmental Oceanographic Commission (IOC)

Peter Burkill provided an overview of SCOR's interactions with IOC. SCOR continues to co-sponsor several activities with IOC, including IOCCP (see item 4.1), the GlobalHAB project (see item 4.4), and the Second International Indian Ocean Expedition (see item 3.6). Peter Burkill

introduced Henrik Enevoldsen, acting director of the IOC Ocean Science Section, who provided an update on IOC ocean science activities. Enevoldsen discussed three major IOC ocean science activities that will contribute to the IOC Ocean Science Program objectives and which are all within the current Programme and Budget:

1. The International Working Group for Marine Time Series (IGMETS) is a group designed to combine global ship-based time series of phytoplankton and zooplankton data, nutrient and physical information (temperature, salinity), and satellite data to obtain spatially distributed information to try to determine whether the observations can best be attributed to natural variations or human-induced changes. This group was formed by IOC, IOCCP, and the U.S. Ocean Carbon and Biogeochemistry program in 2013. Currently, IOC leads this effort. IOCCP is a partner with IGMETS. See http://igmets.net/.
2. TrendsPO is a project to collect and analyse phytoplankton time-series data to determine whether and why phytoplankton populations are changing. This activity is based, in part, on the data compiled and the work completed by SCOR WG 137 on Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation.
3. The IOC Global Ocean Oxygen Network (GO_2NE) is designed to improve the comparability of oxygen data collected worldwide, from coastal areas to the open ocean, to improve understanding of the increasing problem of ocean deoxygenation. See http://www.unesco.org/new/en/natural-sciences/ioc-oceans/sections-and-programmes/ocean-sciences/global-ocean-oxygen-network/.

Enevoldsen continued by informing SCOR that the IOC Ocean Science Section is reconvening its ad hoc Advisory Group on Ocean Science, which will revisit and advise IOC on updating the OSS priority areas of work to help IOC continue to lead effectively the development of international cooperation in ocean science.

Enevoldsen continued with an update of the IOC Global Ocean Science Report (GOSR). The purpose of this report is to document for IOC Member States their investments, resources, and scientific productivity in ocean science, to help IOC understand how it can harness these resources to fulfil IOC missions. IOC distributed a questionnaire to Member States, which was answered by 34 of them. The report will be launched at the UN Ocean Conference in June 2017. A GOSR data portal is being set up, to allow access to a searchable database of the information gathered from the questionnaire and other sources, such as bibliometrics. Enevoldsen presented some preliminary results, such as for the number of ROVs, AUVs, gliders per country, and the number of publications in ocean science per country.

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

Ed Urban provided an update about this activity. SCOR has funded GESAMP Working Group 38 on Atmospheric Input of Chemicals to the Ocean through grants from the U.S. National Science Foundation. 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 (two additional workshops) and NSF has agreed to provide partial funding through

SCOR for this work.

6.3 North Pacific Marine Science Organization (PICES)

Hal Batchelder, PICES Deputy Director, provided an update about PICES activities. PICES and SCOR cooperate on a variety of activities and PICES helps to implement global SCOR projects in the North Pacific region. PICES leads several meetings in the North Pacific region every year and cooperates with other organizations, such as ICES, to convene meetings in other regions. Ed Urban will represent SCOR at the 25th PICES anniversary meeting in November 2016.

PICES sent a representative of the PICES Section on Ecology of Harmful Algal Blooms in the North Pacific to the first meeting of the GlobalHAB Scientific Steering Committee in Oban, Scotland in March 2016. This is important for GlobalHAB, which is seeking to coordinate its work with the work of other regional and global organizations. PICES is funding an Associate Member of SCOR WG 149 on Changing Ocean Biological Systems (COBS): How will biota respond to a changing ocean? Unfortunately, this member could not attend the first meeting WG 149. Corina Brussaard asked if the funding could have gone to another Associate Member. Batchelder replied that he would have to check, but that it would at least have to have been from a PICES member nation. PICES contributed funding for the IMBER ClimECO5 Summer School in 2016 and is contributing toward the IMBER-ESSAS 2017 Open Science Meeting. Batchelder requested support from SCOR for SCOR-relevant sessions at the 2017 PICES annual meeting; SCOR regularly provides support for SCOR-relevant sessions at annual PICES meetings.

7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

7.1 International Council for Science

Peter Burkill informed meeting participants that ICSU had been reviewing SCOR and SCAR in 2015 and 2016, and the review was completed. SCOR will consult with national SCOR committees about SCOR's response to the review, particularly in relation to the ICSU Review Panel's recommendation regarding SCOR's mission:

> "SCOR needs to update its "mission", in particular by including further references to science/policy work within the context of the current scientific and political landscape and current activities, and to public outreach and communication."

Peter Burkill and Ed Urban met with the ICSU Executive Director, Heide Hackmann, and the ICSU Head of Science Programs, Lucilla Spini, in June 2016 to discuss the SCOR review, the evolution of Future Earth, and the potential merger of ICSU and the International Social Science Council.

7.1.1 World Climate Research Programme (WCRP)

Antonio Caltabiano presented an update about WCRP, whose work is organized into:

- 2 councils: Modeling Advisory Council and Data Advisory Council

- 4 Working Groups (Numerical Experimentation, Seasonal to Interannual Prediction, Coupled Modeling, and Regional Climate)
- 5 research projects (CliC, CLIVAR, GEWEX, SPARC, CORDEX)

overseen by the WCRP Joint Scientific Committee.

Seven Grand Science Challenges crosscut the five research projects:

1. Melting Ice and Global Consequences
2. Regional Sea Level and Coastal Impacts
3. Water for Food Baskets
4. Weather and Climate Extremes
5. Clouds, Circulation and Climate Sensitivity
6. Near-term Prediction (decadal)
7. Carbon and Climate

WCRP, with several partners, including the Prince Albert II Foundation, has raised a 500,000 CHF euro prize for the first 2,000-mile AUV mission under sea ice, the WCRP Polar Challenge (see http://www.wcrp-climate.org/index.php/polarchallenge). SCOR contributed to this prize.

WCRP co-sponsors the SOLAS project. WCRP projects particularly related to SCOR interests include the CLIVAR project and the WCRP Grand Challenge on Regional Sea-Level Change and Coastal Impacts.

CLIVAR (Climate and Ocean: Variability, Predictability and Change) project is the primary ocean component of WCRP. CLIVAR's objectives are to

- describe and understand the dynamics of the coupled ocean-atmosphere system;
- identify processes responsible for climate variability, change and predictability; and
- develop—through the collection and analysis of observations—and apply models of the coupled climate system.

CLIVAR's objectives are achieved through the work of 8 Core Panels. Four are subject area panels (Ocean Model Development Panel, Global Synthesis and Observations Panel, Climate Dynamics Panel, and CLIVAR/GEWEX Monsoons Panel) and four are regional panels, for the Atlantic, Pacific, Indian, and Southern oceans. More recently, CLIVAR has established the possibility for the community to define and implement Research Foci (RF). These Research Foci provide the CLIVAR project with the ability to remain flexible in the changing landscape of scientific research priorities, whilst the traditional CLIVAR panels maintain a focus on the core activities critical to advancing CLIVAR and WCRP goals. The current These panels orient around the following research themesfive RF are: Ddecadal Cclimate Vvariability and Ppredictability (DCVP), Eeastern Bboundary Uupwelling Ssystems (EBUS – jointly with IMBeR), Rregional sea-level change and coastal impacts (a WCRP GC), Pplanetary energy balance and ocean heat storage (CONCEPT-HEAT), and ENSO in a changing climate. Caltabiano presented scientific highlights from the CLIVAR panels and CLIVAR research foci. IMBER and SOLAS are cooperating with CLIVAR on the eastern boundary upwelling systems topic.

CLIVAR will celebrate its 20th anniversary at an Open Science Conference at the end of September 2016, in Qingdao, China. Caltabiano provided details about the event. SCOR is providing travel support for developing country students to participate in that event.

7.1.2 Scientific Committee on Antarctic Research (SCAR)

Corina Brussaard updated meeting participants about SCAR activities and cooperative activities between SCOR and 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. Steven Chown (Australia) became the new SCAR chair in August 2016, and Austria, Colombia, Thailand and Turkey became new associate members. BEPSII (formerly SCOR WG 140) was approved for two years as an Action Group under the Standing Group on Life Sciences.

7.1.3 Future Earth

Peter Burkill introduced the topic, then introduced Erik Pihl to update meeting participants about Future Earth. The Future Earth initiative continues development. It is comprised of 5 global hubs, 7 regional centers and offices, more than 20 global research projects, and 20 national networks so far. Eight Knowledge-Action Networks (KANs) are under development, include one on oceans. SCOR is working with Future Earth in relation to the Phase II science plans for SOLAS and IMBER. These two projects are working with other Future Earth-sponsored projects to develop the Ocean KAN. The Ocean KAN will be designed to

- build communities that will use scientific results as the result of actions to deal with societal issues;
- connect researchers, civil society, public and private sector organizations, communicators, and funders;
- build transdisciplinary teams; and
- identify transdisciplinary research priorities for the oceans sustainability community.

Future Earth is contributing to developing a Collaborative Research Action (CRA) on Oceans. CRAs are a funding mechanism used by the Belmont Forum to promote transdisciplinary (natural science, social science, societal partners) research and requires contributions from at least three countries that are part of the Belmont Forum.

7.1.4 Belmont Forum

Peter Burkill explained the Belmont Forum to meeting participants. “The Belmont Forum is a group of the world's major and emerging funders of global environmental change research. It aims to accelerate delivery of the environmental research needed to remove critical barriers to sustainability by aligning and mobilizing international resources. It pursues the goals set in the Belmont Challenge by adding value to existing national investments and supporting international partnerships in interdisciplinary and transdisciplinary scientific endeavors.” – from http://belmontforum.org/belmont-forum. Peter Burkill and Ed Urban had a conference call with the Executive Director of the Belmont Forum and in in-person meeting with the Deputy Director, to discuss potential interactions with SCOR.

7.2 Affiliated Organizations

7.2.1 International Association for Biological Oceanography (IABO)

Patricia Miloslavich presented an update about IABO activities and reminded meeting participants that IABO is a constituent Section of the International Union of Biological Sciences (IUBS). The goal of IABO is to promote the advancement of knowledge of the biology of the sea, by providing opportunities for communication among marine biologists (e.g., meetings and discussions during General Assemblies of IUBS or others), and cooperating with organizations and individuals with similar aims and interests. 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 next IABO General Assembly will be held in conjunction with the 4th World Conference in Marine Biodiversity (WCMB) in Montreal in May 2018. The theme of the meeting will be "Connecting with the living ocean". IABO is establishing the Carlo Heip Memorial Medal to honor leadership of a researcher in the field of marine biodiversity. It will be awarded for the first time at the 4th WCMB. Annelies Pierrot-Bults, Past President of IABO and past SCOR Executive Committee member, was a member of the ICSU Review Panel.

IABO invites members of the SCOR community to join the listserv: MARINE-B: the MArine Research Information NEtwork on Biodiversity. This is the official IABO email network, currently with about 1,000 subscribers. The email network is designed for communication related to marine biodiversity research. Messages are archived at https://listserv.heanet.ie/marine-b.html. To join, send the message "SUBSCRIBE MARINE-B firstname surname" to listserv@listserv.heanet.ie.

Miloslavich continued by presenting an update about the GOOS Biology and Ecosystems Panel. This is one of three GOOS panels. The tasks of each panel are to

- identify of set requirements for Essential Ocean Variables (EOVs);
- develop EOV implementation strategies and plans for coordination of observations; and
- promote standards and interoperability of data and information products.

Biological changes relevant for GOOS to measure include variables related to marine biodiversity, marine ecosystem function, and marine ecosystem services. EOVs are being identified to monitor these kinds of changes. Impacts and feasibility are evaluated for each proposed biological EOV. Impact relates to the relevance of the EOV to helping answer science questions and address societal needs, and to contribute to improve management of marine resources. Feasibility of an EOV relates to whether the proposed EOV is scientifically credible; technically practical, cost effective, and within human capabilities; and enduring. GOOS will recommend implementation of EOVs that are high impact and high feasibility. The Drivers-Pressures-State-Impact-Response approach can also be used to identify potential biological EOVs. The GOOS Panel reviewed 30 international bodies for drivers and pressures. For determining "state of the marine environment" variables, they designed a survey and distributed it globally. One hundred twenty responses were received and are summarized at http://dev.iobis.org/goos/#/eov. The biological EOVs identified include EOVs related to

functional groups (phytoplankton biomass and productivity, incidence of harmful algal blooms, zooplankton diversity, fish distribution and abundance, apex predators' abundance and distribution) and ecosystem EOVs (live coral cover, seagrass cover, mangrove cover, microalgal canopy cover.

Hal Batchelder noted that zooplankton biomass is in best quadrant (high impact and high feasibility), but not on the summary slide. Miloslavich responded that yes, this is a mistake in the slide. The flyer is correct and they are still determining the best grouping names.

7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS)

John Turner, President of IAMAS, updated meeting participants about IAMAS activities. IAMAS is one of the eight associations of IUGG, which in turn comes under the International Council for Science. Like SCOR, IAMAS is a non-governmental body with no individual members, but they have adhering bodies and countries. IAMAS was established in 1919 as the International Association of Meteorology and Atmospheric Physics (IAMAP). It was renamed IAMAS in 1995 to reflect its increasing involvement with atmospheric chemistry. There is no permanent IAMAS Secretariat; they rely on the voluntary efforts of scientists to carry out the work of a secretariat. IAMAS science is carried out by 10 commissions. Turner described the special events of each commission. The IAMAS Bureau and Executive have been heavily involved in the planning of the joint IAPSO-IAMAS-IAGA assembly, which will be held in Cape Town, South Africa on 27 August–1 September 2017. A conference web site is now available at http://www.iapso-iamas-iaga2017.com. A request for bids has been issued for the IAMAS Scientific Assembly 2021 and a decision on location is expected to be made at the 2017 assembly. IAMAS has a Facebook page to reach out to younger scientists and awards the IAMAS Early Career Scientist Medal to recognize their achievements. IAMAS is responsible for the Springer journal *Advances in Atmospheric Sciences.*

The international Commission on Atmospheric Chemistry and Global Pollution (iCACGP) of IAMAS is the most relevant to SCOR and co-sponsors SOLAS.

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

Denise Smythe-Wright, president of IAPSO, updated meeting participants about IAPSO activities. It is one of eight Associations of the International Union of Geodesy and Geophysics (IUGG). The prime goal of IAPSO is to promote the study of the ocean and the interactions taking places at the seafloor, and coastal and atmospheric boundaries through the use of physics, chemistry, mathematics, and biogeochemistry. IAPSO works mainly through biennial scientific assemblies, working groups, commissions, and information transmitted through its Web site. A major approach of IAPSO is to involve scientists and students from developing countries in IAPSO activities by awarding travel grants. The IAPSO Secretariat moved from University of Gothenburg, Sweden to the Institute of Marine Science of the National Research Council of Italy, Trieste in 2015, with Stefania Sparnocchia assuming the post of Secretary General. The IUGG General Assembly 'Earth and Environmental Sciences for Future Generation' was held in Prague, Czech Republic on 22 June-2 July 2015. IAPSO organized 13 IAPSO-only symposia and 11 interdisciplinary symposia. 345 scientists registered as IAPSO participants, with 446 oral and poster presentations. As mentioned in the IAMAS report, the next event will be the IAPSO-

IAMAS-IAGA assembly, which will be held in Cape Town, South Africa on 27 August–1 September 2017.

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. Emeritus Professor Toshio Yamagata (also a Nominated Member to SCOR from Japan) was awarded the medal in 2015 for "his ground-breaking work and exceptional contribution to our understanding of El Niño/Southern Oscillation and the newly discovered Indian Ocean Dipole". The award ceremony took place on 29 June at IUGG 2015, during which Prof. Yamagata gave the Albert I Memorial Lecture. The Eugene LaFond Medal 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 Dr. Sana Ben Ismail from Tunisia for her oral presentation "Surface circulation features along the Tunisian coast (central Mediterranean Sea): the Atlantic Tunisian current". It was delivered during the IAPSO symposium "Physics and Biogeochemistry of Semi-Enclosed and Shelf Seas" at the IUGG 2015 General Assembly.

IAPSO supports several commissions and services:

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

The commissions and services report to IAPSO and their reports are posted on the IAPSO website at http://iapso.iugg.org/working-groups.

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).

IAPSO now has formal links with IIOE-2 and there will be a large joint session at the IAPSO-IAMAS-IAGA Assembly in Cape Town 2017. This provides the infrastructure for future IIOE-2 conferences and opens up IAPSO funding to IIOE-2 scientists from developing countries. IUGG, IAPSO, and SCOR worked together on the document *Future of Oceans and its Seas*, input to the G7 Science Ministers. IAPSO invited SCOR to participate and the three organizations identified a group of 14 experts to write short sections on marine litter, ocean acidification, biodiversity loss, deoxygenation, ocean warming, ecosystem degradation, and deep-sea mining (see http://www.icsu.org/news-centre/news/pdf/Report%20to%20G7%20SMins%20on%20FOSs.pdf).

7.3 Affiliated Programs

7.3.1 InterRidge - International, Interdisciplinary Ridge Studies

Colin Devey reported that 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. The main InterRidge activities over the past year or so have been the following:

- Third Theoretical Institute "Magmatic and Tectonic Processes and Seabed Resources at Mid-Ocean Ridges", Hangzhou, China, Sept. 2015. There were sessions on "Magmatic and Tectonic Processes" (Conveners: Lin (WHOI), Maia (France), Seama (Japan)) and "Seabed Resources" (Conveners: Li (China), Silantyev (Russia), Dyment (France)). Many young scientists from China attended and a student poster prize was awarded. Significant science questions were developed and the InterRidge Steering Committee meeting was held in conjunction with the event.
- Update of InterRidge hydrothermal vent database. This is available for Google Earth and GIS applications, and has in interface to the International Seabed Authority and contracting parties. It is becoming progressively more difficult to enter new data to the database as commercial interests grow.
- Second InterRidge workshop on Circum-Antarctic Ridges, Oct. 2015. This group is looking at vent ecosystem connectivity around Antarctica, mantle connectivity (no continental "road-blocks"?), and operational challenges to studying these systems.
- WG meeting "Ecological connectivity and resilience" at Deep Sea Biology Symposium, Aviero, Sept. 2015
- Office move to Toulouse, France

Ed Urban added that GEOTRACES and InterRidge are working together as trace metals emitted by hydrothermal vents travel further than expected.

7.3.2 International Ocean Colour Coordinating Group (IOCCG)

Sun Song reported that SCOR co-sponsors various IOCCG activities through support from the U.S. National Aeronautics and Space Administration. Currently, the SCOR/IOC GEOHAB project and IOCCG are co-sponsoring a project on applications of remote sensing to detection of harmful algal blooms. SCOR provided support for developing country scientists to participate in the 2016 IOCCG Summer School. Plans are underway for the third International Ocean Colour Science (IOCS) meeting, which will be convened by the IOCCG in partnership with EUMETSAT, ESA, the European Commission and likely NASA. The meeting is scheduled to take place from 15-19 May 2017, in Lisbon, Portugal.

7.3.3 Global Alliance of CPR Surveys (GACS)

Peter Burkill reported that GACS continues work toward fulfilling its goals of providing a global network of Continuous Plankton Recorder (CPR) surveys and has achieved some success in helping establish new CPR surveys and providing training for people responsible for these new surveys. There are currently CPR surveys conducted by or within the waters of Angola,

Australia, Brazil, Canada, China, Cyprus, Japan, India, Namibia, New Zealand, South Africa, and the United Kingdom. The surveys are designed to have 10 nm resolution along transects at monthly intervals. They are capable of monitoring the biodiversity of phytoplankton and zooplankton species, and pathogens (e.g., *Vibrio*), as well as the levels of microplastics.

There has been no meeting of GACS since the SCOR meeting in Goa (GACS meetings are held in September of each year); however, there has still been a significant amount of activity in the past year. Early in 2016, a workshop was held at the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) to provide CPR training for technicians from the National Institute of Oceanography in Kochi, India and technicians from Brazil. In February 2016, the Brazilian CPR Survey undertook 720 miles of towing across Drake's Passage and into the Southern Ocean. In May 2016, an 80-mile test deployment of a CPR was carried out in the Bay of Bengal from the ORV *Sindhu Sankalp*.

The latest Global Status report was released in June 2016, available at https://www.sahfos.ac.uk/publications/scientific-reports/ecostatus-reports/.

Burkill raised the possibility of the cooperation of GACS with SOOS.

7.4 Other Organizations

7.4.1 Partnership for Observation of the Global Oceans (POGO)

Sergey Shapovalov presented 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 that meet the requirements of international research and operational programs. Members value POGO as a forum in which they can meet their peer directors at least annually, in well-attended meetings, to discuss matters of common interest. Sun Song, one of SCOR's Vice Presidents, is also a member of the POGO Executive Committee. POGO currently has 38 member institutions from 19 countries.

SCOR and POGO have many areas of mutual interest and have a good history of cooperation over the years of POGO's existence:

- 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 (see section 5.3).
- 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 global level in marine science and coordinate their respective capacity-building programs.
- In 2015 and 2016, SCOR and POGO Secretariats worked on an impact evaluation questionnaire to send all past trainees of their training programs.
- SCOR has established jointly with POGO a new research initiative, the International

Quiet Ocean Experiment (IQOE) (see item 3.4).

- POGO contributed to the establishment of, 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 second International Indian Ocean Expedition (IIOE-2).
- POGO has been in correspondence with SCOR regarding possible input in the second round of the World Ocean Assessment. POGO members have discussed the importance of providing some feedback to the United Nations, Division for Ocean Affairs and the Law of the Sea (DOALAS) with recommendations for the next round of the World Ocean Assessment. A letter was submitted by POGO to DOALAS to include the recommendations, and dialogue has been initiated with representatives of DOALAS.

8.0 MEMBERSHIP AND FINANCES

8.1 Membership

8.1.1 National Committees

The background book for the meeting reported the following changes in representatives of national SCOR committees:

CHINA-TAIPEI	Ben Chao, C.-F. Dai, and Shu-Kun Hsu replaced by Pao-Kuan Wang (chairman), Ching-Ling Wei and Hui-Ling Lin
ECUADOR	Francisco Medina was replaced by Mercy Borbor Córdova
INDIA	M. Dileep Kumar, Manish Tiwari, and Satheesh C. Shenoi were replaced by M.M. Sarin, D Sengupta, and K Somasundar
RUSSIA	Andrey Kostianoy replaced Victor Akulichev
TURKEY	Temel Oguz and Bilge Tutak were replaced by Gülsen Avaz
UNITED STATES	E. Virginia Armbrust and Don Walsh were replaced by Claudia Benitez-Nelson and Kevin Arrigo.

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 a Finance Committee consisting of Annalisa Griffa (Italy), Paul Myers (Canada), Johan Rodhe (Sweden), and Jing Zhang (Japan). This committee conducted its work during the SCOR meeting. Paul Myers reported for the committee. The tasks of the committee were the following:

- Retrospective check of 2015 including audit
- Check current 2016 budget and suggested revisions
- Check projected budgets for 2017 for affordability and realism
- Recommend dues for 2018

2015

Membership dues totaled US$349,000, to which was added discretionary income of $105,000 from NSF and others, for a total of $454,000. Working group expenses were $117,000, other science expenses were $107,000, and administrative expenses were $272,000, for a total expense of $496,000, and a deficit of $42,000. This decreased the cash balance from $236,000 at the end of 2014 to $194,000 at the end of 2015. SCOR requires a cash balance of at least $100,000 at the end of each year. The Finance Committee recommend that SCOR accept the 2015 financial report and meeting participants agreed.

The Finance Committee reviewed the auditor's report of 2015 finances. The auditor found no accounting discrepancies (and found SCOR a low-risk auditee). The Finance Committee found the Auditor's report in accordance with SCOR financial report, and there are no special remarks in the Audit to consider.

2016

Myers presented the 2016 SCOR budget proposed at the 2015 SCOR meeting and the proposed revisions. Some countries are unlikely to pay their 2016 dues, for a dues shortfall of around $15,000. $20,000 is expected from other sources for the current working groups. Some working groups had not or will not spend their budgeted amount by the end of 2016. This is normal. There has not been an IIOE-2 Steering Committee meeting yet, so the amount in the budget will be transferred to 2017. The same is true for capacity building; the separate meeting planned for this year was not held. The Finance Committee recommended approval of the revisions to the 2016 SCOR budget and this was approved by meeting participants.

2017

The Finance Committee presented the SCOR draft budget for 2017. Income and expenses are similar to the amounts in 2016, with a projected budget deficit of -$57,887, bringing the ending cash balance to $123,166, above the required minimum level of $100,000. This budget assumes that two new working groups would be approved in 2017. Meeting participants approved the budget.

2018

The Finance Committee recommended, and meeting participants approved, a dues increase of 3% for 2018.

9.0 SCOR-RELATED MEETINGS

9.1 SCOR Annual Meetings

9.1.1 2016 General Meeting: Sopot, Poland

Peter Burkill and Ed Urban thanked the local hosts on behalf of SCOR, for hosting the meeting and for excellent local support and help with the logistics. Gifts were presented to the chair of the Polish SCOR Committee, Janusz Pempkowiak, and to the lead local organizer, Joanna Potrykus.

9.1.2 2017 Executive Committee Meeting

Peter Burkill announced that the 2017 SCOR Executive Committee meeting will be held in South Africa following the IAPSO-IAMAS-IAGS Assembly. The dates will be decided by the SCOR Executive Committee; 4-6 September is very likely. Mike Lucas (South Africa) made a presentation about the meeting details: potential locations, travel logistics, visa regulations, climate, health and safety, and finance.

9.1.3 2018 General Meeting

The SCOR Executive Committee accepted an offer from the UK SCOR Committee to meet in Plymouth for the 2018 SCOR General Meeting. Burkill presented the rationale for meeting in Plymouth. It was recommended that the SCOR meeting be held in September 2018 at Plymouth University's Marine Station, which is located convenient to hotels, the National Marine Aquarium, restaurants, and historic Plymouth Harbor area.

Peter Burkill closed the meeting by thanking participants and wishing them safe travel home.

APPENDICES

APPENDIX 1
LIST OF PARTICIPANTS

SCOR Executive Committee:

President:

Peter Burkill (NM)
Drake Circus
Plymouth University
Plymouth PL4 8AA
UNITED KINGDOM
Email: peter.burkill@plymouth.ac.uk

Secretary:

Corina Brussaard (NM)
NIOZ - Royal Netherlands Institute for Sea Research
P.O. Box 59
Den Burg, Texel, 1797 BA
NETHERLANDS
Email : corina.brussaard@nioz.nl

Past-President:

Wolfgang Fennel (NM)
Leibniz Institute for Baltic Sea Research
Seestr. 15
Rostock 18119
GERMANY
Email: wolfgang.fennel@io-warnemuende.de

Vice Presidents:

Sergey Shapovalov (NM)
P.P. Shirshov Institute of Oceanology
36 Nakhimovsky ave
Moscow, 117997
RUSSIA
Email: smshap@ocean.ru

Song Sun (NM)
Institute of Oceanology
Chinese Academy of Sciences
7 Nanhai Road
Qingdao, 266071
PEOPLE'S REPUBLIC OF CHINA
Email: sunsong@qdio.ac.cn

Ilana E. Wainer (NM)
University of São Paulo
praca do Oceanografico 191
São Paulo, SP, 05508-120
BRAZIL
Email: wainer@usp.br

Ex-Officio Members:

Patricia Miloslavich (IABO)
Project Officer GOOS Biology & Ecosystem Panel
Universidad Simon Bolivar / AIMS
PMB No. 3
Townsville, Queensland, 4810
AUSTRALIA
Email: pmilos@usb.ve

Denise Smythe-Wright (IAPSO)
National Oceanography Centre
European Way
Southampton, Hampshire, SO14 3ZH
UNITED KINGDOM
Email: dsw@noc.ac.uk

John Turner (IAMAS)
British Antarctic Survey
High Cross, Madingley Road
Cambridge, CB3 0ET
UNITED KINGDOM
Email: jtu@bas.ac.uk

Co-opted Members

Colin Devey
Geomar
Wischhofstr. 1-3
Kiel, Schl.-H., 24148
GERMANY
Email : cdevey@geomar.de

Wajih A. Naqvi
National Institute of Oceanography
Rajbhavan Road, Dona Paula
Goa, 403004
INDIA
Email : naqvi@nio.org

SCOR Secretariat:

Ed Urban
SCOR Secretariat
Robinson Hall
College of Earth, Ocean, and Environment
University of Delaware
Newark, DE 19716
USA
Email: ed.urban@scor-int.org

Other Participants:

Ewa Antao
Institute of Meteorology and Water Management
ul. Waszyngtona 42
Gdynia,woj. Pomorskie, 81-342
POLAND
Email: ewa.antao@imgw.pl

Riitta M Autio
Erik Palmenin aukio 1, SYKE
Helsinki, 00560
FINLAND
Email: riitta.autio@ymparisto.fi

Harold Batchelder
PICES
9860 West Saanich Road
Sidney, BC, V8L4B2
CANADA
Email: hbatch@pices.int

Elisa Berdalet
Institut de Ciències del Mar (ICM-CSIC)
Passeig Marítim de la Barceloneta, 37-49
Barcelona, Catalonia 08003
SPAIN
Email: berdalet@icm.csic.es

Agnieszka Beszczynska-Moeller
Institute of Oceanology PAS
Powstancow Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: abesz@iopan.gda.pl

Katarzyna Blachowiak-Samolyk
Instytut Oceanologii Polskiej Akademii Nauk
Powstańców Warszawy 55
Sopot, Pomerania, 81-712
POLAND
Email: kasiab@iopan.gda.pl

Antonio Caltabiano
International CLIVAR Project Office
30 Willow Gardens
North Baddesley
Southampton, Hampshire, SO52 9FY
UNITED KINGDOM
Email: nico.caltabiano@clivar.org

Marta Cegłowska
University of Gdańsk
Al. Wojska Polskiego 39/24
Gdańsk, Pomorskie, 80-268
POLAND
Email: ma.ceglowska@gmail.com

Aleksandra Czajkowska
Institute of Oceanology
Polish Academy of Sciences
Powstańców Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: office@iopan.gda.pl

Jerzy Dera
Polish Academy of Sciences
ul. Powstańców Warszawy 55
Sopot,Woj. Pomorskie, 81-712
POLAND
Email: dera@iopan.gda.pl

Marta Gluchowska
Institute of Oceanology
Polish Academy of Sciences
Powstancow Warszawy 55
Sopot, 81-712
POLAND
Email: mgluchowska@iopan.gda.pl

Annalisa Griffa (NM)
CNR Consiglio Nazionale Ricerche
Forte S. teresa, Pozzuolo di Lerici
La Spezia, Liguria, 19032
ITALY
Email: annalisa.griffa@sp.ismar.cnr.it

David Halpern (NM)
Jet Propulsion Laboratory
4600 Oak Grove Drive
MS 183-501
Pasadena, CA 91109
USA
Email: david.halpern@jpl.nasa.gov

Venugopalan Ittekkot
Chair, SCOR Committee on Capacity Building
Berner Chaussee 114
Hamburg, 22175
GERMANY
Email: ittekkot@uni-bremen.de

Monika Kedra
Institute of Oceanology
Polish Academy of Sciences
Powstancow Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: kedra@iopan.gda.pl/

Ryszard Kotlinski
University of Szczecin
ul. Mickiewicza 16a
Szczecin, Zachodniopomorskie, 70383
POLAND
Email: ryszard.kotlinski@univ.szczecin.pl

Alicja Kosakowska
Institute of Oceanology
Polish Academy of Sciences
ul. Powstańców Warszawy 55
Sopot, 81-712
POLAND
Email: akosak@iopam.gda.pl

Andrey Kostianoy (NM)
P.P. Shirshov Institute of Oceanology
Institute of Oceanology
36 Nakhimovsky Prospekt
Moscow, 117997
RUSSIA
Email: kostianoy@gmail.com

Piotr Kowalczuk
Institute of Oceanology
Polish Academy of Sciences
Powstańców Warszawy 55
Sopot, Województwo Pomorskie, PL-81-712
POLAND
Email: piotr@iopan.gda.pl

Michael Lucas (NM)
University of Cape Town
21 Van Hoogstraten Street
Penzance Estate
Hout Bay,Western Cape, 7806
SOUTH AFRICA
Email: mikelucasuct@gmail.com

Hanna Mazur-Marzec
University of Gdañsk
Marszalka Pilsudskiego 46
Gdynia, Pomorskie, Poland, 81378
POLAND
Email: biohm@ug.edu.pl

Paul Myers (NM)
University of Alberta
Dept. of Earth and Atmospheric Sciences, 1-26
Edmonton, Alberta, T6G 2E3
CANADA
Email: pmyers@ualberta.ca

Miroslawa Ostrowska
Institute of Oceanology
Polish Academy of Sciences
ul. Powstañców Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: ostra@iopan.gda.pl

Ksenia Pazdro
Institute of Oceanology
Polish Academy of Sciences
Powstańców Warszawy 55
Sopot, Pomorskie Voivodeship, 81-712
POLAND
Email: pazdro@iopan.gda.pl

Tomasz Petelski
Institute of Oceanology
Polish Academy of Sciences
Powstancow Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: petelski@iopan.gda.pl

Janusz Pempkowiak
Director General
Institute of Oceanology
ul.Pow.Warszawy 55
Sopot, woj.Pomorskie, 81712
POLAND
Email: pempa@iopan.gda.pl

Erik Pihl
Future Earth
Stangholmsbacken 46
Skarholmen, Stockholm, 12740
SWEDEN
Email: erik.pihl@futureearth.org

Joanna Potrykus
Institute of Oceanology
Polish Academy of Sciences
ul. Powstańców Warszawy 55
Sopot, 81-712
POLAND
Email: potrykus@iopan.gda.pl

Teresa Radziejewska
University of Szczecin
ul. Mickiewicza 16a
Szczecin, Zachodniopomorskie, 70-383
POLAND
Email: tera@univ.szczecin.pl

Johan Rodhe (NM)
Univ. of Gothenburg
Villabrovagen 11
Styrso, Vastra gotaland, 430 84
SWEDEN
Email: johan.rodhe@gu.se

Sabine Schmidt (NM)
Université de Bordeaux (NB18) Avenue de Geoffroy
St Hilaire CS 50023
Pessac, Aquitaine, 33615
FRANCE
Email: sabine.schmidt@u-bordeaux.fr

Marie-Alexandrine Sicre (NM)
CNRS
UPMC, 4 place jussieu, Case 100
Paris, 75252
FRANCE
Email: malslod@locean-ipsl.upmc.fr

Adam Sokolowski
University of Gdansk
Al. Pilsudskiego 46
Gdynia, pomorskie, 81-378
POLAND
Email: oceas@univ.gda.pl

Joanna Stoń-Egiert
IO PAS
Powstańców Warszawy 55
Sopot, 81-712
POLAND
Email: aston@iopan.gda.pl

Waldemar Surosz
Institute of Oceanography
University of Gdansk
Al. Pilsudskiego 46
Gdynia, pomorskie, 81-378
POLAND
Email: waldemar.surosz@ug.edu.pl

Marta Szubska
Institute of Oceanology
Polish Academy of Science
Powstancow Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: szubi@iopan.gda.pl

Maciej Telszewski
IOCCP
ul. Powstancow Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: m.telszewski@ioccp.org

John K Volkman (NM)
CSIRO
GPO Box 1538
Hobart, Tasmania, 7005
AUSTRALIA
Email: johnkvolkman@gmail.com

Anna K. Wåhlin
University of Gothenburg
PB 405
Göteborg, Göteborg, 40130
SWEDEN
Email: anna@gu.se

Waldemar Walczowski
Institute of Oceanology PAN
Powstancow Warszawy 55
Sopot, Pomerania, 81-712
POLAND
Email: walczows@iopan.gda.pl

Jan-Marcin Węsławski (NM)
Institute of Oceanology PAS
Powstancowe Warszawy 55
Sopot, Pomerania, 81-712
POLAND
Email: weslaw@iopan.gda.pl

Malgorzata Witak
University of Gdańsk
Institute of Oceanography
al. Piłsudskiego 46
Gdynia, Pomorskie, 81-378
POLAND
Email: malgorzata.witak@ug.edu.pl

Toshio Yamagata (NM)
Japan Agency for Marine-Earth Science and Technology
3173-25 Showa-machi, kanazawa-ku
Yokohama, Kanagawa, 236-0001
JAPAN
Email: yamagata@jamstec.go.jp

Sinjae Yoo (NM)
KIOST
2670, Iljudong-ro
Gujwa-eup
Jeju-si, Jeju-do, 63349
SOUTH KOREA
Email: sinjae.yoo@gmail.com

Jing Zhang (NM)
University of Toyama
3190 Gofuku
Toyama, 9308555
JAPAN
Email: jzhang@sci.u-toyama.ac.jp

Rui Zheng
State Oceanic Administration
No. 1 Fuxingmenwai Ave.
Beijing, 100860
People's Republic of China
Email: zhengrui047@163.com

Tymon P. Zielinski
IOPAN
Powstancow Warszawy 55
Sopot, Pomorskie, 81-712
POLAND
Email: tymon@iopan.gda.pl

NM = Nominated Member

Appendix 2
Special Session on Polish Marine Science

Institute of Oceanology PAN, Sopot, 5th Sept. 2016, 14.00-17.45

Session schedule

14.00-14.15 W. Surosz (Gdańsk University)
Polish marine research capacity mapping

14.15-14.30 R. Kotliński (Szczecin University)
Geology of the Clarion Clipperton Fracture Zone in the Pacific

14.30-14.45 T. Radziejewska, B. Wawrzyniak-Wydrowska (Szczecin University)
Research on benthic communities in a Pacific deep-sea area targeted for mineral resource development

14.45-15.00 P. Kowalczuk (Institute of Oceanology PAN)
CDOM distribution as derived from Atlantic Meridional Transect cruises

15.00-15.15 K. Blachowiak-Samolyk et al. (Institute of Oceanology PAN)
Exploration of bathymetric and latitudinal distribution patterns of pelagic ostracods in Atlantic Ocean

15.15-15.30 W. Walczowski, A. Beszczyńska (Institute of Oceanology PAN)
Large-scale oceanographic observations in the subpolar North Atlantic and Nordic Seas

15.30–16.00 Coffee

16.00-16.15 M. Głuchowska et al. (Institute of Oceanology PAN)
Spatial and inter-annual zooplankton variability within Atlantic water flow to the Arctic

16.15-16.30 M. Węsławski (Institute of Oceanology PAN)
Recent change in Arctic fjords ecosystem function

16.30-16.45 T. Zieliński, T. Petelski (Institute of Oceanology PAN)
Polish Activities within the SOLAS Initiative

16.45-17.00 H. Mazur-Marzec (Gdańsk University)
Linkage between Harmful Algal Blooms and other environmental problems

17.00-17.15 A. Sokołowski (Gdańsk University)
Current issues in the Baltic biological research

17.15-17.30 M. Witak (Gdańsk University)
Polish experience in marine geology

17.30-17.45 M. Ostrowska (Institute of Oceanology PAN)
Physical and chemical investigations in the Baltic

APPENDIX 3
Agenda

1.0 OPENING

1.1 Opening Remarks and Administrative Arrangements	*Pempkowiak, Burkill, Urban*
1.2 Approval of the Agenda	*Burkill*
1.3 Report of the President of SCOR	*Burkill*
1.4 Report of SCOR Executive Director	*Urban*
1.5 Appointment of an *ad hoc* Finance Committee	*Burkill*
1.6 2016 Elections for SCOR Officers	*Fennel*

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	*Smythe-Wright*
2.1.2	SCOR/IGBP WG 138: Modern Planktic Foraminifera and Ocean Changes	*Brussaard*
2.1.3	WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean	*Naqvi*
2.1.4	WG 140: Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII)	*Shapovalov*
2.1.5	WG 141 on Sea-Surface Microlayers	*Burkill*
2.1.6	WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders	*Burkill*
2.1.7	WG 143 on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4	*Turner*
2.1.8	WG 144 on Microbial Community Responses to Ocean Deoxygenation,	*Urban*
2.1.9	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	*Naqvi*
2.1.10	WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5)	*Smythe-Wright*
2.1.11	WG 147: Towards comparability of global oceanic nutrient data (COMPONUT)	*Naqvi*
2.1.12	WG 148 on International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)	*Wainer*
2.1.13	WG 149 on Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?	*Miloslavich*
2.1.14	WG 150 on Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)	*Fennel*

2.2 Working Group Proposals

2.2.1 Atmosphere-waves-current interactions and oceanic extremes (EXTREMES) *Shapovalov*

2.2.2 Climate-Change Impacts of Ocean Carbon Chemistry/Synergism with Other Stressors: How can Seamount Deep-Sea Coral Ecosystems respond to ASH/CSH Shoaling/Ocean Acidification? (IBDIOCC) *Smythe-Wright*

2.2.3 Iron Model Intercomparison Project (FeMIP) *Devey*

2.2.4 Measuring Essential Climate Variables in Sea Ice (ECV-Ice) *Turner*

2.2.5 Building a coral reef marine biodiversity observation network (CoralMBON) *Miloslavich*

2.2.6 Global Assessment of Nutrient Export Through Submarine Groundwater Discharge (NExT SGD) *Naqvi*

2.2.7 The dynamic ecogeomorphic evolution of mangrove and salt marsh coastlines (DEMASCO) *Miloslavich*

2.2.8 Towards strategic observatories for regional ocean-atmosphere interactions in the Eastern Boundary Upwelling Systems (cOCtEAU) *Wainer*

2.2.9 Towards the science-based jellyfish observing system (JOS) *Sun*

2.2.10 Eastern Boundary Upwelling Ecosystems (EBUE): inter-comparisons, variability and forecasting responses to climate and global change *Fennel*

2.2.11 Carbon Hot Spot: Drivers and Sensitivities of Large Carbon Uptake in Western Boundary Currents *Smythe-Wright*

3.0 LARGE-SCALE SCIENTIFIC PROGRAMS

3.1 SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research *Burkill*

3.2 GEOTRACES *Naqvi*

3.3 Surface Ocean – Lower Atmosphere Study (SOLAS) *Turner*

3.4 SCOR/POGO International Quiet Ocean Experiment (IQOE) *Urban, Shapovalov*

3.5 SCOR/IOC/IOGOOS Second International Indian Ocean Expedition (IIOE-2) *Burkill*

4.0 INFRASTRUCTURAL ACTIVITIES

4.1 IOC/SCOR International Ocean Carbon Coordination Project *Fennel*

4.2 SCAR/SCOR Southern Ocean Observing System (SOOS) *Wainer*

4.3 IAPWS/SCOR/IAPSO Joint Committee on Seawater *Smythe-Wright*

4.4 GlobalHAB *Berdalet, Sun*

4.5 Workshop on Seafloor Ecosystem Functions and their Role in Global Processes *Urban*

5.0 CAPACITY-BUILDING ACTIVITIES

5.1 SCOR Committee on Capacity Building *Ittekkot*

5.2 SCOR Visiting Scholars *Ittekkot*

5.3 POGO-SCOR Visiting Fellowships for Oceanographic Observations *Urban*

5.4 NSF Travel Support for Developing Country Scientists *Urban*

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1 Intergovernmental Oceanographic Commission (IOC) *Burkill*

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

6.3 North Pacific Marine Science Organization (PICES) *Batchelder, Sun*

7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

7.1 International Council for Science *Burkill*
- 7.1.1 World Climate Research Programme (WCRP) *Caltabiano, Fennel*
- 7.1.2 Scientific Committee on Antarctic Research (SCAR) *Brussaard*
- 7.1.3 Future Earth Initiative *Burkill*
- 7.1.4 Belmont Forum *Burkill*

7.2 Affiliated Organizations
- 7.2.1 International Association for Biological Oceanography (IABO) *Miloslavich*
- 7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS) *Turner*
- 7.2.3 International Association for the Physical Sciences of the Oceans (IAPSO) *Smythe-Wright*

7.3 Affiliated Programs
- 7.3.1 InterRidge - International, Interdisciplinary Ridge Studies *Urban*
- 7.3.2 International Ocean Colour Coordinating Group (IOCCG) *Sun Song*
- 7.3.3 Global Alliance of CPR Surveys (GACS) *Burkill*

7.4 Other Organizations
- 7.4.1 Partnership for Observation of the Global Oceans (POGO) *Shapovalov*

8.0 MEMBERSHIP AND FINANCES

8.1 Membership *Urban*
- 8.1.1 National Committees

8.2 Publications Arising from SCOR Activities *Urban*

8.3 Finances *Finance Committee, Urban*

9.0 SCOR-RELATED MEETINGS

9.1 SCOR Annual Meetings
- 9.1.1 2016 General Meeting: Sopot, Poland *Burkill*
- 9.1.2 2017 Executive Committee Meeting *Burkill*
- 9.1.3 2018 General Meeting

9.2 Locations of Past SCOR Annual Meetings

9.3 SCOR-Related Meetings Since the 2015 SCOR Executive Committee Meeting and Planned for the Future

APPENDIX 4

WG Proposal: Iron Model Intercomparison Project (FeMIP)

1. Summary

The micronutrient iron is at the heart of biological activity in the ocean, shaping marine resources and the global carbon cycle. The iron model intercomparison project (FeMIP) SCOR working group proposes to bring together a diverse set of scientists to deliver new insight into the functioning of the ocean iron cycle, using observations and, in particular, to improve its representation in ocean models. This is important, as the multi-disciplinary work we propose will improve confidence in the projections about how environmental change will affect ocean productivity in iron-limited areas and facilitate the use of numerical models to test hypotheses within a community-driven context of model skill. We aim to produce guidelines for how models can best represent the iron cycle and develop tools for objective interpretations of model skill relative to observations. The impact of underlying inter-model differences in iron cycling will be evaluated and consensus input fields will be produced. Importantly, we will also review how models can take the next important steps and represent the complexity of biological interactions within the iron cycle. A SCOR working group such as proposed here is the only practical means to achieve these important aims.

2. Background and motivation for the working group

2.1 The importance of iron models and their shortcomings

With the recognition that the availability of iron (Fe) plays a central role in shaping biological activity in the ocean [Boyd, et al., 2007; Moore, et al., 2013], most of the numerical models we rely on to test hypotheses and make projections of change now typically represent this resource explicitly. This means that, for example, the projected impact of climate change on biological activity and the carbon cycle in iron-limited regions (e.g. [Bopp, et al., 2013; Cabré, et al., 2014]) can be strongly controlled by how a given model represents the iron cycle [Tagliabue, et al., 2016]. Moreover, due to the central role played by Fe, it is invoked as a potential driver of past changes to the global carbon cycle [Martinez-Garcia, et al., 2014] and as a regulator of both phytoplankton diversity [Ward, et al., 2013] and nitrogen cycling [Monteiro, et al., 2011]. These multi-faceted roles for iron in regulating important components of the coupled ocean-terrestrial-atmosphere system requires that we have good quantitative constraints on its cycling in the ocean, which will raise confidence in the conclusions drawn from numerical models.

Traditionally, numerical model skill is evaluated against global gridded climatologies such as those produced for temperature, salinity, nitrate, phosphate, silicic acid and oxygen by the World Ocean Atlas [Levitus, et al., 2013]. These climatologies can be statistically compared against model outputs to assess model skill and used as initial conditions for model simulations. This process thus provides confidence in the rigour of a given model in reproducing these aspects of the ocean environment. However, despite the importance of Fe to ocean processes, a lack of widespread iron data (in both space and time) has hampered similar efforts to evaluate the skill of iron modelling. Fortunately, there has been a large increase in the availability of Fe measurements over recent years thanks to the GEOTRACES programme [Anderson and Henderson, 2005]. This international effort has begun producing full ocean section distributions for trace elements (including Fe) on a systematic basis and publicly releasing data [Mawji, et al., 2015]. However, the community is still faced with a relatively sparse Fe dataset, relative to those available for the major nutrients. This not only hampers skill assessment, but also in a lack of consensus on appropriate initialisation fields for iron: a crucial component of model results, as seen for the major nutrients.

In response to the greater availability of data, members of this working group initiated a first intercomparison of global iron models with available data [Tagliabue, et al., 2016]. Two important results emerged from this effort: (i) there is a wide variety of residence times for Fe across contemporary models (from 5 to 500 years), with important implications for the sensitivity of the modelled iron cycle to perturbations; and (ii) most models failed to reproduce the broad aspects of the observed Fe distributions, raising concern about the confidence we may have in our iron models and their implications for climate projections. Models that reflected emerging constraints from field observations and process studies often performed better in certain regards, but a given model's complexity was not necessarily the first-order driver of model skill [Tagliabue, et al., 2016].

A stark example of the challenge in modelling Fe comes from the meridional section along the western half of the Atlantic Ocean basin, where the clear water mass structures evident in the distributions of nitrate and phosphate are absent in the iron distribution [Rijkenberg, et al., 2014]. This highlights the unique nature of the ocean iron cycle. Allied to this, the sparse nature of iron data requires us to develop suitable skill metrics to evaluate attempts to represent the unique features of the iron cycle in models.

2.2 The Challenge

Ultimately, improving the modelling of the ocean iron cycle will come from a better understanding of the key processes from both modelling and observations. Broad conceptual understanding is emerging regarding the importance of certain sources and the key facets of the internal cycling of iron, but we lack the quantitative insight that will yield suitable model parameterisations. For example, despite being represented as a key Fe source to the ocean since the very first models [Archer and Johnson, 2000; Parekh, et al., 2005], the amount of Fe supplied by dust deposition still varies widely among contemporary models [Tagliabue, et al., 2016]. In recent years, hydrothermal sources have been recognised as a potentially important Fe source [Klunder, et al., 2011; Nishioka, et al., 2013; Resing, et al., 2015], but are only included in two current global iron models [Tagliabue, et al., 2016]. Equally, evidence for unique aspects to Fe biological cycling and interior ocean regeneration is accumulating [Boyd, et al., 2015; Strzepek, et al., 2012; Tagliabue, et al., 2014; Twining and Baines, 2013; Twining, et al., 2014], but many models still represent these processes very simply, with close coupling to phosphorus cycling. The goal of the FeMIP working group is to assemble an iron model intercomparison project, cutting across different modelling and working closely with observational communities, to address these key challenges. The goal of FeMIP rests on the nexus between observational and modelling science and is three-fold:

(i) to provide our best understanding of how Fe should be represented in global climate models and to develop tools for consistent evaluation of model skill

(ii) to deliver the necessary combination of observation and theoretical insight to parameterise the key processes regulating internal Fe cycling

(iii) to appraise the state of the art and key outstanding gaps in our understanding in the impact of Fe on biological processes.

2.3 Why a SCOR Working Group

We have already shown willingness in the community to conduct this work via our initial intercomparison effort [Tagliabue, et al., 2016]. However to achieve further progress, there needs to be a concerted effort for dialogue between the relevant communities to help improve iron modelling. These communities are diverse and include the modellers themselves, those taking the iron observations (e.g. GEOTRACES), iron chemistry experts, experts in phytoplankton physiology and those investigating iron sources (e.g. atmospheric chemists). This FeMIP working group will assemble this diverse set of scientists to work jointly towards delivering a set of clear objectives that will have wide impact and resonance across the larger ocean and climate scientific communities, ranging from global coupled climate modellers, paleoclimatologists, and IPCC experts to microbial biologists and chemists. The multi-disciplinary and international work we propose would be impossible to support in any other way (e.g. from national or European funding).

3. Terms of reference

(Objective 1, O1) To identify best practices for minimum complexity representations of the iron cycle in models, with options given for more advanced aspects, and publish the guidance in a peer-reviewed paper.

(Objective 2, O2) To develop tools for a wide variety of platforms to validate global model results in a standardised way and make these available via a peer-reviewed publication and a website.

(Objective 3, O3) To facilitate a focussed intercomparison of iron models to constrain the impact of varying residence times and a consensus dust deposition scheme and publish the results in a peer-reviewed journal.

(Objective 4, O4) To review how to represent biological interactions in the iron cycle, the linkages to key phytoplankton species and the interactions with zooplankton and bacteria, as well as broader connections with other biogeochemical cycles and publish the results in a peer-reviewed journal.

4. Work Plan

To deliver O1 we will initially review (using expertise from the working group) the state of the different levels of ocean iron cycle complexity from current models. In parallel, we will assess the key aspects of iron cycling that are crucial for global climate models. This step will be expedited by dialogue between modellers and observationalists on the working group. We will then determine the minimum number of iron pools and the underlying processes to be included in global models. Finally, we will produce governing equations in a unified mathematic notation and default parameter values necessary for parameterisation and test these across a subset of models (e.g. using a relatively simple iron model and one of the most complex models as end members). As part of this effort, we will produce consensus initialisation fields that can be used by the global ocean modelling community. At this point, we will write a peer-reviewed paper in the open access journal *Geoscientific Model Development* (GMD) describing the theoretical underpinning and practical implementation of our recommended minimum complexity iron scheme and initial conditions. Options for the representation of more advanced processes will be included as optional.

To deliver O2 we will review the main computing platforms (e.g., R, Matlab, Ferret and Python) to perform analyses of model skill and identify a platform leader from amongst the working group membership to lead the development of the skill scripts. We will then agree on a common set of model skill metrics and diagnostic plots required to evaluate model performance, as well as a reference iron database from the observations. Each platform leader will be responsible for writing the code, which will be tested against a common model from the initial FeMIP work. An important part of Objective 2 will be the maintenance of 'consensus values' from users to have a community benchmark for contemporary model skill (mean or median, with associated error). This mirrors the efforts made in the observational community with the "SAFe" [Johnson, et al., 2007] trace metal reference samples. A short tutorial to demonstrate how these tools are used will be produced.

To deliver O3 we will first assign two champions to steer this intercomparison work and identify the participants available to conduct additional model experiments, with the aim to encompass a range of residence times. We will choose a series of reference dust deposition schemes and participants will conduct parallel experiments to assess model sensitivity. Linking to Associate Member expertise on these issues will be crucial. A further set of idealised perturbation experiments across the range of models will assess the impact of different underlying residence times to the biogeochemical response on different space and time scales.

Delivering O4 requires reaching out across the full scope of expertise we have assembled from Full and Associate members. We have a broad suite of observational experts who will review key aspects of the biological cycling of Fe: bioavailability, phytoplankton Fe uptake, different iron requirements among diverse phytoplankton species, zooplankton and bacterial recycling and linkages to other biogeochemical cycles (e.g. carbon cycling, nitrogen fixation, silica cycling, food web structure). In detailed dialogue between modellers, experimentalists and observationlists, we will then identify the key phenomena that need to be represented and review how they may be parameterised in models. This will proceed via simplified model experiments at reduced dimensions (e.g. 1-dimensional models) that will made available to the community for further testing with future observational information and may ultimately be used in global scale models.

We plan to hold four annual working group meetings by stretching the funding available from SCOR and other sources, by meeting in conjunction with other related meetings to minimize airfare costs.

Month 1: Kick off meeting. This will focus on planning, with emphasis on O1 and O2, but with reference to O3 and O4. Key champions will be tasked for O1 and O2 and sub-groups will be assembled. We will assign a writing team for the short *Eos* article (Deliverable 1).

Months 1-12: Work on O1 and O2, submit and publish *Eos* article announcing working group.

Month 12: 2nd working group meeting timed to coincide with Ocean Sciences or similar conference. Results from work on O1 and O2 will be presented and reviewed by the group. Work will begin on planning O3. While it is anticipated that O1 will require feedback and continued work, it is planned that O2 will be completed and we will discuss and decide how to publicise the results. At this meeting we will begin discussing work for O4 via presentations on the current state of the art in ocean models and, importantly, emerging paradigms from observational and experimental studies.

Months 12-24: Continued work on O1 and work on O3. Publicise results of O2 via peer-reviewed paper or website (as decided at 2nd working group meeting).

Month 24: 3rd working group meeting. Finalise results of O1 and decide on dissemination strategy. Further discussion of the key processes needed for O4, emphasising the identification of well described phenomena from observations. Sub-group assembled to lead write up key phenomena for O4.

Months 24-36: Continued work on O3 and work on O4.

Month 36: 4th working group meeting. Presentation of results from O3 and writing of peer-reviewed paper. Review of potential means to represent key phenomena identified for O4 in global ocean models.

Months 36-48: Finalising and submitting peer-reviewed paper for O3. Continued work on O4, finalising and submitting paper.

Month 48: Final symposium – we will seek co-sponsors for this workshop, including GEOTRACES, the Ocean Carbon and Biogeochemistry programme (USA), the marine biogeochemistry forum of the Challenger Society (UK), SOLAS and IMBER, as well as others identified in due course. The aim of the symposium will be to highlight progress made in the linking observational work on the internal cycling of Fe to its representation in models. A key challenge for the symposium will be to consider how to extend theory for Fe to other important micronutrients that are at present ignored by biogeochemical models.

5. Deliverables

(1) Inform the community of this working group via a short article in *Eos* or similar publication.
(2) Produce a website to share and publicise our goals and meetings, as well as the outputs of the working group. Contributes to delivering O2.
(3) A peer-reviewed paper in GMD detailing the equations allowing the minimum level of complexity needed to capture important aspects of the iron cycle in climate models, as well as a consensus initialisation field. Delivers O1.
(4) A set of scripts for common data processing platforms, linked to a reference database that produce standardised metrics for model skill, with consensus values updated and publicised via the website. Delivers O2.
(5) A peer-reviewed paper detailing the results of the intercomparison of different dust deposition schemes and the sensitivity of models with varying residence times to fluctuations in iron supply. Delivers O3.
(6) Presentation of the O1, O2 and O3 at international ocean sciences meetings to publicise the findings and stimulate uptake and discussion. Delivers O1-3.
(7) A review article, aimed at *Nature Geoscience* or similar, detailing how to represent important biological linkages in the iron cycle and their connections to wider biogeochemical cycles. Delivers O4.
(8) Organise a co-sponsored symposium to bring observational and modelling scientists together around topic of the review article and towards extending the work done with Fe to other important micronutrients.

6. Capacity building

Numerical models provide an excellent platform for capacity building as many global model codes are open source (e.g. NEMO, MITgcm) and the major barrier to progress is often theoretical understanding rather than expensive equipment. Better dialogue between those taking the iron measurements, conducting experiments on the role of iron in the organism and the modellers is crucially important, but often hampered by lack of common language and forum for the discussions. Moreover, the area of Fe modelling would clearly benefit from a wider user base, applying a suite of theoretical approaches. However, new users are often held back due to the apparent complexity of the ocean Fe cycle. We will provide several practical contributions to aid the uptake and proliferation of biogeochemical modelling. These efforts will link strongly with the activities of the Ocean Model Intercomparison Project as part of the World Climate Research Programme efforts (see Sec 9.2) and will maximise the inclusion of Fe within these 'IPCC-class' models.

Our vision is to open up better dialogue between modellers and observationalists/experimentalists by bringing together these groups in focused forum (this proposed working group). We also envision increasing access to Fe modelling to a wider user base through the activities of this working group. Four practical steps will achieve this. First, the wide distribution of a recommended minimum complexity set of equations and parameters for the modelling of Fe biogeochemistry via Objective 1 will provide a simple means for new users to include Fe cycling in their models to facilitate further development. Moreover, as we will provide options for including more advanced aspects that are linked

to working group members there will be clear opportunity for mentorship in further developing understanding. Second, the suite of model skill evaluation scripts and datasets that we will distribute via Objective 2 will facilitate the entry of new ways of modelling Fe cycling by providing a community accepted means of benchmarking model skill. It is anticipated that this will work in a similar way to consensus values for Fe samples that have facilitated new laboratories joining international efforts. We will prepare a short web based video to explain how our model skill scripts should be used. Third, our website and publication efforts will focus effort on understanding the ocean iron cycle, from both modelling and observational standpoints. Finally, we will conduct two training days at the final symposium aimed at training advanced level graduate students that are already working on ocean modelling in use of our recommended iron cycle model and evaluation scripts. Overall, these activities will maximise the building of long lasting global capacity within this important topic.

7. Composition of Working Group

FeMIP has 10 Full and 10 Associate members that bring together state-of-the-art skills in iron cycling modelling, biogeochemical modelling, model skill evaluation and coupled climate modelling, as well as experimental work that will inform on key requirements and future developments. The Full Members are responsible for the delivery of our objectives, while the Associate Members provide important input from the complimentary fields (e.g iron observation, biological cycling, dust deposition) and additional modelling platforms (e.g. intermediate complexity models). Our Full members represent 7 different nations, including 2 emerging/developing nations (South Africa and Turkey). Moreover, we include a number of early career researchers as Full members, which will aid their career development [Urban and Boscolo, 2013].

7.1 Full Members:

Name	Gender	Place of Work	Expertise
Alessandro Tagliabue (co-chair)	M	University of Liverpool United Kingdom	Global iron and biogeochemical modelling
Stephanie Dutkiewicz (co-chair)	F	MIT USA	Ecosystem and biogeochemical modelling
Olivier Aumont	M	IRD/LOCEAN France	Global iron and biogeochemical modelling
Tatiana Ilyina	F	Max Planck Institute for Meteorology Germany	Global biogeochemical and coupled climate modelling
Fanny Monteiro	F	University of Bristol United Kingdom	Modelling links between biogeochemistry, biology and climate
J. Keith Moore	M	UC Irvine USA	Global iron and coupled climate modelling
Yeala Shaked	F	IUI – Eilat Israel	Iron biouptake and bioavailability
Marcello Vichi	M	University of Cape Town South Africa	Global biogeochemical and coupled climate modelling
Christoph Völker	M	Alfred Wegener Institute Germany	Global iron modelling
Mustafa Yücel	M	Middle East Technical University, Turkey	Iron observation

7.2 Associate Members:

Name	Gender	Place of Work	Expertise
Alex Baker	M	University of East Anglia, United Kingdom	Dust supply of iron
Philip Boyd	M	University of Tasmania Australia	Coupled biological and chemical iron cycling
Peter Croot	M	Galway University Ireland	Iron speciation and chemical cycling
Christel Hassler	F	University of Geneva Switzerland	Cycling of iron binding ligands
Jun Nishioka	M	Hokkaido University Japan	Iron distributions in the Pacific and Indian Oceans and colloidal iron cycling
Maite Maldonado	F	University of British Columbia, Canada	Biological iron cycling through the food web
Kazuhiro Misumi	M	CRIEPI Japan	Iron cycling in global models, working on aggregation dynamics
Mark Moore	M	University of Southampton United Kingdom	Biological iron limitation and requirements
Andy Ridgwell	M	UC Riverside USA	Earth system models of intermediate complexity
Benjamin Twining	M	Bigelow USA	Determinations of phytoplankton and zooplankton iron demand

8. Working group contributions

Alessandro Tagliabue is involved in the development of the PISCES model iron component, initiated the FeMIP process and has strong links into the GEOTRACES community via membership of their steering committee and co-chair of Data Management Committee.

Stephanie Dutkiewicz maintains the biogeochemical – biological component of the MIT DARWIN project model (including iron cycling), with a particular focus on diversity of phytoplankton resource requirements.

Olivier Aumont develops and maintains the iron and ocean biogeochemical components of the PISCES model.

Tatiana Ilyina is a climate modeller (MPI) and represents the needs of this community as end users of the working group's outputs.

Fanny Monteiro is a modeller working on the nexus between biogeochemical cycling, biological activity, and past and future climate (e.g. the role of iron dust deposition on nitrogen cycling).

J. Keith Moore develops and maintains the iron and ocean biogeochemical components of the BEC model, with a particular focus on dust iron input.

Yeala Shaked has a long track record in observing and modelling iron bioavailability and biouptake.

Marcello Vichi develops and maintains the iron and ocean biogeochemical components of the BFM model.

Christoph Völker develops and maintains the iron and ocean biogeochemical components of the RECoM model.

Mustafa Yücel is an expert in the speciation of iron, especially nanoparticulate forms that are thought to dominate supply from dust and hydrothermal vent systems

9. Relationship to other programmes and SCOR working groups

9.1 Other SCOR Working Groups

The activities of SCOR Working Group 139 on organic ligands and in particular the development of ligand datasets and model closures, as well as SCOR/InterRidge Working Group 135 on hydrothermal energy transfer, which provided inputs on hydrothermal iron plumes, will be of benefit to our group (Objective 1). Our working group will interface well with current SCOR Working Group 145 on chemical speciation, with the potential to provide a platform for the wide testing of their chemical speciation models for iron through a range of model platforms. SCOR Working Group 149 is concerned with the responses of ocean biota to environmental change and will ultimately benefit from new models of biological Fe cycling (Objective 4) to assess future projections.

9.2 Ocean Model Intercomparison Project (OMIP) and World Climate Research Programme (WCRP)

The OMIP is an international effort aimed at intercomparing global biogeochemical models that are used in the next IPCC set of simulations as part of the WCRP. We will benefit the activities of OMIP by producing consensus recommendations for model parameterisations, spin up times and initial conditions for Fe (Objective 1). Moreover, our set of skill metrics (Objective 2) will be invaluable of model appraisal. Ultimately, our deliverables as part of Objectives 1 and 2 will facilitate the representation of Fe within a wider set of IPCC global coupled climate models, enhancing confidence in their projections. For example, at present, no consensus exists within OMIP on iron input fields or initial conditions.

9.3 GEOTRACES

Our work is closely linked to that of the GEOTRACES programme. We will make use of their datasets to deliver Objective 2, facilitated by Tagliabue acting as co-chair of their Data Management Committee. Moreover, our activities within Objective 4 will link strongly to ongoing 'bioGEOTRACES' efforts. We anticipate GEOTRACES being invited to co-sponsor our final workshop.

9.4 SOLAS and IMBER

Both the SOLAS and IMBER programme will benefit from our work. For example, Objective 3 is aimed at constrained iron deposition from dust, which is a key SOLAS aim. Equally, efforts to improve the representation of Fe cycling by the biological community links strongly to the objectives of the IMBER programme. We anticipate both SOLAS and IMBER being invited to co- sponsor our final workshop.

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APPENDIX 5

Proposal for a Working Group on Measuring Essential Climate Variables in Sea Ice (ECVice)

Summary/Abstract
Observations over recent decades suggest that sea ice plays a significant role in global biogeochemical cycles, providing an active biogeochemical interface at the ocean-atmosphere boundary. However, a pressing need exists to perform methodological intercalibration experiments in sea ice in order to obtain reliable measurements of basic biogeochemical properties [e.g., Arrigo et al., 2010; Miller et al., 2015], including many of the Essential Climate Variables of the Global Climate Observing System. With newly emerging techniques, and pressed by the rapid changes in sea ice, the time has come to evaluate and improve our approach to studying sea-ice systems. An international working group is required to synthesize past intercalibration exercises and to design and coordinate new experiments. Our ultimate goal is to provide the international community with standardized protocols for processing sea-ice samples and collecting data for key variables, including partial pressure of CO_2, nutrients, algal biomass and production, and gas exchange. We will also establish the effectiveness of new techniques to deal with the great heterogeneity (often referred to as "patchiness") found in sea ice. These tasks will directly serve a long-term community goal of understanding variations in polar marine environments severely affected by ongoing global change.

Scientific Background and Rationale
Sea ice is one of the largest and most dynamic ecosystems on Earth, covering ~10% of the ocean and harboring, in some locations, standing crops similar to productive oceanic regions. In addition to affecting climate through physical processes, sea ice plays a significant but still poorly understood role in the biogeochemical dynamics of the polar oceans [Vancoppenolle et al., 2013]. For example, sea ice contributes up to 60% of the primary production in some parts of the Arctic Ocean [Fernandez-Méndez et al., 2015] and 50% of the CO_2 uptake south of 50°S [Delille et al., 2014]. The algae communities that grow within and on the bottom of sea ice are a fundamental contributor of halogens and aerosols to the polar atmosphere [Abbatt et al., 2012], and the role of sea-ice brine rejection in the global overturning circulation spreads the impact of sea-ice biogeochemical processes throughout the world ocean.

The Global Climate Observing System (GCOS) program has developed a list of essential climate variables (ECVs) and called for systematic observations of these critical variables, in order to support assessment of climate changes. The ECVs have been identified based on relevance for characterizing the climate system and its changes, while maintaining feasibility and cost effectiveness. In the ocean domain the ECVs are: temperature, salinity, sea level, sea state, sea-ice concentration, currents, ocean color, carbon dioxide partial pressure, ocean acidity, nutrients, oxygen, phytoplankton, and tracers. However, GCOS has not been able to provide adequate guidelines for measuring the ECVs in sea ice, a gap this working group will address for a number of variables.

Analyzing biogeochemical properties in sea ice is fundamentally complicated by its inherent heterogeneity and multiphase nature (composed of solid ice, brines, gas bubbles, solid mineral salts, and organic matter), which also introduce difficulties in performing biochemical incubations (which require that the sea ice be homogenized and melted), and thorough evaluations of the various methods used to study sea ice are crucially needed [Miller et al., 2015]. Sea ice is a semisolid matrix permeated by a network of channels and pores, strongly responding to variations in temperature [Golden et al., 2007]. The brine-filled spaces are colonized by sympagic (ice-associated) communities that are both taxonomically diverse and metabolically active [Arrigo et al., 2010], with multiple trophic levels, efficiently consuming, reprocessing, and redistributing chemicals within the ice and exchanging with both the overlying atmosphere and the underlying ocean. Sympagic microbial adaptations involve changes in intracellular processes, but also in extracellular controls, in particular the secretion of extracellular polymeric substances, which modify how the microbial community functions (i.e., by introducing biofilms) and the physical-chemical properties of the ice [Krembs et al., 2011; Ewert and Deming, 2013]. Traditionally, sea-ice ecological studies have been based on methods and concepts from planktonic research. However, in terms of organism

distributions, fluid (and nutrient) transport, and predator-prey interactions, the seawater model is less useful than, perhaps, soils or sediments for conceptualizing the sympagic community.

Sea-ice physical, chemical, and biological properties are also extremely variable, both temporally and spatially. Spatial and temporal changes in physical properties are among the largest observed in the oceans, with temperature varying by up to 40 °C over a meter and brine salinity varying by as much as 200 over centimeters. Biomass can vary by an order of magnitude on the sub-meter scale [Eicken et al., 1991], making it difficult to (i) acquire representative measurements or (ii) compare parallel analyses on adjacent cores. In addition, because sea-ice structure is so strongly dependent on temperature, both physical and chemical properties of the ice are easily altered upon sampling or even upon deployment of in-situ sensors (which affect the energy balance).

Numerous approaches have been developed to address these concerns, and there is now a need to rigorously compare them and develop standardized protocols for assessing biological and biogeochemical parameters in sea ice. The following issues are of particularly high priority:

- *Storage of sea-ice samples* can affect measurements in ways that are still difficult to predict. Not only do melting (or even just warming) and refreezing after sampling change the samples, possibly irreversibly (i.e., brine loss, chemical speciation, mineral stability), but bacterial activity has been recorded in intact cores stored in the dark at temperatures below -20°C months after sampling [S. Becquevort, unpublished results]. Instability of the samples affects both biological properties and abiotic compounds.
- *Processing of sea-ice samples* often involves melting them, but many analytes, organisms, and processes are strongly affected by the drastic changes in temperature and salinity that results when sea ice melts [Miller et al., 2015], and quantification of those impacts has been elusive. For example, early studies showed that the drop in salinity with melting can cause losses of 13 to 97% of eukaryotic cells [Garrison and Buck, 1986], but other studies have found no such impact [Rintala et al., 2014].
- *Assessing sea-ice patchiness* and recovering representative data by traditional methods is labour intensive and confined to relatively small areas [e.g., Miller et al., 2015], as well as largely excluding thicker and highly deformed ice categories [Williams et al., 2015]. New methods using remotely operated vehicles and non-invasive equipment [Külh et al., 2001; Mundy et al., 2007] need to be directly compared with traditional transect and nested sampling techniques.
- *Sea-ice primary production measurements* are scarce, span three orders of magnitude, and have used numerous, distinctively different methods ranging from in-situ sensors to in-vitro isotope labeling studies [e.g., Arrigo et al., 2010; Fernandez-Méndez et al., 2015], for which largely varying results are reported. In addition, preliminary comparisons between incubation protocols (i.e., using melted, crushed, or intact ice sections) for determining metabolic rates in sea-ice communities have identified large differences between treatments [A. Roukaerts, unpublished results]. Additional data need to be collected to evaluate the relative ability of these approaches to estimate sea ice primary productivity.
- *Gas flux measurements over sea ice* using chamber and eddy covariance techniques give results that differ by up to an order of magnitude. In addition to the different spatial scales of the two methods [Nomura et al, 2013], specific technical limitations of both methods impact the measurements [Miller et al., 2015]. These methodological gaps are still not yet fully understood.
- *Measurements of CO_2 partial pressure* in sea ice also use a number of different techniques that give different results [e.g., Miller et al., 2011; Brown et al., 2015], with implications for predictions of carbon release to either the atmosphere or the underlying water. Unlike more inert gases, CO_2 undergoes complex chemistry within ice brines, hydrating to form dissolved carbonate species and precipitating carbonate minerals, and different methods respond differently to that chemistry.

These problems must be solved jointly at the international level, by bringing together sea-ice specialists in these analytical fields to synthesize existing information and determine the best ways to evaluate the differences. Individual, small initiatives are not sufficient to effectively test and evaluate the methods in question, as experts in each of the techniques need to be involved. In addition, the high financial and logistical costs of working in the sea-ice environment requires extensive collaboration. By working together, we will thus be able to deliver to the international community standardized protocols for some of the basic biogeochemical parameters in sea ice.

Terms of Reference

The proposed working group will gather international experts on chemical and biological measurements in sea ice to design and coordinate the required intercomparison and intercalibration experiments. The group will synthesize the results of past experiments, identify what type of new experiments are needed, and support the community in executing those experiments.

- **Publish synthetic reviews compiled from measurements demonstrating large, unresolved discrepancies.** These detailed reviews will draw on both the literature and unpublished studies to evaluate the strengths and weaknesses related to each methodology.
- **Design and coordinate intercalibration experiments to evaluate different methods for key parameters.** In addition to organizing field experiments, we will pursue use of ice tank facilities and stimulate and support applications for funding, at both national and international levels, to further facilite the experiments.
- Design intercomparison studies to facilitate validation and adoption of new technologies for assessing the complexity and heterogeneity of sea ice at various spatial and temporal scales.
- **Create a guide of best practices for biological and biogeochemical studies in the sea-ice environment.** This will be accomplished using a web-based forum for compiling and disseminating the outcomes of past and new intercomparison studies.

Working plan

A representative panel of the international community studying sea-ice biogeochemistry will gather at annual meetings to discuss methodological discrepancies, determine priorities for new intercomparison experiments, and develop funding applications. As further detailed below, the primary tasks will be to (i) synthesize available intercalibration experiments, (ii) to design and coordinate intercalibration experiments, and (iii) develop standardized protocols for biogeochemical studies in sea ice. Some of these meetings will be held in conjunction with other conferences, such as the annual meetings of BEPSII (Biogeochemical Exchange Processes at the Sea-Ice Interfaces; a newly designated SOLAS-CliC (Surface Ocean-Lower Atmosphere Study; Climate and Cryosphere)) consortium or sea-ice summer schools.

Task 1: Synthesize current knowledge of discrepancies between methods (years 1-2)

Both published and unpublished studies report large discrepancies between methodologies, especially around protocols for melting ice samples, determining primary production, and measuring gas exchanges. In addition to collating available information from the literature and recent, unpublished experiments, we will attempt to develop mechanistic understandings of the observed discrepancies. The following subjects are our priorities:

- Ice storage and processing (i.e., melting protocols) for basic biogeochemical parameters: biomass, nutrients, microbial community, organic matter, carbonate chemistry, gas concentrations, and primary production.
- Gas exchanges: gas-flux chambers vs. eddy covariance methods.
- Primary Production: a comprehensive critical analysis of the perceived strengths and weaknesses of the methods used to date.

These syntheses will allow us to define the needs for further intercalibration experiments, to test and validate our concepts and assumptions about the methods.

Task 2: Design and coordinate intercalibration excercises (years 1-4)

We will design specific intercalibration experiments to produce funding applications at both national and international levels for intercalibration experiments in readily accessible sea-ice locations (Cambridge Bay, Canada (lead B.T. Else); Tvärminne zoological station, Finland (lead J.-M. Rintala); and Saroma-Ko lagoon, Japan (lead D. Nomura)), as well as joint experiments at the ASIBIA (Atmosphere-Sea-Ice-Biogeochemistry in the Arctic) mesoscale chamber facility at the University of East Anglia (lead J. France). Our initial priorities will be:

- Comparison of storage conditions and the processing of sea ice for accurate determination of basic biological and biogeochemical parameters.
- Comparison of the available methods (including emerging techniques) to assess primary production in

sea ice: isotopic tracer incubations, O_2 fluxes by under-ice microelectrodes and eddy covariance, O_2:Ar budgets, and biomass accumulation. We will also assess the most suitable tracer incubation protocols for general metabolic rate determinations in sea ice (e.g., bacterial production, nutrient transformations). That is, how to collect a representative in-situ sea-ice microbial community and to ensure tracer homogenization within the brine network prior incubation.

- Comparison of the available methods for determining pCO_2 in sea ice. Preliminary experiments comparing results from in-situ silicone chambers, solid-headspace equilibration, and calculations based on analyses of brines and melts could be conducted under controlled laboratory conditions. However, complex, high-molecular weight organic matter, as well as precipitated carbonate minerals, likely impact measurements of pCO_2 in natural sea ice, and therefore, parallel intercalibration experiments will also be required at one or more of the field sites.

We hope to organize our third meeting in conjunction with an intercalibration excercise. If we are sufficiently successful in raising supplementary funding, we aim to hold that meeting in Cambridge Bay, Canada; Tvärminne zoological station, Finland; or Saroma-Ko, Japan. Otherwise, we would hold the meeting at the experimental sea-ice facility, at the University of East Anglia. Funding for access to the ASIBIA chamber facility has already been solicited through a European Research Council large consortium proposal (EUROCHAMP 2020). A funding decision for EUROCHAMP 2020 is anticipated in mid-to-late 2016.

Task 3: Produce a framework for a living guide of best practices for sea ice biogeochemical studies (years 3-4)
Throughout the lifetime of the working group, we will explore and experiment with frameworks for disseminating the evolving understandings of the best approaches to measure biogeochemical parameters in sea ice in a format that is open-access and updatable. This framework might be hosted on the BEPSII, CliC, or SOLAS websites and will include the strengths and weaknesses associated with each method. The first large-scale implementation and testing of this guide to best practices will be during MOSAIC, a one-year time-series in the central Arctic Ocean scheduled for 2019-20.

Deliverables

- Individual review papers on strengths, weaknesses, and uncertainties in the methods used to process and store sea-ice samples before analysis, as well as measurements of primary production in sea ice and gas fluxes over sea ice.
- Concrete, executable designs for intercomparison and intercalibration experiments on ice processing and storage, primary production and incubation methods, gas fluxes, and CO_2 partial pressure of sea ice.
- Recommendations for evaluation of spatial variability in sea-ice characteristics, based on traditional transect and nested sampling strategies coupled with new non-destructive technologies.
- Web-based framework for dissemination of evolving standards of best practices.
- Sea-ice biogeochemical sampling plan and recommended protocols for the 2019-2020 MOSAiC expedition, and other programs that follow it.

Capacity Building
Reliable measurements are a necessity if we want to properly describe the changes and forcing in the global environment and climatic system, in general. Our main goal is to provide the international sea-ice research community with standardized protocols for collecting, preserving, and processing sea-ice samples. The tasks we have described contribute directly to a long-term goal of accurately sensing variations in polar regions, which are among the environments most sensitive to ongoing global change. In addition to our immediate goal of informing the MOSAIC science plan (Task 3), the protocols ECVice will develop will contribute directly to the efforts of all long-term programs coordinating research in the polar oceans, including SOOS (the Southern Ocean Observing System), SCAR (the Scientific Committee on Antarctic Research), and IASC (the International Arctic Science Committee), as well as GCOS.

Support of young scientists is in the genes of ECVice. More than half of the proposed full members are less than 35 years old. The young scientists involved in this working group have carried out pioneering work on sea ice, establishing creative new methods to assess key variables at the beginning of their carriers. With the mentorship of the senior scientists in this working group, these young scientists are in a position to discuss and refine these innovative methods to produce widely-acceptable, extensively tested standardized protocols, a prerequisite for

long-term coverage of these variables. The proposed membership of the working group also includes young experts in sea-ice analyses (i.e., trace metals and genetics) which are not among our focused list of initial priorities, but have, nonetheless, been identified as requiring intercalibration and intercomparison [Miller et al., 2015]. Our hope is that association with ECVice will also help those scientists develop the approaches needed to resolve their methodological issues.

We will also pass this consolidated expertise to new scientists interested in sea ice through a collaboration with a planned international sea-ice summer school to be held in Longyearbyen, Svalbard (to be organized by the BESPII SOLAS-CliC consortium). We hope to hold one of our annual meetings in conjunction with that summer school, with working group members delivering lecturers.

We are also committed to encouraging sea-ice research in nations with emerging polar research programs. Unfortunately, polar research, including investigations of sea-ice biogeochemistry, is still largely an endeavour of wealthy nations, and this is reflected in the proposed membership list. Despite our difficulties in identifying many suitable candidates from developing nations for initial membership in this working group, we will continue to actively seek out and support new sea-ice researchers working in countries that do not already dominate in polar research. Along these lines, we hope to hold at least one of the annual meetings in Asia and include teaching activities. We also hope to invite a few young scientists from under-represented countries, including Russia, to Saroma-Ko, Japan, in conjunction with our intercalibration experiment there, for a short course to expose them to the study of sea-ice biogeochemistry (e.g., through funds from the Japan Society for the Promotion of Science, as well as other sources).

Collaboration with Arctic communities is also fundamental to sea-ice research, and our plan to hold one of our intercalibration experiments in Cambridge Bay (Nunavut, Canada) will provide ECVice with an ideal opportunity to further that collaboration. Cambridge Bay is the location of the Canadian High Arctic Research Station (CHARS), which will be completed in 2017. Once operational, CHARS will employ numerous staff researchers, many of whom will be hired from Arctic communities, who will be tasked with monitoring aspects of the Arctic marine ecosystem and cryosphere. We will integrate CHARS staff scientists into our operations to help build their capacity to accurately measure essential climate variables in sea ice. We will also report back to CHARS the results of our intercalibration experiments to help ensure that the progress we make is integrated into the long-term monitoring conducted at the station. During our work in Cambridge Bay, we will also employ student assistants from Nunavut Arctic College's Environmental Technology Program. By involving these students we will be building the capacity of Inuit scientists to lead and participate in future Arctic research activities.

Working Group composition.
Full Members

Name	Gender	Place of work	Expertise relevant to proposal
1 Daiki Nomura (co-chair)	Male	Hokkaido University, Japan	Gas concentrations and fluxes
2 François Fripiat (co-chair)	Male	Max Planck Institute for Chemistry, Germany (until June 1, 2016, Vrije Universiteit Brussel, Belgium)	Primary production and nutrient cycles
3 Brent Else (co-chair)	Male	University of Calgary, Canada	Gas fluxes, primary production, and emerging technologies
4 Bruno Delille	Male	Université de Liège, Belgium	Gas concentrations and fluxes
5 Mar Fernandez-Méndez	Female	Norwegian Polar Institute, Norway	Primary production, Microbiology

6 Lisa Miller	Female	Institute of Ocean Sciences, Fisheries and Oceans Canada, Canada	Gas concentrations and fluxes, Geochemistry
7 Ilka Peeken	Female	Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Germany	Primary production, microbiology
8 Janne-Markus Rintala	Male	University of Helsinki, Finland	Primary production and microbiology
9 Maria van Leeuwe	Female	University of Groningen, Netherlands	Primary production, microbiology
10 Fan Zhang	Female	Polar Research Institute of China, China	Microbiology

Associate Members

Name	Gender	Place of work	Expertise relevant to proposal
1 Katarina Abrahamsson	Female	Göteborgs Universitet, Sweden	Gas fluxes
2 Jeff Bowman	Male	Lamont-Doherty Earth Observatory, USA	Genetics, Microbiology
3 James France	Male	University of East-Anglia, UK	Gas fluxes Sea ice optics
4 Agneta Fransson	Female	Norwegian Polar Institute, Norway	Gas concentrations and fluxes, microbiology, nutrient cycles
5 Delphine Lannuzel	Female	University of Tasmania, Australia	Trace metals
6 Brice Loose	Male	University of Rhode Island, USA	Gas fluxes
7 Klaus Meiners	Male	Australian Antarctic Division, Australia	Primary Production, microbiology, and emerging technologies
8 Christopher J. Mundy	Male	University of Manitoba, Canada	Primary production, emerging technologies
9 Hyoung Chul Shin	Male	Korea Polar Research Institute, Korea	Microbiology
10 Jean-Louis Tison	Male	Université Libre de Bruxelles, Belgium	Gas concentrations and fluxes, physics

Working Group contributions

Daiki Nomura (co-chair): Dr. Nomura's research focuses on the carbon cycle within the ocean- atmosphere system, especially in the polar oceans. He has studied sea ice in the Southern Ocean, the Arctic Ocean, and the Sea of Okhotsk, in addition to conducing laboratory experiments on sea-ice freezing processes.

François Fripiat (co-chair): Dr. Fripiat's primary interest is in the application of stable isotopes (N, Si, C, O, …) to unravel biogeochemical cycles both in the modern and past polar oceans. He uses both natural variations of isotopes and isotopic-tracer incubations.

Brent Else (co-chair): Dr. Else's primary interests are in gas exchange across the ocean-ice- atmosphere interface, with particular expertise in the use of eddy covariance techniques, both for atmospheric and underwater gas flux measurements. His strong connections to the Canadian High Arctic Research Station and other research organizations located in Cambridge Bay will allow him to facilitate collaborative field research activities in the region.

Bruno Delille: Dr. Delille's research focuses on gases dynamics within sea ice. Since 1999, he has participated in numerous bipolar sea-ice field surveys and sea ice tank experiments, using both extractive and in-situ methods.

Mar Fernández-Méndez: Dr. Fernández-Méndez is a marine microbiologist with a special interest in carbon and nutrient uptake rates, and her current work is focused on sea-ice algae and phytoplankton primary productivity in the Arctic Ocean. She is actively involved in field campaigns every year and is engaged with development and training of early career scientists.

Lisa Miller: Dr. Miller is a classically trained analytical chemist whose research focuses on the role of sea-ice in controlling air-sea partitioning of climatically active gases. She currently serves on the Scientific Steering Committee of the Surface Ocean-Lower Atmosphere Study, as an advocate for polar research, and she was co-lead of the methodologies task group of SCOR Working Group 140 on Biogeochemical Exchange Processes at Sea-Ice Interfaces.

Ilka Peeken: Dr Ilka Peeken is trained as phytoplankton ecologist with a broad experience in the investigation of sea-ice covered pelagic ecosystems with a recent focus on the effect of climate change on sea ice biota in the Arctic Ocean. She conducted and led sea-ice field campaigns in the Arctic and is actively involved in writing the science and implementation plan of the field campaign MOSAIC.

Janne-Markus Rintala: Dr. Rintala is specialized in species identification, i.e., he has described a new cryptophytes (*Rhinomonas nottbecki*), a new dinoflagellate subspecies (*Heterocapsa arctica* subsp. *Frigida*) and a new cyst *Scrippsiella hangoeii*. In addition to field work he has been doing experimental research as well, i.e., investigating the dark survival and photosynthetic efficiencies and published a methodological comparison that is confronting the earlier methods used for melting sea ice samples. Currently he has become interested in identifying key species responsible for gas exchange and CO_2 uptake as well as DMSP production.

Maria van Leeuwe: Dr. van Leeuwe is marine biologist with a specific interest in the photophysiology of microalgae. She is currently working on the application of the stable isotope ^{13}C in tracing carbon fluxes in sea-ice ecosystems.

Fang Zhang: Dr. Zhang is marine ecologist with special interest in microbiology. Her current work focuses on sea-ice biota in the Arctic Ocean, including community composition and diversity, their environmental correlations, and gene functions.

Relationship to other international programs and SCOR Working groups

This proposed working group is a direct follow-up to a broad review of methods used to study sea-ice biogeochemistry [Miller et al., 2015], which was a product of SCOR Working Group 140 on Biogeochemical Exchange Processes at Sea-Ice Interfaces. That paper clearly identified a number of methodological uncertainties that could be resolved by further focused, international coordination. This new proposal is supported by BEPSII, a newly designated network on sea-ice biogeochemistry that is sponsored by both the Climate and Cryosphere (CliC) program and the Surface Ocean-Lower Atmosphere Study (SOLAS).

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Appendix 6
Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Annual Report to SCOR
May 2016

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) until it ended in December 2015, and now Future Earth. IMBER's International Project Office (IPO) in Bergen, Norway is sponsored by the Institute of Marine Research (IMR) and the Norwegian Research Council, and its Regional Project Office (RPO) in Shanghai is hosted and supported by the State Key Laboratory of Estuarine and Coastal Research (SKLEC) and the East China Normal University (ECNU).

IMBER's goal has been 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, as outlined in the 2005 IMBER Science Plan and Implementation Strategy (SPIS) and the 2010 supplementary update. Now, after 10 years, IMBER has a new vision: *ocean sustainability for the benefit of society*, and aims to: *understand, quantify and compare historic and present structure and functioning of linked ocean and human systems, to predict options for securing or transitioning towards ocean sustainability.* A new SPIS providing the basis for the next decade of IMBER research is under review by SCOR and Future Earth. 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 its foundation. 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 crosses the interfaces between these disciplinses (transdisciplinary research). A clear message from the 2014 IMBER Open Science Conference (OSC) and community consultation in 2015 associated with development of the SPIS, was that transdisciplinay research must be part of the future research agenda. This is underscored by the recent science highlights presented in the next section.

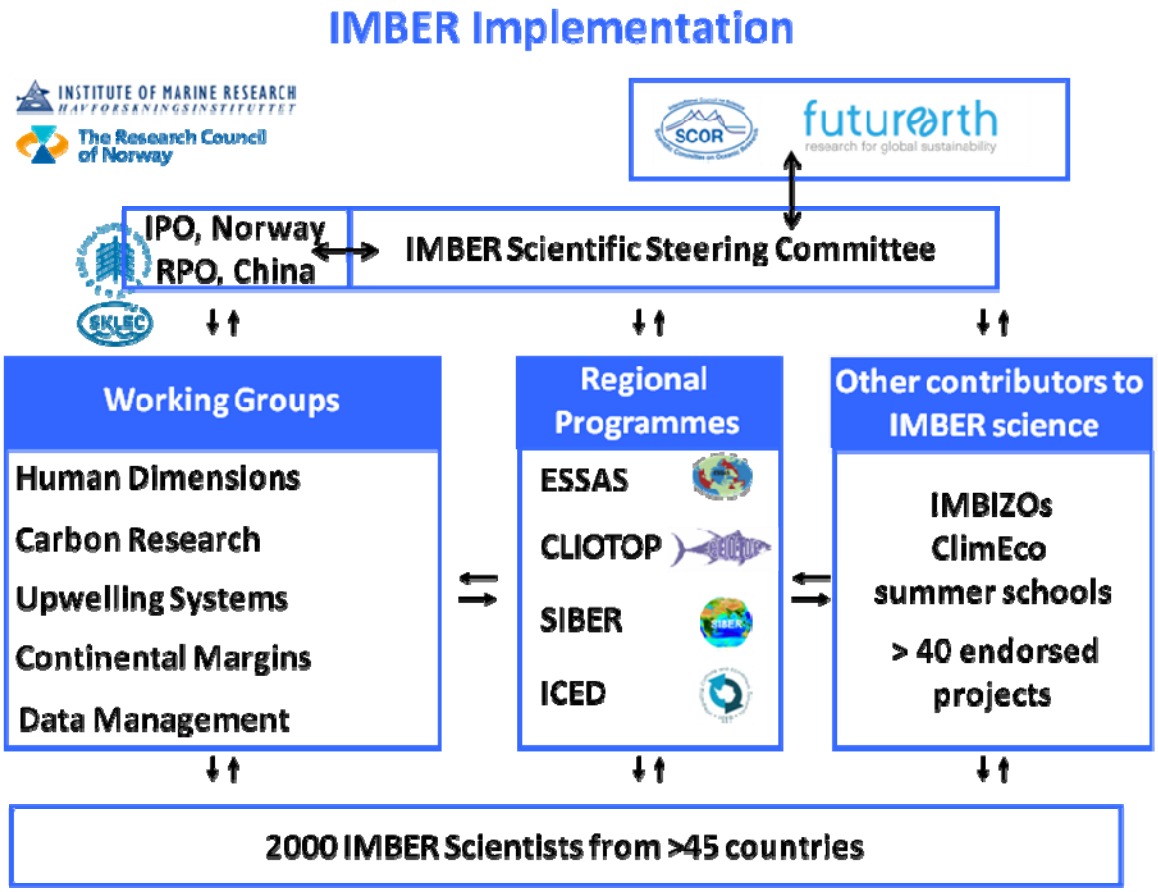

Figure 1. Structure of IMBER.

B. Selected 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 a social-ecological decision support framework for marine systems
- IMBER promoted and undertook capacity building and knowledge transfer activiites
- IMBER research informs sustainable use of marine ecosystems

Selected discoveries and highlights in 2015-16 from IMBER regional programmes, working groups and endorsed research projects. Special relevance to societal issues are marked in red.
From: Ecosystem Studies of Sub-arctic and Arctic Seas (ESSAS):

1. A new hypothesis has been proposed suggesting that the shift in Atlantic mackerel distribution from the Norwegian Sea was a result of reduced food production due to the declining nutrient concentrations (Si) along the northern European continental slope, forcing the mackerel stock to seek new feeding grounds in the nutrient richer waters farther north and west, i.e. around Iceland and east Greenland. *(Pacariz et al., submitted 2016).*

2. A critical review of harvest control rules for fisheries management was undertaken. This includes their historical and institutional development, recent cases and potential harvest control rules for future fisheries management, in terms of both ideal and realistic developments. *(Kvamsdal et al, submitted 2016).*

3. Special Issue of Progress in Oceanography titled "Combining Modeling and Observations to Better Understand Marine Ecosystem Dynamics" *(eds. Curchister et al. 2015)* contains 19 papers on modeling marine ecosystems. The papers focus on approaches to investigate the mechanisms linking environmental

influences to biological responses. An integral component is the use of observational data to ensure the credibility and appropriate interpretation of model results.

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

4. Quantifying the strength of biological feedbacks in Southern Ocean air-sea CO_2 flux is important to understanding the effects of climate change. Several global biogeochemical models under climate change to the end of the century were compared, with a focus on vertical carbon flux and changes in plankton community structure. Although there was no agreement on physical changes in the Southern Ocean, the models did agree that the biological carbon pump will be responsible for increased CO_2 uptake in a future, less well-buffered ocean. *(Hauck et al. 2015)*

5. Understanding the key drivers of population connectivity is essential for effective management of natural marine resources. A 'seascape genetics' approach combining oceanographic modeling and microsatellite analyses was used to investigate the influences on the genetic structure of two populations of Antarctic fishes with contrasting life histories. Inter-annual variability in oceanographic flows strongly influenced the projected genetic structure, suggesting that shifts in circulation patterns due to climate change are likely to impact future genetic connectivity and opportunities for local adaptation, resilience and recovery from perturbations. *(Young et al. 2015)*

6. The uptake of anthropogenic CO_2 is altering the carbonate chemistry and pH of the oceans, and the polar oceans are predicted to be the most severely affected. This study carried out ocean acidification (OA) manipulations of natural Arctic and Southern Ocean pelagic communities. Many responses to OA varied between environments but there was a consistent response with regards to copepods always preferring to graze dinoflagellates compared to other phytoplankton species when in elevated pCO_2 conditions. This demonstrates that changes in food quality and altered grazing selectivity may be a major consequence of the predicted chemical changes to the polar oceans. Such altered trophodynamic interactions will impact how carbon is channelled through polar foodwebs, and the extent to which future anthropogenic CO_2 emissions can be absorbed. *(Tarling et al, 2016)*

7. Jackson et al., 2015 summarises the findings of over a decade of work to reconstruct the population trajectories and assess the recovery status of all Southern Hemisphere humpback whale populations. The study also details methodological advances and the significant challenges overcome during the assessment, and identifies key data gaps and avenues for future work. *(Jackson et al 2015)*

8. 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 CO_2, and the potential of predicting the future states of the fisheries and ecosystems are quite limited. *(Harrison and Chiodi, 2015)*

9. Major uncertainties in modeling frameworks are broadly categorised into those associated with (i) insufficient knowledge about the interactions of climate and ocean dynamics with marine organisms and ecosystems; (ii) lack of observations to assess and advance modeling efforts and (iii) an inability to predict with confidence natural ecosystem variability and longer term changes due to 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. *(Evans et al., 2015)*

10. Zooplankton faecal pellet production is a key control of the efficiency of deep carbon transfer in the Scotia Sea. This region contains the largest seasonal uptake of atmospheric CO_2 yet measured in the Southern Ocean (*Manno, et al., 2015)*.

11. IMBER/ICED scientists contributed to a Southern Ocean biogeographic atlas, www.biodiversity.aq.

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

12. From a biogeochemical sensor at the 80E RAMA mooring, striking chlorophyll "spikes" were observed at the Equator during the fall Wyrtki Jets. These appear to be related to entrainment pulses and/or Yanai waves. *(Strutton et al., 2015)*

13. A Special Issue of Exchanges, Celebrating 50 Years of Indian Ocean Research, initiated by SIBER and the CLIVAR Indian Ocean Regional Panel was published at the launch of the Second International Indian Ocean Expedition (IIOE-2) at the International Symposium on the Indian Ocean, 30 November - 4 December 2015, at the National Institute of Oceanography (NIO), Goa, India (see below) *(Valiard et al., 2015).*

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

14. Using longline catch data from six tuna species in the Pacific, Atlantic and Indian Oceans, a global, comparative perspective of habitat preferences for these species was developed based on a common dataset and consistent approaches. Results confirmed that tropical tunas prefer warm, low oxygen, stratified waters, while temperate tunas tolerate a wider range of environmental conditions, the widest demonstrated by Atlantic bluefin tuna (*Thunnus thynnus*). This view of preferred habitats will be useful for spatial approaches to management and better predictions of the impacts of changing climate on populations and associated fisheries. *(Arrizabalaga et al., 2015).*

15. Trials on yellowfin tuna identified increased hatch times and reduced larval growth under varying levels of increased pCO_2, with varying impacts on larval survivability. Technical challenges during experiments, and limitations on the range of pCO_2 levels used limited the assessment of potential impacts. *(Bromhead et al., 2015).*

16. New projections of the features of the western warm pool in the Pacific Ocean suggest that while its edge is projected to warm, it is likely to remain within 10º of its present longitude. This is in stark contrast to the large projected eastward displacements of the isotherms that are usually used to define the edge. *(Brown et al., 2015)*

17. The southwest Pacific has been identified as an area of particularly rapid warming and this trend is expected to continue. Understanding the effects of increased warming on the distribution of fisheries in the region, and management responses, is essential for the sustainable management of these fisheries. Projections from a high resolution ocean model were used to condition a catch distribution model examining potential changes in the catches of yellowfin tuna off the east coast of Australia. Results suggest that by 2060 the core area fished by the longline fleet in the region will shift both poleward and offshore relative to existing areas. Such shifts may require modification of current fishing behaviours, which in turn may require social and economic adjustments to the fishery. *(Dell et al., 2015).*

18. Interactions between warming, acidification and deoxygenation and their effects on the aerobic scope of yellowfin tuna were investigated using a physiology-based habitat suitability model. The model indicated positive non-linear interactions between temperature and acidification effects, with the largest impacts on aerobic scope occurring under conditions of high oxygen partial pressure, low temperature and low CO_2 partial pressure. Overall, the model suggests that the vertical habitat for yellowfin tuna in the eastern tropical Pacific will contract vertically and that the species will need to rely on adaptations allowing them to utilize less hospitable environments to greater extents. *(Del Raye and Weng, 2015).*

19. Some of the most important development goals for the countries and territories of the Western and Central Pacific Ocean involve the sustainable management of their fisheries in light of environmental, economic and social uncertainties. Research priorities include: (i) improved resolution of processes driving ecosystem model components via the incorporation of higher resolution climate models; (ii) development of seasonal and inter-annual forecasting tools enabling management responses to short-term variability in tuna distributions and abundances; (iii) improved understanding of the population dynamics of, and the energy transfer efficiencies between, food web components; (iv) assessment of the optimal value of access rights and overall fishery value under multiple scenarios of tuna distribution and abundance and influences on decision making by fisheries managers and fleets and (v) utilisation of management strategy evaluation frameworks for testing fishery management procedures to help prioritize research directions and investment. *(Evans et al., 2015).*

20. Finding a balance between ensuring food security, economic health, fishery sustainability, biodiversity conservation and ecosystem function in marine systems is a challenge. Climate change may make this balancing act more difficult, as ranges and productivity of species change in time and space and will require careful and informed development of policy for managing natural resources. Insights into several conflicts and trade-offs associated with the harvesting of pelagic species, including (i) maximizing future food production given the depleted state of some stocks; (ii) minimizing bycatch of non-target species, (iii) setting ecosystem allocation rules for non-target top predators, such as seabirds, and (iv) maximizing value and livelihoods for local economies are identified. Resolving these conflicts is achievable with current approaches and technologies. *(Hobday et al., 2015).*

21. Comparison of parameters from a eutrophic micro-/nanophytoplankton dominated ecosystem showed that systems with small primary producers (such as the oligotrophic western Pacific) have longer food chains than those with large primary producers (such as the eutrophic California Current System). Current projections of ocean ecosystems suggest reductions in net primary productivity and increased contributions of picoplankton size classes associated with warming of surface waters and increased stratifcation. The response of food webs to such changes may be dependent on their linkage structure with ecosystems with longer food chains more resilient and capable of adaptation than those with shorter food chains. *(Hunt et al., 2015).*

22. The end-to-end ecosystem model SEAPODYM was used to investigate the influence of environmental change and fishing on albacore abundance and distribution on past catches and on future catches under climate change scenarios. Projections suggest a decrease in biomass until 2035, stabilization and then growth after 2080 associated with the establishment of a new spawning ground in the Tasman Sea. Simulations identified particular sensitivity of the model to dissolved oxygen concentrations, projections of which include large uncertainty in the tropics. Outputs should help in developing policies for fisheries management robust to a changing environment and identify understanding of changes to oxygen availability as a key priority. *(Lehodey et al., 2015).*

23. An investigation of larval scombrids (e.g. mackerel, tuna) from around the world in relation to water column and sea surface properties found that feeding success was distinctly different between regions, varying from 100% in the Straits of Florida and the Mediterranean Sea to as little as 40% in the Gulf of California and off north-west Australia. The number of prey species consumed was typically low and usually similar for a given scombrid taxon among regions. Larval habitat conditions were often similar, but variability among regions highlighted the potential for region-specific mechanisms regulating larval survival and, ultimately, levels of adult recruitment. This has implications for how recruitment indices are incorporated into global tuna population models. *(Llopiz and Hobday, 2015).*

24. δ15N values across multiple trophic levels and over a large spatial scale were determined in two pelagic marine ecosystems to investigate (i) if isotopic baselines could be determined from a primary consumer rather than more traditonally sampled, but more logistically challenging, primary producers and (ii) how differing methods of baseline assessment might influence estimates of trophic position in the predator yellowfin tuna. Spatial variations of δ15N from particulate organic matter, barnacles and yellowfin tuna showed similar patterns across the two ecosystems suggesting that they all can effectively reflect δ15N isoscapes. Further they suggest that variations in the isotopic composition at the base of the food web, rather than differences in diet, were the main contributors to isotopic variability. The study reinforced the importance of considering isotopic baseline variations, and provided new insights into methods that can be applied to generate nitrogen isoscapes for worldwide comparisons of marine ecosystems. *(Lorrain et al., 2015)*

25. Many climate models describe a decrease in nutrient upwelling in the western Pacific warm pool as a result of increased stratification, leading to projections of lower surface primary production and an overall decrease in net primary productivity. Examination of high-resolution projections suggests, however, that increased mixing due to changes in currents (not fully resolved in lower resolution models), results in increased subsurface primary production. This is expected to result in almost no change in overall net primary production within the warm pool, suggesting that climate change may not have substantive impacts on marine ecosystems within the region. *(Matear et al. 2015).*

26. Although time series of fish catches are the core of many assessments, these time series have largely been underutilised with respect to investigating variability in ecosystems. An extensive time series of drift gillnet survey data from the western North Pacific was used to analyse spatio-temporal variations in the higher

trophic level community structure, revealing clear spatial and temporal patterns. Both longitudinal and latitudinal gradients in metrics calculated were evident, while temporal trends varied between metrics. Co-occurring changes in survey methods, however, prevent causal relationships from being concluded, highlighting the importance of standardized methods for the collection of time series. *(Okuda et al., 2015).*

27. Animal daily routines represent a compromise between maximizing foraging success and optimizing physiological performance, while minimizing the risk of predation. For ectothermic predators, ambient temperature may also influence daily routines through its effects on physiological performance. Using a combination of electronic tags deployed on blacktip reef sharks (*Carcharhinus melanopterus*) and bite rates in herbivorous reef fishes, the activity rates of these predators and their prey was quantified. Activity rates varied in relation to diel cycles of temperature, with predators being most active during cooling periods, when their greater thermal mass would result in their body temperatures being higher than those of their prey. This body temperature difference likely results in an advantage for the predators. *(Papastamatiou et al. 2015).*

28. Biochemical composition of the muscle tissues of predators provide information on dietary histories across much longer time scales than traditional investigations of stomach contents and can therefore be used to investigate longer term variability in the trophodynamics of predators. Using signature fatty acids, spatial variability in the trophic position of albacore and skipjack tuna (*Katsuwonus pelamis*) from the southwestern Pacific Ocean and underlying trophic and physiological reasons for variability were investigated. Latitudinal variability was particularly evident in albacore tuna and was attributed to differences at the base of the food web between temperate and tropical regions. The study identified that signature fatty acids could potentially be used as indicators of thermal change in regions such as the 'tropicalisation' of subtropical and temperate waters. Latitudinal gradients in concentrations of health-benefitting omega-3 fatty acids suggest that such tropicalisation could potentially reduce the lipid quality of albacore tuna for human consumers. *(Parrish et al., 2015).*

29. Increasing water temperature has been associated with range shifts in a number of marine species. While the direction and increase in rates of range shifts have been noted, identification of drivers of variation in range shifts within species and across regions within a species range in areas of intense warming, is lacking. Projected shifts in the core habitat of a number of pelagic species off the east coast of Australia were compared at varying spatial and temporal scales to investigate variability in the rate of shifts and their association with spatial gradients in temperature. Projections across all scenarios showed consistent southern (poleward) shifts in the core habitats of all species. Notably, the trailing edges of habitats shifted faster than their leading edges, due to weaker spatial gradients in water temperatures associated with (northward) trailing edges, in conjunction with relatively constant rates of warming across latitudes. This suggests that spatial gradients in temperature may be important in determining spatial variability in range shifts within species. *(Robinson et al., 2015).*

30. The speed at which the ocean is warming and associated isotherms are moving varies considerably both temporally and spatially. Projections under *business as usual* emission scenarios suggest that the speed at which isotherms migrate will be up to seven times faster in the 21st century compared to the last century, and speeds during summer will be greater than those in winter across most oceanic regions. In response, the thermal ranges of species will undergo sudden, rapid shifts rather than exhibiting gradual uniform movement. Such rapid shifts are likely to present challenges both in data collection and management responses. *(Sen Gupta et al. 2015).*

31. Dynamic optimal foraging theory predicts that foraging efficiency increases with body temperature, maximising energy harvest rates, and that therefore, vertical migrations demonstrated by species such as bigeye tuna are thermoregulatory in nature. The observed behaviour of bigeye tuna was examined to determine if vertical migrations were quantitatively consistent with predictions from dynamic optimal foraging theory using a simple dynamic programming model. Modeled behaviour was found to be consistent with observed data on vertical movement, with small individuals displaying constant-depth strategies and large tuna displaying vertical migrations. The analysis supports the hypothesis that bigeye tuna behaves in such a way as to maximize its energy gains. The model developed provides insight into the processes underlying observed behavioural patterns and allows the generation of predictions of foraging behaviour in unobserved environments. *(Thygesen et al., In Press).*

32. Common oceanic sunfish (*Mola mola*) frequently occur as bycatch in fisheries worldwide and comprise the greatest portion of the bycatch in California's large-mesh drift gillnet fishery. Little is known of their

movements, oceanic drivers of movements or the habitats utilised by individuals. Using data derived from electronic tag deployments, sunfish were observed to undertake seasonal movements between the southern California Bight and adjacent waters off northern and central Baja California. Association with upwelling fronts and surface slicks indicated convergent circulation. Zooplankton sampling in the region suggest sunfish were associating with areas of dense concentrations of salps, a common food item. The study suggests that bio-physical interactions in coastal upwelling fronts create a favourable foraging habitat for this species. *(Thys et al., 2015).*

33. Biologging instruments allow the simultaneous measurement of the fine-scale foraging behaviours of predators and their environment, revealing characterisation of foraging environments and insights into the distributions of their prey. Using such instruments, the relationship between prey encounter events by southern elephant seals and water temperature, light and depth was investigated. Foraging environments were found to be structured by the main frontal systems of the Southern Ocean. Large physical and/or spatial differences in these environments suggest that differing prey communities are targeted by the seals depending on their location, highlighting the dietary flexibility of the species and potentially it's adaptability to future environments. *(Vacquié-Garcia et al., 2015)*.

34. Fishery resource managers and policy makers in Pacific Island countries and territories will be increasingly challenged by the need to ensure food security and resource sustainability within the context of a changing climate. Pelagic fish resources available to the region, challenges to development, capacity and climate change and science needs for identifying and addressing changes to resources and potential conflicts with development goals are outlined. Key to responding to climate change will be investments aimed at expanding the capacity for research, management and sustainable fisheries management within these countries and territories, which could be facilitated through collaboration between PICTs, RFMOs, and scientific centers of excellence. *(Weng et al., 2015).*

35. Extinction risk is closely tied to body size, home range, and species distribution, so quantifying these features is important for conservation, to enable the use of concepts such as 'umbrella species', whose conservation protects other species due to shared habitat. A multi-year study of the home range of humphead wrasse in the central tropical Pacific was conducted to determine the value of this species as an umbrella species for coral reef conservation. Home ranges varied substantially and changed with ontogeny. Females had relatively large home ranges, indicating value as an umbrella species for coral reefs. The home range of the species was then compared to the size distribution of tropical marine protected areas (MPAs), and the MPA length necessary to retain humphead wrasse was estimated. It was determined that most MPAs are too small to effectively protect the humphead wrasse, so small reserves are unlikely to be an effective management tool. *(Weng et al., 2015).*

36. Little is known of the movements and diet of albacore tuna in the South Pacific Ocean, or how variability in both might influence the vulnerability of albacore tuna to fisheries across their range. Using electronic tagging and stomach samples, the diving behaviour and diet of albacore tuna in three locations were investigated. Albacore tuna in tropical regions demonstrated a distinct diel pattern in vertical habitat and consumed significantly more deepwater prey species than those in temperate regions which tended to be limited to shallow waters above the mixed layer. This latitudinal variability in diving behaviour and diet suggests that future changes in the vertical structure of temperate waters might influence the vertical distribution of albacore tuna and, therefore their vulnerability to oceanic fisheries. *(Williams et al., 2015).*

37. Human pressures have resulted in declines in populations of leatherback turtles (*Dermochelys coriacea*) in the eastern Pacific Ocean. How climate change might impact these already threatened populations is not well understood. Using habitat models derived from data collected from electronic tag deployments on turtles and future ocean state derived from climate models, changes to the core habitats of leatherback turtles were investigated. Results suggest that the core pelagic habitat of the eastern Pacific leatherback turtle population will decline by approximately 15% within the next century, compounding recent declines in abundance. This reduction in available habitat may result in distributional shifts, behavioural changes, or even extinction. To ensure resilience of the population to potential habitat modification associated with climate change, existing stressors on the population such as fishing and anthropogenic impacts on nesting beaches need to be reduced *(Willis-Norton et al., 2015).*

38. Time series of commercial fishery catches and scientific survey data of the diet of northern fur seals (*Callorhinus ursinus*) from the waters off northeastern Japan spanning 60 years were examined to investigate potential long-term changes in the marine ecosystem. Variability in both datasets highlighted the

many environmental factors influencing the observed trends and with neither dataset supporting the 'fishing down the food web' postulated for many fisheries in other regions. Inconsistencies in trends observed in the two datasets highlighted the need to use multiple datasets when investigating ecosystem variability, and also careful interpretation of results based on individual environmental time series. *(Yonezaki et al., 2015).*

39. Classical diet studies have provided most of the historical information on trophic pathways in pelagic ecosystems, but biochemical methods (stable isotopes, fatty acid signatures) are allowing new questions to be addressed. Progress on understanding the spatial and temporal variability in the trophodynamics of marine predators was reviewed, and impacts of ocean warming on marine ecosystems from both top-down and bottom-up trophic perspectives were examined. Impacts identified included alterations to energy transfer efficiency, decreased productivity, shifts in biodiversity hotspots, shifts and restrictions in population abundances and distributions and alterations in species assemblages, which can influence food availability for higher predators. For a comprehensive understanding of the trophodynamics of marine top predators, a combination of methodologies is needed. *(Young et al., 2015).*

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

40. An article on the Ocean Acidification International Coordination Centre (OA-ICC) **data compilation on the biological response to ocean acidification (**https://www.iaea.org/ocean-acidification/page.php?page=2203) was published in the journal ***Earth System Science Data*** in February 2016. The data compilation is maintained in cooperation with the State Key Laboratory of Marine Environmental Science, Xiamen University (China) and the German data publisher PANGAEA. It currently offers access to data sets from nearly 700 scientific papers.

41. The Surface Ocean CO_2 Atlas (SOCAT, www.socat.info), compiled by the international marine carbon community, provides access to quality-controlled surface CO_2 data (Fig. 3). The first two versions were released in 2011 and 2013, respectively. Version 2 contains 10.1 million quality-controlled, surface ocean fCO_2 (fugacity of CO_2) values from 1968 to 2011 for the global oceans and coastal seas. Version 3 of the Atlas was released on 7 September 2015 *(Pfeil et al. 2015)*

42. 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 (*Lauvset, et al., 2015, Bakker et al., 2015)*

43. 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.

From: Capacity Building Task Team:

44. 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.,2015)*.

45. The legacy and perspective document on IMBER capacity building aims to assess these activities, and outline a way forward for sustainable capacity development within the IMBER research community as it prepares for the next 10 years of marine biogeochemistry and ecosystem research. *(IMBER Capacity Building Task Team (2016).IMBER Report No. 9, IMBER Regional Project Office /IMBER International Project Office, Shanghai, China. 30pp).*

From: Human Dimensions Working Group (HDWG):

46. I(MBER)-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:

47. 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-Future Earth Coasts 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. 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:

SWAtlantic (SACC-IAI)

48. Shelf-deep ocean exchanges and their variability are key to understand the processes that control retention of planktonic species, and therefore abundance and biodiversity over a wide range of trophic food webs, and may have a strong impact on the carbon budget of continental margins. Satellite-derived surface temperature, salinity and currents combined with in-situ observations and numerical simulations reveal intense shelf-deep ocean exchanges in the western South Atlantic. *(Strub et al., 2015, Guerrero et al., 2014, Matano et al., 2014).*

49. Upwelling is the main process sustaining plant growth in the open ocean. Though the most effective upwelling ecosystems are wind-forced (e.g. mid-latitude eastern boundary currents), other productive marine ecosystems, such as the Patagonia continental shelf in the SW South Atlantic must rely on other upwelling mechanisms. Theory predicts that the interaction of western boundary currents of subpolar origin with the ocean bottom lead to strong shelf break upwelling. *Franco et al., 2015, Matano et al., 2014, Pisoni et al., 2014, Valla and Piola 2015.*

GALATHEA

50. 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 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

51. 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)*

52. 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).*

53. 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 × 10 cm, <20 × 20 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)*.

54. 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 Remotely Operated Vehicle (ROV). Marine litter proved to be an ideal theme to enhance the environmental awareness of schoolchildren *(Ioakeimidis, et al., in press).*

CATARINA

55. The first observation-based acidification trends in the water masses of the Atlantic basin over the past two decades were 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)*.

CARBOCHANGE

56. Several studies have suggested that the carbon sink in the Southern Ocean—the ocean's strongest region for the uptake of anthropogenic CO_2—has weakened in recent decades. We demonstrated, on the basis of multidecadal analyses of surface ocean CO_2-observations, that this weakening trend stopped around 2002, and by 2012 the Southern Ocean had regained its expected strength based on the growth of atmospheric CO_2. The large decadal variations in the Southern Ocean carbon sink suggest a rather dynamic ocean carbon cycle that varies more than previously recognized. *(Landschutzer et al., 2015)*

57. For the year 2014, CO_2 emissions from fossil-fuel combustion and cement production grew to 9.8 ± 0.5 GtC yr^{-1}, 0.6% above 2013, continuing the growth trend in these emissions, albeit at a slower rate compared to the average growth of 2.2%yr^{-1} that took place during 2005–2014. Cumulative emissions of CO_2 will reach about 555 ± 55 GtC for 1870–2015, whereof about 75% from fossil fuel and cement production, and 25% from change in land use. *(Le Quéré et al., 2015).*

58. Century-scale trends and seasonality in pH and temperature for shallow zones of the Bering Sea show a long-term decline of 0.08 ± 0.01 pH units between the end of the 19th and 20th century, which is consistent with atmospheric CO_2 records. Additionally, a strong seasonal cycle (~0.22 pH units) is observed and interpreted as episodic annual pH increases caused by the consumption of CO_2 during strong algal (kelp) growth in spring and summer. The rate of acidification intensifies from –0.006 ± 0.007 pH units per decade (between 1920s and 1960s) to –0.019 ± 0.009 pH units per decade (between 1960s and 1990s), and the episodic pH increases show a continuous shift to earlier times of the year throughout the centennial record. This is indicative of ecosystem shifts in shallow water algal productivity in this high-latitude habitat resulting from warming and acidification. *(Fietzkeet al., 2015)*

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

59. 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).

AMT

60. The Atlantic Meridional Transect (AMT) is a multidisciplinary programme since 1995 (http://www.amt-uk.org/) which undertakes biological, chemical and physical oceanographic research during an annual voyage between the UK and destinations in the South Atlantic. The annual transect crosses a range of ecosystems from sub-polar to tropical and from euphotic shelf seas and upwelling systems to oligotrophic mid-ocean gyres. AMT informs on trends and variability in biodiversity and function of the Atlantic ecosystem during this period of rapid change to our climate and biosphere.

C. Activities of IMBER Regional Programmes

Ecosystem Studies of Subarctic and Arctic Seas (ESSAS) Regional Programme

As ESSAS research is expanding to include the Arctic, at last year´s SSC meeting the name was changed (but retaining the same acronym) to include Arctic seas.

ESSAS Annual Science Meeting on The Role of Ice in the Sea was held in Seattle, Washington, in June, 2015 with 51 oral presentations and 13 poster presentations. Four themes were explored: Humans, Ice and the Sea in the Subarctic and Arctic Past, the Role of Sea Ice in the Arctic and Subarctic, the Ecological Role of Tidewater Glaciers, and Social Science Investigations of Changing Sea Ice Conditions. Over 100 scientists attended from 11 countries. This was the largest ESSAS ASM and by all indications one of the most successful.

The ESSAS RACArctic (Resilience and Adaptive Capacity of ARCTIC marine systems under a changing climate) Project funded by the Belmont Forum began with fall meetings in 2015 in each of the co-sponsoring countries, Japan, the US and Norway. The first international meeting was held 1-3 March 2016 in Hakodate, Japan, beginning with a stakeholders' meeting. The aim of the project is to synthesize information from completed and ongoing regional studies on how climate variability and change in the Subarctic to Arctic transition zones may affect future marine ecosystems of the Pacific and Atlantic Arctic. In particular, it will examine how fish populations and their prey are able to adapt or respond to natural and anthropogenic changes in the Arctic and how these are expected to affect existing and future fisheries, subsistence harvests, and the socio-economic systems that depend upon them.

The ESSAS 3rd Open Science Meeting is planned for June 2017 in Tromsø, Norway – "Moving in and out and across the Subarctic and Arctic – shifting boundaries of water, ice, flora, fauna, people and institutions".

A Special Issue by the ESSAS WG on Modelling Marine Ecosystems entitled Combining Modeling and Observations to Better Understand Marine Ecosystem Dynamics and dedicated to the late Bern Megrey was published in November 2015 with 19 papers. The idea for this special issue was formulated at the ESSAS Open Science Meeting in Seattle during 2011 and was edited by Enrique Curchitser, Ken Rose, Shin-ichi Ito, Myron Peck and Michio Kishi.

ESSAS will continue with its current structure. There are currently four working groups:
WG: Modelling ecosystem response – published a special issue on modelling and observational approaches.
WG: Arctic-Subarctic interactions, had a session at the 2016 ASLO Ocean Sciences meeting.
WG: Human dimensions, has organised a session at the ESSAS Annual Science Meeting 2015 in Washington.
WG: Comparative Paleo-ecology in Sub-Arctic seas (a longer term assessment of the mechanisms linking climate, oceanography, ecology and human system relationships).

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. www.iced.ac.uk/index.htm.

Highlights from ICED science over the past year are in section B. In addition, ICED scientists were involved in the following international events:

International workshop on Pteropod and Ocean Acidification, British Antarctic Survey, June 2015. The outcomes from the workshop were submitted to Biological Review and will be presented at the High CO_2 Symposium in May 2016. A further output may be the preparation of a paper by the joint OSPAR/ICES Ocean Acidification Study Group on the potential of pteropods as an ocean acidification bio-indicator species.

Scientific Committee on Antarctic Research (SCAR) Cross-Program Workshop on Interactions between Biological and Environmental Processes in the Antarctic, Institut de Ciències del Mar, 16-18 September 2015, Barcelona, Spain. ICED links with SCAR, in particular AnT-ERA, were strengthened through our involvement in this interdisciplinary activity which followed directly on from and complemented the ICED Workshop on *Southern Ocean Food webs and Scenarios of Change, British Antarctic Survey.* The ICED workshop focused on the pelagic food web in exploring the use of climate models and data in scenarios and projections of change.The SCAR workshop focused on the benthic food web with ICED scientists providing the link between the two towards a more complete picture of changing Southern Ocean ecosystems.

IMBER IMBIZO IV, 26-30 October 2015, Trieste, Italy. ICED scientists convened one of the workshops *Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change.* This brought together natural and social scientists from the modelling community, as well as experts in policy and the human dimensions related to the marine environment to consider approaches to integrate modelling efforts to address societal questions on marine social-ecological system change and management. ICED scientists had a leading role in developing and leading the workshop, which generated a stimulating discussion and a series of new insights. A number of outputs from the workshop are in development, including a short high profile paper and a more detailed paper on future directions. A theme section/special issue is under consideration.

EURO-MARINE Consortium General Assembly, 28-29 January 2016, Portugal. The EURO-MARINE Network is a FP7 Coordination and Support Action, launched in June 2014, and represents the merger of three former FP6 Networks of Excellence that have involved ICED Scientists (EUR-OCEANS- ICED scientists led the Southern Ocean System, MarBEF - marine biodiversity, and Marine Genomics Europe - high throughput approaches for marine biology), as well as their follow-up legacy structures the EUR-OCEANS Consortium (involving ICED scientists) and the MarBEF+ Association. EURO-MARINE represents 'a bottom-up organisation and the voice of the European marine scientific community supporting and promoting initial development of emerging science topics'. ICED scientists from the British Antarctic Survey (a paying member of EURO-MARINE) attended this year's General Assembly meeting, ensuring links between ICED and the shared vision of this European network whilst building on the legacy of EUR-OCEANS in developing the ICED network and science strategy. For further information see http://www.euromarinenetwork.eu/.

ICED scientists also presented at conferences, for example: American Geophysical Union Fall Meeting, 12-16 December 2015, San Francisco, USA; World Seabird Conference 26-30 October 2015, Cape Town, South Africa.

In addition ICED contributed to the annual SCAR report and Science Highlights for the Antarctic Treaty Consultative Meeting 2015; to the SCAR Cross-Program Workshop; and Richard Bellerby has led the development of a major SCAR report on ocean acidification and potential impacts in the Southern Ocean. This has involved input from a range of ICED scientists and the report is due to be formally completed in early 2016. ICED has continued its close partnership with SOOS with members of ICED also on the SOOS SSC. Collaborations are ongoing and most recently include SOOS's request for ICED to contribute to the development of a Southern Ocean database and map of field activities.

As ICED is a regional programme of IMBER, it has benefited from SCOR's financial support for various programme activities. We also appreciate SCORs work in developing science themes and capacity building.

ICED contributes to the development of the EU-PolarNet Consortium: In September ICED scientists submitted a contribution to the newly formed EU-PolarNet Consortium's (2015-2020, see www.eu-polarnet.eu) future series of white papers addressing urgent polar research questions. ICED's contribution focused on the need to advance knowledge of polar marine ecosystems and their influence on global cycles by coordinating strategic comparative research activities on both the Arctic and the Antarctic. The EU-PolarNet Consortium will transmit science priorities and a strategic framework to the European Polar Board, which then gives advice to the European Commission and other international bodies to strengthen polar research, optimise infrastructure and provide tangible benefits to society.

ICED and ESSAS scientists have undertaken a series of joint activities. A joint programme paper on advection (led by George Hunt) is in review in Progress in Oceanography and one on Antarctic and Arctic biodiversity and ecosystem functioning (led by Eugene Murphy) is also in review. We intend to build on and develop these links and are currently investigating possible mechanisms for doing this (e.g. COST Action).

ICED are continuing its work with CCAMLR to ensure that ICED science is relevant to CCAMLR and that scientific results are translated appropriately into messages that resonate with policy makers. ICED will be represented at the second Joint Workshop of the CCAMLR Scientific Committee and the Antarctic Treaty's Committee on Environmental Protection (CEP), to be held 19-20th May 2016 in Punta Arenas, Chile.

ICED scientists have also been involved in key International Whaling Commission work including the completion of the Southern Hemisphere humpback whale assessment led by Jen Jackson.

CLimate Impacts on Oceanic TOp Predators (CLIOTOP) Regional Programme

CLIOTOP is an international research network open to researchers, managers, and policy makers involved in research related to large marine species. Network participants organise large-scale comparative efforts to elucidate key processes involved in the interaction between climate variability and change and human use of the ocean on the structure of pelagic ecosystems and large marine species. CLIOTOP seeks to develop predictive capability for these socio-ecological systems and evaluate adaptation options to ensure future sustainability. www.imber.info/CLIOTOP.html.

During the 18 months since the last report to the IMBER SSC, the regional program CLIOTOP finalized activities associated with its second phase (2011-2015) and transitioned to its third phase (2016-2020) as part of IMBER under the Future Earth program. In association, CLIOTOP held its third symposium in September 2015 where activities conducted under its second phase were presented and discussions regarding its third phase occurred.

Interaction between the CLIOTOP leadership team has been through a "semi-monthly" update from the co-chairs, conference sessions and working group meetings. Every member of CLIOTOP is a volunteer, and we appreciate the efforts of all over the last 18 months. The CLIOTOP SSC met face-to-face just prior to the symposium and largely focused on development of the framework for the third phase of CLIOTOP.

Funding for CLIOTOP activities, such as workshops remains an ongoing issue, as for all the regional programs. Most activities conducted by the CLIOTOP working groups were opportunistic and largely planned in synchrony with conferences where reasonable numbers of working group members were already attending. Several working groups have sought funds via varying avenues, but there have been few successes to date. Remaining activities (such as writing of publications) have been coordinated remotely.

Working groups have generated a number of publications either through a special issue of the journal Deep Sea Research II associated with the previous CLIOTOP symposium and published in May 2015, or individually through activities associated with working groups.

At the third CLIOTOP symposium Alistair Hobday stepped down as co-chair of the SSC after six years as co-chair. Karen Evans (CSIRO, Australia) has formally replaced Alistair as co-chair. Osamo Abe and Robert Cowen retired from the SSC during 2015 and were formally thanked for their contributions to the SSC by the outgoing co-chair Alistair Hobday. A number of candidates to join the SSC were identified during the SSC meeting and these will be followed up by the co-chairs.

Under the third phase of CLIOTOP, the SSC has agreed on a re-working of the structure for CLIOTOP. Rather than the SSC setting the science directions of working groups, with working group chairs then developing science initiatives, the SSC and the CLIOTOP community will work together to develop a series of task teams. These task teams will be cross-disciplinary, problem solving and output oriented, with varying life times (e.g. 6 months to 2 years). They will bring together experts from domains needed to resolve overarching questions orientated around the goals of CLIOTOP and be consistent with the Grand Challenges and Innovative Challenges of IMBER (www.imber.info) and in turn, the focus of Future Earth.Task teams may be led by individuals or groups, tasks may be simple (e.g. writing a paper) or complex (developing new approaches to addressing a problem) and they may be seed funded by CLIOTOP or unfunded, but either aligned to CLIOTOP or conducting science that is consistent with CLIOTOP's objectives.

In early November 2015, the first call for task team proposals was sent out to the CLIOTOP community with eight proposals submitted to the SSC. The SSC through online discussions has since decided on those proposals that will form the first tranche of teams in Phase 3 of CLIOTOP. The next step in getting teams operational will be to work with the IMBER IPO in dispersing funds allocated to CLIOTOP to teams. The first tranche of teams is expected to be in place and operational before summer of 2016. Formal reporting systems for task teams will require teams to report on their activities at the end of each calendar year for inclusion in CLIOTOP reports to IMBER.

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).

Launch of the 2nd International Indian Ocean expedition (IIOE-2): This expedition was motivated by SCOR, SIBER, IOP and IOGOOS and it is sponsored by SCOR, IOC and IOGOOS. The IIOE-2 has become the main focus of SIBER.

Completion/publications of the IIOE-2 Science Plan (Hood et al., 2015): The IIOE-2 Science Plan was commissioned by SCOR and developed by the SCOR IIOE-2 Science Plan Development Committee beginning in April/May 2014. The development was based on several IOC-sponsored "Reference Group" planning meetings and national meetings. A progress report was delivered to SCOR in Bremen in September 2014. The first draft was completed in February 2015. The final peer-reviewed and revised draft was delivered to the IOC Interim Planning Committee in April 2015 and accepted. The plan was finalized and printed for the Goa Symposium in November 2015.

Completion/publication of the IIOE-2 Implementation Strategy (IPC, 2015): In June/July 2014 the IOC establish (through Resolution EC-XLVII.1) the IOC IIOE-2 Interim Planning Committee (IPC). The IPC was tasked to propose to the IIOE-2 sponsoring organizations (IOC, SCOR and IOGOOS) the establishment of committees to oversee the planning and implementation of IIOE-2. The IOC Executive Secretary coordinated the establishment of the IPC (through a call via IOC Circular Letter No. 2541, in September 2014). The IPC met four times by teleconference and twice in person in 2015 to undertake these assigned tasks. The IIOE-2 Implementation strategy was finalized and printed for the Goa Symposium in November, 2015.

Goa IIOE 50th Anniversary Symposium and Launch of the IIOE-2: The symposium was convened at NIO in Goa, November 30 through December 4, 2015. Special sessions followed the IIOE-2 Science Plan research themes. The first cruise of IIOE-2 was launched on the last day of the symposium. The symposium was followed by the SCOR general assembly and the joint SIBER/IOP/IOGOOS/IRF meetings.

Launch of the Eastern Indian Ocean Upwelling Research Initiative (EIOURI): EIOURI is a major SIBER research initiative under IIOE-2. Planning for EIOURI is at an advanced stage. The main foci of this initiative is on the upwelling regions that develop seasonally off Java, Sumatra, and northwestern Australia. The Science Plan for EIOURI has also been completed (Yu et al., 2016).

Development of the Western Indian Ocean Upwelling Research Initiative (WIOURI) (Roberts et al., in preparation): In addition to EIOURI, planning efforts have been initiated to develop a complementary upwelling research initiative under IIOE-2 on the western side of the basin.

SIBER has strong collaborations with various regional organizations (e.g., Indian Ocean Panel of CLIVAR and IOGOOS). This collaboration provides a model for successful CLIVAR-IMBER collaboration.

D. Activities of IMBER Working Groups and Task Teams

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 Surface Ocean CO_2 Atlas (SOCAT) includes more than 100 contributors, and has assembled surface ocean carbon dioxide (CO_2) data in a uniform, quality-controlled format. Version 1 was made public in 2011 at the IMBER-SOLAS Carbon conference in Paris. Version 3 was released just before the SOLAS Open Science Conference 2015 in Kiel, Germany.

SOCAT Version 3 provides surface water fCO_2 (fugacity of CO_2) values from 1957 to 2014 (i.e., 58 years) for the global oceans and coastal seas with 14.5 million unique data points (4.4 million data points more than Version 2), from over 3,600 datasets. The SOCAT synthesis and gridded data products can be interrogated via interactive online viewers or downloaded in a variety of formats from the SOCAT website (www.socat.info). The quality control criteria have been adapted for Version 3 to accommodate calibrated CO_2 data from new sensors and alternative platforms. Data submitted before the end of January 2016 will be quality-controlled and

made public in SOCAT version 4 on 30 June 2016. Applications of the SOCAT Atlas include process studies, quantification of the ocean carbon sink, 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 pCO_2 Mapping intercomparison (SOCOM) is a recent initiative that compares a total of 14 surface ocean CO_2 gridded products, derived by a variety of methods, many of them based on SOCAT.

Interior Ocean Carbon (SIC!-IOC)

Recent activities focused on analysing the carbon data from hydrographic surveys to determine change in the oceans' anthropogenic CO_2 content since the 1990s. The preliminary results from the first decade of GO-SHIP were presented in a review paper. The WG will finalize the results on the basis of GLODAPv2, the quality-controlled database released in January 2016 for CO_2-relevant biogeochemical and physical parameters from 724 scientific cruises covering the global ocean.

IOC also contributed to the joint GO-SHIP/Argo/IOCCP "Sustained ocean observing for the next decade" meeting in Galway, Ireland http://www.gaic2015.org. They continue to support the development and application of biogeochemical sensors on Argo floats. Recently, they contributed to the draft BGC-Argo Implementation Plan and reported on it to the Argo steering team in March 2016. IOC is likely to engage fully in the data synthesis and integration on a global/basin-scale.

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 SIOA was instrumental in the development of the OA International Coordination Centre (OA-ICC) and in co-design and co-production with a range of stakeholders. OA-ICC is mainly driven by the SIOA. 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, the IMBER SSC Chair and is chaired by a SIOA member.

The 4th Ocean in a High-CO_2 World Symposium was held in Hobart, Australia, 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)

With the tragic death of past CMWG co-chair Konkee (K.K.) Liu, and the re-organisation of LOICZ as Future Earth Coasts (FEC), the CMWG has been semi-quiescent this year. However, Karin Limburg has now been appointed as the IMBER CMWG co-Chair and Don Forbes her FEC counterpart. New activities are being planned to progress the ideas developed by the CMWG in the previous three years. The priority areas identified in Glavovic et al. (2015) map well onto the IMBER Grand Challenges. Because these are somewhat general, it is necessary to refine and test them with case studies. Accordingly, it is suggested that two good test areas would be: 1) a densely populated part of the world, where severe pollution/hypoxia/etc. is in conflict with fisheries, aquaculture, and other consumptive activities, e.g. southern Asia, and 2) a sparsely populated part of the world, e.g. the Arctic, where climate warming is driving an increase in economic activities and exploitation in fragile, largely pristine continental margins. New CMWG members are being selected according to expertise relevant to the case studies.

A proposal to fund a workshop to organize the first case study was submitted to the Asia Pacific Network (APN), however unfortunately it was rejected. The Arctic case study has yet to be developed and connections with the IMBER ESSAS programmes and ESA are being made. Both IMBER and FEC succesfully applied for IGBP/ESA funds to support a workshop on the Arctic focus within the CMWG, and the planning for this is underway.

Data Management Committee (DMC)

The current Data Management Committee (DMC) has achieved what it set out to do. If the group is to continue, new members with expertise in social science data, and maybe in animal tracking, GOOS, etc. need to be appointed and new Terms of Reference developed.

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 in October 2015 the DMC provided advice and guidance on all data-related issues.

Capacity Building Task Team (CBTT)

At the last IMBER SSC meeting it was agreed that the Capacity Building Task Team has done an excellent job, and has fulfilled its mandate. As capacity building is now included in all IMBER activities and events, once the IMBER capacity building legacy document is published, the members will be thanked and the Task Team disbanded. IMBER will ensure that the recommendations in the legacy document are properly considered/ fulfilled.

Human Dimensions Working Group (HDWG)

The group is finalising a book comprising 19 chapters related to I(MBER)-ADApT (Assessment based on Description, Responses and Appraisal for a Typology, http://www.imber.info/Science/Working-Groups/Human-Dimensions/I-MBER-ADApT) and has published a special issue (February 2016) in *Regional Environmental Change*. They will also convene a session at the World Fisheries Congress in Korea in May 2016 together with ICES and PICES. It is hoped this might lead to better linkages with natural and social sciences, including governance. 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 achievments has been the development of the I(MBER)-ADApT decision support tool.

Four new members have agreed to join the HDWG next year, including van Putten, thus ensuring a continued HDWG-SSC link when Bundy and Chuenpagdee rotate off.

I-ADApT has been published and is now being tested with an increasing number of case studies. The goal is to include about 100 cases.

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

There have been two major events on upwelling since the last IMBER SSC meeting in June 2015. Enrique Curchitser, leader of the Research Focus (RF) group, organized a workshop in Ankara, Turkey, in October 2015 to further plan the work of the Upwelling WG. It was held following a CLIVAR summer school. A total of 18 participants were involved representing several disciplines: physical oceanography models and observations, atmospheric sciences, biogeochemistry, climate modelers, and fisheries scientists. Reuben Escribano was the IMBER representative although a number of other IMBER scientists such as Colleen Maloney, also attended. The discussion centered primarily on Eastern Boundary Upwelling Systems (EBUS). Particular attention was paid to global climate model biases resulting from the lack of resolution in EBUS.

Some of the major points of the discussion included:

- There is need to design proper metrics for climate models. Significant work is needed on the atmospheric and coupled atmosphere/ocean dynamics in EBUS.
- What observations are needed, e.g. glider lines, etc.? Oxygen Minimum Zones (OMZs) and their interaction within upwelling regions were discussed.

- More information is needed on the origin and destination of the upwelled waters.
- The definition of an EBUS needs to be refined and comparison between different systems need to be highlighted
- The role of the meso- and sub-mesoscale processes in determining characteristics of EBUS needs to be elucidated.
- Detailed resolution of coastal winds in upwelling zones is required.
- It was recognized that fisheries in upwelling areas need to be addressed and a plan was drafted regarding the use of models to understand the impacts of climate variability on EBUS Schematics of EBUS processes in a coupled atmosphere/ocean system were drawn up.

The second major event was the Upwelling Workshop at IMBIZO IV in Trieste, Italy led by Francisco Chevez, Eddy Allen and Nina Bednarsek. The main objectives of the workshop were to:

1. Determine how integrated and coordinated projects can be developed so that the relative roles of natural climate variability, anthropogenic climate change, broader global change and human responses can be elucidated and predicted.
2. Integrate perspectives from a broad range of disciplines, including oceanographers, ecologists, economists, political scientists and others with interests in coastal systems and their dependent human populations.
3. Prepare a white paper/synthesis paper incorporating novel ideas generated during the sessions

E. Other IMBER activities

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

Developing the new SPIS (2016-2025) "IMBER into the Future" wasa major task for the SSC Chair and the IPO.The SPIS 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 was submitted to SCOR and Future Earth (FE) in November 2015 for joint review, and about 10 reviewers (selected by SCOR and FE) have delivered their reviews. Based on this SCOR and FE are producing a joint document suggesting improvements/changes for IMBER to consider before making the final version openly available.

IMBER will maintain its focus on fundamental biogeochemisy and ecosystem reseach 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.

Preparing for the ClimEco5 Summer School

IMBER ClimEco Summer Schools are held every two years and are a successful capacity building mechanism for engaging students and early-career scientists. The planning for the summer school to be held in August in Natal, Brazil is on schedule. The theme is *Towards more resilient oceans: Predicting and projecting future changes in the ocean and their impacts on human societies*. We have had > 200 applicants, approved about 90 from more than 30 different countries and expect about 10% to drop out. There is some concern regarding the zika virus outbreak, and all approved candidates has been thoroughly notified and given links to important websites.

IMBIZO IV & V

The IMBIZO IV (held in Trieste, Italy 26-30 October 2015), co-convened by Xavier Arístegui and Ingrid van Putten, was very successful. There were four concurrent workshops instead of the usual three. Presentations during the workshops showed the state of the art of the science in the four themes, and there was discussion regarding the way forward and IMBER´s role.

Before the start of the IMBIZO, early career workshops were held on how to write a good publication, and how to write a good grant proposal.

Each workshop will produce a synthesis paper or special issue.

An article on the IMBIZO was published in the April edition of the OCB newsletter.

IMBIZO V will be held in 2017 in Woods Hole, most probably at the beginning of October, and it was suggested that the next IMBER SSC meeting should be held in conjunction with IMBIZO V, to involve more SSC members.

Based on the IMBER SSC decision to use the workshops to specifically progress implementation of the SPIS, potential topics for IMBIZO V are:

IMBIZO V – Overall theme: Sustainable Oceans in the 21st Century

1. Metabolic diversity and adaptation (Herndl/Rynearson)
2. IMBER scenarios/projections and their applications (Bopp and FISHMip)
3. Putting human behaviour into models (MSE) (van Putten/ Werner)

IMBER contributions to IGBP synthesis and celebration at AGU

The IMBER manuscript to the IGBP synthesis special issue of *Anthropocene* was accepted and published in late 2015.

A final IGBP celebration was held at the Fall Meeting of the American Geophysical Union in San Francisco, 14-18 December 2015. An IGBP-IMBER session was convened at the meeting, where Hofmann presented results from the four workshops of IMBIZO IV and a summary statement.

IMBER and Future Earth (FE)

IGBP ended in December 2015 and a transition document (TD) to Future Earth (FE) was developed (lead by Hofmann) being a formal request by IMBER to become a core project of FE. Reviews of the TD have been very positive this far, so the process is essentially a formality. The signing of a FE-SCOR-IMBER Memorandum of Understanding (MoU), outlining how they will work together, will be the final formality.

The IMBER chair and IPO is actively taking part in the development of Future Earth, in particular delivering inputs to several Knowledge Action Networks (KAN) with a focus on the OCEAN KAN. We will participate in aFE Core Project meeting in Bern in June 2016, and the IPO is involved in the FE/IPBES fast track initiative.

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

IPO

The present IPO funding from IMR and the Norwegian Research Council (NRC) runs out at the end of March 2017. Meetings have been held with the IMR leadergroup and several NRC directors, resulting in a "promise" for cofunding for another three years (until end of March 2020). An IPO project proposal has been sent to NRC on this, and the final decision is expected mid June 2016.

Since the present IPO director is getting close to retirement, a process is underway for his replacement. The IMR leadergroup decided this would happen via an internal advertisement process at IMR, and IMBER will have key IMBER people in the evaluation committee.

The IPO also planned and executed (in late November 2015) a Sweden-IMBER workshop in Stockholm on "Effects of ocean acidification on ecosystems and human societies" which recuited about 40 new "members" to the IMBER community. At the same time the IPO took part and presented IMBER at the opening of the Stockholm Future Earth Hub.

The IPO organised the IMBER SSC meeting in New Orleans in February 2016 alongside the ASLO/AGU/TOS Ocean Science Meeting.

The IPO director is part of the Science and Technology Advisory Board for the European Copernicus Marine Environment Monitoring Service (CMEMS) having about two meetings per year. CMEMS is looking for more users of their services related to marine ecosystems, and this may be a source for IMBER to use.
In March 2016 the IPO attended the Future Earth/IPBES indicator workshop in Switzerland.

The IPO is struggling with getting the new web site up to a quality ready for release,

RPO

The present RPO funding from the East China Normal University in Shanghai ends in 2016. An active process is ongoing to renew the funding.

The leader of the RPO, Yi Xu represented IMBER at the successful 7th China/Japan/Korea (CJK) IMBER symposium at the KIOST Jeju centre. The results from the symposium will soon be presented in an IMBER newsletter.

Xu also participated in the IOC/WESTPAC-CorReCAP Workshop which was held at SKLEC, ECNU. Under the leadership of Dr. Jing Zhang, the RPO will produce a book synthesizing the anthropogenic impact on Coral Reefs in the West Pacific region, and they are applying for funds from IOC/WESTPAC to run a summer training course about the influence of ocean acidification on Coral Reefs.

F. IMBER SSC member nominations

Hofmann ended her term as SSC Chair at the end of 2015. There is no call for nominations with regard to the Chair. Rather, the Executive Committee identifies individuals who is/has been involved with IMBER. The Executive Committee suggested Carol Robinson (University of East Anglia, UK and former IMBER SSC member), and she took over from the beginning of 2016. Hofmann remains as *ex officio* Past Chair in 2016.

Three new SSC members are needed and a call for nominations went out in April 2016. In relation to the existing and outgoing expertise we search for scientists with skills in:

- marine sustainability science
- marine policy/governance science
- integrated modelling of social and marine ecological systems
- biodiversity/adaptation science
- communication (ocean literacy)

Nominations are still being received with a deadline in late May 2016.

G. IMBER cooperation

IMBER has been closely collaborating for many years with SOLAS (see SIC!) and LOICZ (now Future Earth Coast, see CMWG above) and recently with CLIVAR, and with other projects and 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 issf.toobigtoignore.net, and this can be used for case studies for I-ADApT. There was collaboration at IMBIZO IV. A TBTI Fellowship (3-4 month placement or Postdoc) will soon be launched. Chuenpagdee recommended that IMBER-relevant organisations with mutual interests should be encouraged to consider hosting a TBTI-IMBER Fellow

b. Ocean Carbon Biogeochemistry (OCB)
OCB continues to actively support IMBER by advertising its activities and events, and by providing financial support for activities. OCB provided travel support for five participants from the USA to attend IMBIZO IV. IMBER has always had a SSC member on the OCB SSC. Hofmann rotated off and is replaced by Mike Roman (IMBER Vice-Chair 2006-2012).
In the interests of raising IMBER's profile in the USA, Hofmann has suggested a session proposal for the OCB summer workshop in 2017.

c. WCRP

CLIVAR, a core project of WCRP and its Indian Ocean panel works closely with SIBER. CLIVAR will hold an OSC from 19-23 September 2016 in Qingdao, China and several IMBER-related sessions will be convened as this conference. A Joint Upwelling WG is established, now represented with Escribano from the IMBER SSC.

d. 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). Also the SOLAS-IMBER Carbon WG have good links to GOOS. Increased alignment with GOOS will help IMBER deal with the challenge of ocean data. Links have been established with Eric Lindstrom (co-chair of GOOS). IMBER responded to the recent GOOS Biology Panel survey for metadata.

e. ICES

The IMBER IPO had an information booth at the ICES Annual Science Conference in Copenhagen, Denmark in September 2015. In addition to having more than 100 WGs on IMBER-relevant science, ICES provides official management advice (for the north Atlantic) with strong interaction with stakeholders. The management advisory processes have very strict quality assurance procedures, which are beyond IMBER´s capacity. ICES is funded by member countries and has a secretariat of more than 50 people and arranges annual science conferences (ASC) with about 700 participants including several IMBER scientists. Next ASC will be in Riga, Latvia 19-23 September 2016, and next year in Fort Lauderdale, US 18-21 September 2017.

f. IOC

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.

g. Hjort Centre

The Hjort Centre for Marine Ecosystem Dynamics is an active research cluster in Bergen with similar goals to IMBER. The Hjort Centre administration is collocated with the IMBER IPO at the Institute of Marine Research in Bergen with effective exchange of information between the two research communities

h. PICES

IMBER and PICES continue to collaborate, with representatives from both communities attending and funding each others activities, such as summer schools and science meetings. PICES will hold their 25th Annual Meeting in November 2016

H. Selected IMBER Publications

IMBER has produced more than 1000 refereed research papers since its implementation; about 150 papers were published in 2015-2016.

Publications related to recent discoveries and highlights

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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 and soon ready for release and 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, and the transfer has taken much longer than anticipated. Once the new site at IMR is launched, it will have a new more regularly updated news section, and the community will be encourged 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 a year, and re-directed through multiple channels to about 10,000 researchers:

- ***Issue n°30*** – April 2016. The IMBER IMBIZO IV that was held in Trieste, Italy last year provides the impetus for this issue of the IMBER Update. IMBIZOs are IMBER´s flagship 'gatherings' (this is the meaning the Zulu word 'IMBIZO'). They are held every second year and bring together about 120 mutlidisciplinary scientists to discuss and synthesise the current state of knowledge about marine and human systems and their linkages, and to consider key research questions for the IMBER community to address going forward. The overall theme of IMBIZO IV was *Marine and human systems: Addressing multiple scales and multiple stressors*.
- ***Issue n°29*** – December 2015, is dedicated mostly to articles pertaining to the CLImate Impacts On Top Oceanic Predators (CLIOTOP) Regional Programme. They held their 3rd Symposium, titled "Future of oceanic animals in a changing ocean", in Spain in September. In addition to highlighting some of the excellent work that CLIOTOP working groups and individual scientists have done in the years since the last symposium in New Caledonia, this gathering also provided the opportunity to get community input about the direction that the programme should go in its next phase.
- ***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.

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, workshops and conference announcements are also included.

The IMBER contact database is continually 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 national and international meetings during 2015.

I. 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 IMBIZO V that will be held in Woods Hole in early October 2017.

Amount requested: 10 000 USD

J. Strategic development

IMBER is entering into its second decadal period based on the new IMBER SPIS and involving Future Earth instead of IGBP

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 forms the basis for FE's incorporation of IMBER as a core project. The transition document (TD) includes a description of what IMBER can bring to FE in terms of science and as an international network of researchers. The TD also includes 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.

The IMBER SSC met in February 2016, and proposed the following strategic actions for IMBER:

1. To work towards better integration between the regional programmes and working groups, focusing particularly on the priority research areas.
2. IMBIZO workshops will be targeted towards implementation of the SPIS.
3. Link to experts on governance, maintain social science expertise on the SSC
4. Delegate members of the SSC as "champions" to lead the progress of the different SPIS challenges
5. Create stronger links to organisations dealing with global observations
6. Implement an action plan to raise the profile of IMBER
7. Revamp the Data Management Committee to better deal with both natural and social science data,
8. Decide whether to change the name of IMBER and if so, create a strategy to communicate the new name
9. Make a strong contribution to the FE Oceans KAN
10. Start preparing for the 2nd IMBER open science conference in 2019
11. Find ways to better measure success
12. Find more funding

K. Budget

The SCOR omnibus grant from the National Science Foundation, which provides support for IMBER, was last year funded for three years. Support for the SSC meeting was also achieved from Future Earth. In addition leftover money from IGBP and IGBP/ESA were received making 2016 a quite good financial year. If no extra funds are achieved for 2017, the IMBER program and WG activities must be reduced significantly. A proposal through SCOR was sent to NASA for a new grant that supports activities of the HDWG, ESSAS and the SIOA, + extra support to the IMBER/CLIVAR Upwelling Group. There are signals that the NASA proposal will be approved. A European Cost Action proposal is planned to be submitted in 2016. Ideally an additional 100K USD per annum sponsorship would enable us to do all the new things, as well as continuing the on-going work. There are currently no funds available to allow us to increase IMBER's visibility, so activities to raise the profile of IMBER have to be cost-neutral for the time being.

Some activities may be reduced in 2016, and related funds are requested to be transferred to 2017.

APPENDIX 7

Surface Ocean – Lower Atmosphere Study (SOLAS)

SOLAS Annual Report to SCOR

Reporting period: September 2015- May 2016 Version of 13 May 2016 by Stefan Kontradowitz

I. Progress on implementation of project science and implementation plans, and schedule for major project activities, including open science meetings, major data releases, synthesis activities, and project completion

I.a. **SOLAS Scientific Steering Committee**

Since January 2015 Véronique Garçon from France serves as Scientific Steering Committee (SSC) chair, with her term ending in December 2017. Before becoming the SSC chair she spent two terms as an SSC member between 2007 and 2012.

SOLAS has an Executive Committee composed of the chair, Lisa Miller, Brian Ward and Cristina Faccini. Since the last report the following SSC members rotated off in December 2015:

- Cecile Guieu,
- Christoph Heinze, and
- Nojiri Yukihiro.

Ending his first term and being selected for a second term in the SSC was Ilan Koren. In January 2016 three new SSC members were appointed:

- Philip Boyd (M, Australia),
- Andrew Jessup (M, USA), and
- Parvadha Suntharalingam (F, UK).

The SOLAS SSC met in Hamburg, Germany, 11-13 September 2015 for its 15th SSC meeting following the SOLAS Open Science Conference 2015, which took place in Kiel, Germany. The next SSC meeting is currently scheduled to take place between 24 and 26 October 2016 in Qingdao, China. This meeting will be followed by a `SOLAS Symposium Day` where some SSC members and local researchers will be able to present their work. This will be the third time a SOLAS SSC meeting will be followed by a `Symposium Day` as it proved very successful in Japan in 2013 and in Israel in 2014. Because of the SOLAS Open Science Conference a Symposium Day was not organized in conjunction with the 2015 SSC meeting in Hamburg.

The current membership of the SOLAS SSC is listed below (16 members including the chair):

Last name	First name	Country of employment	Gender	Scientific expertise	Term end on 31 Dec
Boss	Emmanuel	USA	M	Ocean optics and biogeochemistry	2017
Boyd	Philip	Australia	M	Marine biogeochemistry	2018
Engel	Anja	Germany	F	Microbial biogeochemistry, sea surface microlayer	2017

Facchini	Cristina	Italy	F	Physical and chemical processes in multiphase atmos. systems	2017
Gao	Huiwang	China	M	Atmospheric deposition and ecological effect	2017
Garbe	Christoph	Germany	M	Air-sea physical interaction	2016
Garçon	Veronique	France	F	Marine biogeochemistry and ecosystems dynamics	2017
Graco	Michelle	Peru	F	Biogeochemical cycles in upwelling systems, OMZ	2017
Jessup	Andrew	USA	M	Air-sea interactions, remote sensing	2018
Koren	Ilan	Israel	M	Cloud Physics	2018
Levasseur	Maurice	Canada	M	Ocean biogeochemistry, dimethylsulfide, Arctic, ice algae	2017
Miller	Lisa	Canada	F	Sea-ice/CO_2 exchanges	2016
Saiz-Lopez	Alfonso	Spain	M	Atmospheric halogens/modelling	2016
Sarma	VVSS	India	M	Biogeochemical cycling of C and N in the ocean and estuaries, stable isotopic geochemistry/ocean acidification	2017
Suntharalingam	Parvadha	UK	F	Numerical modelling / C, N, S bgc cycles	2018
Ward	Brian	Ireland	M	Air-sea physical interaction	2016

The current gender and country balance of the SSC is as follows; for a total of 16 members including the chair:

- 6 female members and 10 male members
- 3 members from developing countries and 13 from developed countries

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

Since 2008, SOLAS has supported the development of the Mid-term strategy (MTS) themes, identified as areas where progress can be accelerated significantly with the support of an international programme such as SOLAS. A good summary/overview of the research of the MTS is available through the article

> Law C. *et al.* (2013) Evolving Research Directions in Surface Ocean - Lower Atmosphere (SOLAS) Science. Environmental Chemistry. Available on the SOLAS website and at http://www.publish.csiro.au/view/journals/dsp_journals_pip_abstract_Scholar1.cfm?nid=188&pip=EN12159

Since the 2015 report, the new SOLAS science plan has been finished and provided to the sponsors. Because of new themes mentioned and described in detail in the science plan (see I.g) some topics of the Mid-term strategy have progressed less than in previous years.

- Sea-ice biogeochemistry and interactions with the atmosphere

Activities of the MTS on sea-ice are intrinsically linked to the **Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) SCOR WG 140**, chaired by Jacqueline Stefels and Nadja Steiner.

Because of the strong linkage to SOLAS and the conclusion of the SCOR support to this group in 2016, BEPSII is now co-sponsored by SOLAS and CliC (Climate and Cryosphere) since early 2016.

During the SOLAS Open Science Conference 2015 a discussion session on `**Towards joint SOLAS-CliC activities on sea-ice biogeochemistry**` took place which led to the co-sponsorship mentioned above. The session was convened by Lisa Miller and Martin Vancoppenolle. Below is a short summary provided by Lisa Miller:

Following on their successes, SCOR working group 140 on "Biogeochemical Exchange Processes at Sea-Ice Interfaces" (BEPSII) identified a need to sustain the community studying sea-ice biogeochemistry beyond the lifetime of the SCOR working group, in order to develop consistent methodologies, establish effective sea-ice data archiving approaches and databases, integrate observational and modelling efforts, and foster technological developments. While sea-ice biogeochemistry has been a mid-term strategy of SOLAS, which has endorsed BEPSII, the WCRP Climate and Cryosphere (CliC) project has Arctic and Antarctic sea ice working groups and a Sea Ice and Climate Modelling Forum that are also working towards similar goals from a more physical perspective. Therefore, we held a discussion at the SOLAS Open Science Conference to explore ways SOLAS and CliC can jointly promote activities in sea-ice biogeochemistry.

The goal of the discussion was to develop a draft proposal to the CliC and SOLAS steering committees for a joint framework to support continuing developments in sea-ice biogeochemical research. We were largely successful in achieving that goal, in that a CliC Forum application is being prepared for their November 15th deadline, and we will also submit a modified version of that proposal to SOLAS. However, the requirements for that application are very brief and general, and much of the discussion pursued more detailed ideas for long-term BEPSII activities.

We started the session with a presentation by BEPSII co-chair Jacqueline Stefels on BEPSII history, starting with the SOLAS mid-term strategy and an initial COST-SOLAS workshop in Amsterdam in 2011, followed by provisional acceptance as a SCOR working group later that year and their first (unofficial) meeting at the 2012 SOLAS Open Science Conference. The final BEPSII meeting under the auspices of the SCOR working group will be held in Paris during March 2016.

The initial aim of BEPSII was ambitious: To improve our understanding of the role of sea ice in global biogeochemistry by bringing together sea-ice modelers and observationalists. This goal was approached through four activities:

1. Standardisation of methods for data inter-comparison;
2. Summarizing existing knowledge in order to prioritise processes and model parameterizations;
3. Up-scaling of processes from 1D models to earth system models; and
4. Analysing the role of sea ice biogeochemistry in climate simulations. Despite substantial successes, much of this work still remains incomplete, and the need for additional activities has become apparent.

Martin Vancoppenolle then presented the general goals and structure of CliC (www.climate- cryosphere.org), including their 'Fora' which provide a framework for long-term association of communities addressing specific issues in crysopheric science. Support provided for a forum includes 5000 CHF/year to support a workshop, travel bookings, and hosting a website. Lisa Miller then described the activity structures and resources available from SOLAS, noting that their structures are in no way incompatible with those of CliC.

The open discussion was then set up with a list of ideas for future BEPSII activities identified at the last BEPSII meeting (in Barga, Italy, March 2015) and through a survey of the BEPSII mailing list in late summer. The discussion was framed by 4 themes: networking mechanics and funding; scientific topics and issues; membership, including entraining more atmospheric scientists; and boundaries.

In March 2016, a three day **BEPSII meeting** took place in Paris to discuss about the future of the project. This was the last meeting under the SCOR umbrella, and dedicated to discuss the continuation of BEPSII. The SOLAS chair attended the meeting.

In addition to 1.5 days of interesting talks, the group had several discussion sessions and worked out a set of new and continued task groups with focused research covering: Methodologies and data collation, modeling and observational process studies, synthesis and outlook as well as outreach. A full list of tasks with requests for community participation will be accessible from the BEPSII website as well as communicated via BEPSII's new Twitter page. BEPSII's next meeting will be at Scripps Institution of Oceanography in San Diego, on April 3-5, 2017, with support from SOLAS and CLIC. A proposal for additional support from IASC has been submitted. Members of the BEPSII group also submitted a new SCOR proposal in support of method intercomparison studies.

An additional short outcome report of the meeting provided by Lisa Miller can be found below:

BEPSII's FUTURE: Discussion Paris meeting 18 March 2016

Goals and Objectives

- Develop dedicated consistent methodologies for sea ice biogeochemical research
- Establish effective sea-ice biogeochemical data archiving approaches and databases
- Foster ecological process studies to determine their impact on biogeochemical cycles.
- Foster technological developments towards large-scale, autonomous and high-frequency sampling of sea ice biogeochemical parameters
- Improve the representation and evaluation of sea ice biogeochemistry in regional and Earth System numerical models
- Synthesize and integrate observational and modeling efforts
- Continually revise and renew scientific foci, teams, and objectives

Task groups and Products
TG1 on Methodologies and data collation
(Leads: Lisa Miller Lisa.Miller@dfo-mpo.gc.ca and Klaus Meiners Klaus.meiners@aad.gov.au)

- Intercalibration & intercomparison campaign (SCOR prop) (Francois Fripiat ffripiat@ulb.ac.be)
- In-situ platforms / sensor development & validation (Hauke Flores, Klaus Meiners)
- Remote-sensing tools and algorithms (who?)
- Designing time series process studies (inform MOSAIC) (Bruno Delille, Anya Waite anya.waite@awi.de , Martin Vancoppenolle)
- Guide of best Practice as life document (Lisa Miller, Bruno Delille, Klaus Meiners)
- Historical data collation and analysis; emphasis on Arctic (Ilka Peeken ilka.peeken@awi.de, Martin Vancoppenolle, Nix Geilfus nxgeilfus@gmail.com)
- Tools and protocols for genetic community assessments (Jeff Bowman bowmanjs@ldeo.columbia.edu , Katja Metfies Katja.Metfies@awi.de)

TG2 on Modeling and observational process studies
(Leads: Nadja Steiner nadja.steiner@canada.ca and Hauke Flores Hauke.Flores@awi.de)

- Ridges-associated processes (Giulia Castellani Giulia.Castellani@awi.de)
- Impact of micro plastics on sea-ice ecosystems (Ilka Peeken, Gunnar Gerdts: ilka.peeken@awi.de , Gunnar.Gerdts@awi.de
- Time variability of algal wax and wane (Nadja Steiner, Maria van Leuuwe m.a.van.leeuwe@rug.nl)
- Interactions of snow and sea ice (James France J.France@uea.ac.uk, Jennie Thomas Jennie.Thomas@latmos.ipsl.fr, Thorsten Bartels-Rausch thorsten.bartels-rausch@psi.ca , Bruno Delille)
- Impact of biochemistry on physical ice properties (Elena Golubeva elen@ommfao.sscc.ru, Nadja Steiner)
- Upscaling (Hauke Flores, Klaus Meiners, Nadja Steiner)
- Intercomparison of 1D models (Letizia Tedesco, Martin Vancoppenolle)
- Intercomparison of 3D models (Nadja Steiner, Clara Deal deal@iarc.uaf.edu)
- Analysis of regional and global climate models (CMIP 5 / 6; FAMOS) (Martin Vancoppenolle, Nadja Steiner)

TG3 on Synthesis and outlook
(Leads: Martin Vancoppenolle martin.vancoppenolle@locean-ipsl.upmc.fr and Delphine Lannuzel Delphine.Lannuzel@utas.edu.au)

- Conceptual model development: ice-pelagic-benthic coupling and OA (Sebastian Moreau Sebastien.Moreau@hotmail.com, Jacqueline Stefels, Nadja Steiner, Letizia Tedesco)
- Conceptual model development: DMS(P) cycle and connection to paleoclimatology (DMS in sea ice review) (Jacqueline Stefels, Gauthier Carnat gauthier.carnat@gmail.com , Nadja Steiner)
- Conceptual model development: sea ice - paleoclimatology connection (Celia C.J.Sapart@uu.nl , Gauthier Carnat, Jacqueline Stefels)
- Functional interactions across trophic levels (Hauke Flores, Maria van Leuuwe, Janne Rintala, Letizia Tedesco)
- Methane-in-sea ice synthesis (Celia Sapart, Ellen Damm, ellen.damm@awi.de
- Review papers on major biochemical processes (Elementa special issue – in progress – contact Nadja Steiner)

TG4 on Outreach
(Leads: Bruno Delille Bruno.Delille@ulg.ac.be , Letizia Tedesco Letizia.Tedesco@ymparisto.fi)

- Stakeholder links (Nadja Steiner)
- Outreach to general public: Facebook (Bruno Delille),
- Outreach to stakeholders: Twitter (Letizia Tedesco)
- Outreach to science: website (Bruno Delille)
- Capacity building: Summer school (Letizia Tedesco)
- Logo

Following is a short overview provided by the task groups of BEPSII:

Task Group 1 on Methodologies and Intercomparisons (Leads: Lisa Miller and Lynn Russell):
Task Group 1 on Methodologies was not very active over the last year except preparing the new SCOR working group proposal, which was submitted to SCOR in April 2016. There was at least one small-scale intercalibration experiment in Hokkaido this winter, but the outcome is not yet known.

Task Group 2 on Data (Leads: Klaus Meiners and Martin Vancoppenolle, information provided by K. Meiners):
The BEPSII Task Group 2 on Data has progressed several historical data collation efforts over the last 12 months. New data collations contributing to, or conducted through BEPSII, include: i) a circum-Antarctic fast ice core chlorophyll a data set from a total of >900 ice cores collected over the last three decades, ii) an Antarctic sea ice core (particulate and dissolved) iron data set, and an iii) Antarctic sea ice macro-nutrient data set. European teams have progressed the collation of Antarctic sea ice dissolved inorganic carbon/total alkalinity data sets and a bi-polar ice algal biodiversity data set. The task group recommends further collation and analysis of existing/historical data, in particular particulate organic carbon (POC) and dissolved organic carbon (DOC) data from Antarctica. The group is also looking for colleagues to lead and champion the collation of various Arctic data sets (e.g., macro-nutrients, POC and DOC). The BEPSII data team has also developed a variety of new MATLAB scripts to read information from standardised data-entry forms (ASPEct-Excel sheets), and these will be made available through the BEPSII home page in the near future. Discussion within this task group and the BEPSII research community also identified the need for simultaneous long-term observation of physical/biological/biogeochemical sea ice parameters and recommends the development of automated sampling platforms and in-situ sensors.

Task Group 3 on Modeling (Leads: Nadja Steiner and Clara Deal, information provide by N. Steiner): Task 1- The paper "What sea-ice biogeochemical modellers need from observationalists" is now published in *Elementa* (BEPSII SF)1 and the task completed

1 http://www.elementascience.org/articles/84

Task 2-Review papers on major biogeochemical processes – This task is still in progress, more than 10 papers are submitted or published and a similar amount is in preparation. Submission deadline for the *Elementa* SF has been extended to June 30, 2016. A summary of all BEPSII papers is attached.

Task 3 - 1-D model intercomparison. Ice-algae comparison has been delayed due to issues with the Antarctic data set. It was decided to continue with the intercomparison with the Arctic (Resolute) data set only. A publication comparing parameterisations of mixed layer processes is in preparation. A DMS intercomparison has not yet been done, due to a lack of models, but will be pursued in the future. Despite limited progress in 1-D model intercomparisons, lots of progress has been made in 1-D model development.

Task 4 – Application and evaluation of regional and global models. Several intercomparsions of Arctic biogeochemistry have been performed and published; however, so far hardly any of the models included sea-ice biogeochemistry and evaluation was restricted to the pelagic environment. Progress is being made with respect to the implementation of sea ice algae in regional and global models and an intercomparisons will be pursued in the near future within the framework of FAMOS. The link to FAMOS will be strengthened in the next phase of BEPSII due to enhanced focus on ice -pelagic and benthic coupling.

- Air-sea gas fluxes at Eastern Boundary upwelling systems

During the SOLAS Open Science Conference 2015 a discussion session on this topic titled `**Priorities and integrated programs for the study of eastern boundary upwelling systems**` took place. A report about the session can be found below:

Introductory talk EBUS by F. Chavez (F.C.)
The main biogeochemical features which are common to all EBUS result from the occurrence of coastal upwelling. In these systems cold, nutrient and CO2-rich waters transported to the surface not only result in enhanced gas exchange with the atmosphere, but also in fertilization of the upper layers of the ocean which in turn stimulates biological production at all trophic levels. In addition, the creation of low oxygen (O2) environments is a typical characteristic of EBUS, due to the enhanced rain of organic material from the surface.

Understanding long-term physical and biogeochemical variability in EBUS is important considering their potential socio-economic impact for activities such as fisheries. EBUS are susceptible to climatic variability due to their close association with atmospheric circulation. Hence, large-scale climatic changes (e.g. ongoing global warming) might have significant effects, although the individual responses of different EBUS can be markedly different. Nevertheless, EBUS are poorly represented in global models and more work is needed to elucidate their potential responses to future climate change.

Given the fact that EBUS are sites of intense ocean-atmosphere coupling, and because their study requires a multidisciplinary approach with cooperative efforts from different areas of expertise, EBUS are suggested to be one of the focal points of SOLAS.

Introduction to cross-topics: Veronique Garcon (V.G.)
Due to the upcoming transition from IGBP to Future Earth, a call for more integrated efforts from the various scientific, socio-economic and political sectors is in order, with the main purpose being the improvement of the current regional coupled models considering ocean-atmosphere interactions. In order to achieve this goal it is suggested to coordinate international multi-model experiments with enhanced observations both in atmosphere and ocean, and which also include socio-economic impacts. The development of a monitoring system for near-coastal areas is particularly relevant considering the current observational limitations as well as the bias between in situ and modeled data. Recent studies showed that, for example, there is a clear trend towards higher biases between in situ and global climate models-derived SST in EBUS. Some possible reasons for this are underestimation of stratocumulus clouds, errors in surface wind stress, as well as unresolved offshore transport by ocean eddies.

Discussion:
The discussion was centered on the identification of key questions which could lead to set priorities for the study of EBUS. As a start, the following points were presented:

- Changing climate

- Declining/varying oxygen, fisheries
- Changing fluxes of critical elements
- Integration with other scientific and social programs
- Define observational and experimental programs
- Define how to improve model forecasts
- Define technology development efforts

As a result of the discussion, a list of general questions/needs based upon which it would be easy to achieve a synergy between scientists of different expertise was produced:

- Quantification of upwelling (e.g. volume transport, depth of upwelling)
- Are the respiration rates in OMZ's oxygen-dependent? (direct measurements of rates are needed)
- What is the extent of vertical transport and decay of organic matter? (in situ export profiles are needed)
- More information about remineralization rates is required
- Higher resolution view of oxygen vertical distribution in OMZ's
- What is the role of sedimentary rates of N-cycling?
- What is the role of iron in sediments underlying EBUS?
- How to include upper trophic levels?
- How primary productivity will change with global change and what is the impact for the local economies of the bordering countries?
- Detect trends and variability? Develop and implement an observational system: where to observe, how to observe, what to observe and how often?

SCOR WG 144 workshop
The SCOR WG 144 on `Microbial Community Responses to Ocean Deoxygenation` organized a workshop between 30 August and 3 September 2015 in Warnemunde, Germany. The final workshop report was not finished at the time of this report.

Another meeting is currently planned to take place in Goa, India in December 2016, with a book or special issue in a journal planned following the meeting. An additional workshop in Chile after the Goa meeting is also planned.

A workshop took place at the IMBER IMBIZO in October 2015 titled `Eastern Boundary Upwelling Systems (EBUS) and Oxygen Minimum Zones (OMZ): A natural Future Earth priority`. An abridged report is below. Original report was written by Paulmier A., Dewitte B., Illig S., and V. Garçon:

The tropical and subtropical systems at eastern oceanic boundaries are characterized by upwelling-induced high primary production and export that, in combination with weak ventilation, causes oxygen depletion and the development of oxygen minimum zones (OMZs) in intermediate waters. Associated with strong physical-biogeochemical gradients, OMZs affect nearly all aspects of ecosystem structure and function in the water and on the seabed. The economies of countries neighbouring upwelling zones are largely reliant on marine resources for food and employment. There is an urgent need for increased capacity to predict changes in ecosystem structures and coastal water quality as a result of deoxygenation and acidification to define sustainable management strategies of their marine resources. The OMZs also play critical roles in atmospheric chemistry and climate through emission of active trace gases. These regions also feature extensive stratocumulus cloud decks that play a pivotal role on the Earth's radiation budget and thus, in the response of the climate system to greenhouse gas forcing. IPCC coupled global circulation models (CGCM) have great difficulties simulating eastern boundary regions, and exhibit severe biases in Sea Surface Temperature (SST; Richter et al., 2015) and OMZs structures (Cabré et al., 2015). Since 2009, the Surface Ocean - Lower Atmosphere Study (SOLAS) project has produced an Eastern Boundary Upwelling System (EBUS) and OMZs Strategy Initiative and has held three international workshops (Peru, November 2010 and 2012; EUR-OCEANS Conference, Toulouse, October 2011). An integrative approach for future EBUS research should join the efforts of various Future Earth core projects to combine atmosphere, ocean, continents and socio-economic dimensions. Some major scientific findings regarding EBUS are presented here.

Work is currently being undertaken to determine the cause of the warm SST bias in CGCMs (e.g.: VOCALS program, EU Preface project). Because the low-resolution global coupled models tend to underestimate the upwelled

waters and are not able to simulate a well-defined upwelling cell at the coast, they have difficulties in accounting for the strong air-sea contrast in the EBUS. For instance, they usually represent more diffuse air temperature inversion zones located at lower altitudes than observed in forced atmospheric models (see Wyant et al. (2010) for the Humboldt system). This bias in particular prevents the formation of low-level clouds, which in turn significantly alters the radiative heat budget at the air-sea interface and results in SST bias ~+3°C (Richter et al., 2015). Other possible mechanisms of air-sea interaction at work in the EBUS include wind-upwelling-SST gradients, SST-low clouds, wind-SST-low clouds, wind-evaporation-SST and SST-PBL (Planetary Boundary layer) turbulence-wind. However, the temporal and space scales at which they operate have yet to be elucidated. Therefore, a better understanding of these air-sea coupled processes and their relative contribution is required, all the more so because the radiative budget in the upwelling regions may involve zonal heat transfer from the coast to the inner ocean by offshore propagating eddies. Conflicting model results on the role of eddies in the heat budget in the South Eastern Pacific (Colas et al., 2012; Zheng et al., 2010; Toniazzo et al. 2010) calls for further observational analysis (Holte et al., 2013) and for better understanding of the control of eddy activity by equatorial variability (Dewitte et al, 2012; Combes et al., 2015).

The main biogeochemical issue is to determine the net effect of the upwelled OMZ on the Earth system, as a result of the many feedback mechanisms involved (Law et al., 2013). Particularly important are the interactions between the remineralization processes in subsurface waters associated with chemical anomalies and bacterial activity, and primary production at the surface. In addition, EBUS and OMZ do not match exactly, suggesting a sensitivity of the oxygen budget to some aspects of the global circulation, as well as basin-scale and interhemispheric differences. According to the World Ocean Atlas (WOA) 2013 database, the lowest oxygen concentrations in the Atlantic, the most oxygenated ocean, go down to 23µM and 14µM in the Canary and Benguela EBUS, respectively, whereas in the Pacific, the least oxygenated ocean, the minimum oxygen concentrations are close to the detection limit. Future challenges to understanding the EBUS-OMZ systems lie with identifying relevant domains and documenting relevant parameters of the appropriate space and time scales. All the EBUSs are linked to the equatorial dynamics, in particular showing an extreme sensitivity of the OMZ extension to the mean equatorial circulation (e.g. Montes et al., 2014). In terms of variability, the EBUSs are also very connected to the equatorial system through trapped coastal Kelvin waves controlling the interannual variability, particularly during El Niño and the Benguela El Niño events (Dewitte et al., 2012; Bachèlery et al., 2015). Another important domain for the EBUS-OMZ are mid-latitude anti-cyclonic gyres. These control the intra-annual variability as their sea level pressure is highly correlated to the coastal alongshore winds off both Peru and Namibia, (Dewitte et al., 2011). Relevant space scales include sub-regional domains, and three or four sub-components (or biomes and ecosystems) of the EBUS-OMZs are usually described (Fréon et al., 2009). In particular, the intense cross-shore gradient between the shelf and the open ocean sub-systems in terms of physical forcing and the biogeochemical activity and ecosystem communities must be correctly represented. For instance, simulations from the ROMS-BIOEBUS model in the Benguela system (Gutknecht et al., 2013) indicate off-shore O2 fluxes (production and aerobic processes) twice as often as near the coast. By contrast, the highest microbiological rates appear close to the coast of Peru, with a local ammonium release fueling the nitrogen loss in the nitrogen cycle through denitrification and anammox processes. The signature of this biogeochemical activity (relative nitrite maxima and nitrogen deficit) is advected off-shore in a second stage (Kalvelage et al., 2013).

EBUS-OMZs are also typically subjected to mesoscale and submesoscale variability and are populated by eddies. As evidenced from a modelling lagrangian study off Peru (Fig. 1), the paths (corridors) of mesoscale structures maintain the boundaries of the OMZ, whereas higher frequency submesoscale fluctuations ventilate the OMZ through eddy fluxes and local mixing (Bettencourt et al., 2015). This fine-scale pattern not only impacts the OMZ structure but also impacts the air-sea fluxes of greenhouse gases, illustrated for example in the extreme variability of CO2 and N2O between the coast and the open ocean, inducing complex coupled and decoupled source/sink situations (e.g. Paulmier et al., 2008; Kock et al., 2016).

In terms of relevant time scales, the EBUS-OMZ are subjected to interannual (with a thermocline and oxycline deepening during the El Niño events: e.g. Morales et al., 1999) and longer scales. The annual/seasonal cycle is also well marked (Vergara et al., 2016). In particular off Peru and Namibia, the annual O2 cycle presents a possible de-phasing between the Humboldt and Benguela systems, but also within the same system (Fig. 2; note especially the differences between 12°S off Peru and 21°S off Chile). The winds as a main physical forcing may also show seasonal latitudinal shifts off Chile (e.g. Monteiro et al., 2011). Sub-seasonal to intra-seasonal timescales have been reported from SST observations, an activity that is modulated seasonally by changes in stratification for the Peru (See Dewitte et al., 2011; Illig et al., 2014) and Benguela (Goubanova et al., 2013) systems. Data collected during recent cruises

and a mooring off Peru (cf AMOP project: http://www.legos.obs-mip.fr/recherches/projets-en-cours/amop) also revealed large variability in dissolved oxygen at higher frequency, which could be partly associated with internal waves (such as a tide).

Modifications in physics and biogeochemistry impact the biological processes and ecosystems (e.g. habitats), and ecosystem services and ocean-related human activities. EBUS-OMZ systems exhibit high gradients and variability, including extreme events. They are the richest ecosystems in the ocean with strong ocean-atmosphere coupling. Consequently, they can be considered as natural laboratories in terms of multiple drivers and new technology challenges. There is a pressing need to improve the predictive capacities of regional coupled models, considering the breath of interactive processes between atmosphere, ocean, biogeochemistry and land at regional scales, and the limitations of global climate models for these regions. Coordinated multi-model experiments are crucial to achieve this, as are enhanced ocean and atmosphere observations of the eastern boundary regions. Future plans and actions need to include the EBUS-OMZ systems as a Future Earth priority, supporting international initiatives like the IOC UNESCO Global Oxygen Network (GO2NE).

Global Ocean Oxygen Network
Listening to the calls demanding increased cooperation and communication around low oxygen concentration in the marine environment, IOC-UNESCO initiated an ad hoc network of scientists focused on oxygen in both the open ocean and coastal areas – the Global Ocean Oxygen Network (GO2NE).

The GO2NE expert meeting took place on 12-13 December 2015 to develop terms of reference and a plan for the continuation of this interdisciplinary IOC-UNESCO network. The plan will be presented to the IOC Executive Council in June 2016 for possible adoption.
http://www.unesco.org/new/en/natural-sciences/ioc-oceans/sections-and-programmes/ocean- sciences/global-ocean-oxygen-network/

SOLAS joined the CLIVAR Focus on EBU´s in March 2016. More information about the existing research focus on upwelling between CLIVAR and IMBER can be found on the CLIVAR website at: http://www.clivar.org/research-foci/upwelling. The full `Prospectus for CLIVAR Research on Eastern Boundary Upwelling Systems` is available in an Addendum to this report as it would be too detailed to be included here.

SCOR WG proposals
A proposal has been submitted to SCOR for a working group called cOCtEAU (Ocean Atmosphere Upwelling) and is aimed at increasing the scientific understanding of the interactive processes between land, ocean, and atmosphere and their impacts on the marine biogeochemistry and ecosystems at the regional scale. Another proposal for a working group called EBUE (Eastern Boundary Upwelling Ecosystems: inter-comparisons, variability and forecasting responses to climate and global change) has also been submitted.

- Ship plumes: impacts on atmospheric chemistry climate and nutrient supply to the oceans
As the interest in this topic has increased over the last years it was an important topic during the SOLAS Open Science Conference 2015 in Kiel, Germany. During the plenary session on `SOLAS science and society` a talk was given by David Turner on ship plumes. Also an entire discussion session on this topic was convened by D. Turner. A short report of the discussion session is provided below (by D. Turner):

Ship Plumes have been suggested as a SOLAS research topic for some time. The first SOLAS Ship Plumes discussion session was held in Barcelona in 2009. That session focused to a very large extent on the atmospheric science questions associated with Ship Plumes, with only limited interest from the marine science community. As a result, the Barcelona initiative did not gain momentum as an integrated SOLAS activity. In contrast, at the Kiel SOLAS Ship Plumes discussion session we had a fairly even division of research interests between atmospheric and marine sciences among the 30 participants.

Ship plumes are an important part of the environmental footprint of shipping. Emission regulations, which are most advanced for sulphur and nitrogen oxides, SOX and NOX, have been entirely driven by concerns about air quality and human health but are still very lax in comparison with the regulation of terrestrial emissions of these gases.

The meeting first reviewed the composition of ship plumes. In addition to CO2 this includes SOX and NOX, NHX,

CO, metals, organic compounds, and particulates. Almost all these materials have a limited residence time in the atmosphere, and are therefore deposited relatively close to the source, usually within some hundreds of kilometres. Among the metals, Fe is of particular interest since it acts as a micronutrient in the marine environment: a recent study has suggested that shipping may become the major source of Fe to surface ocean waters by the end of the century. Organic compounds and particulate materials are mainly of concern for human health: PAH emissions are a concern, and also small (< 2.5 μm) particles that penetrate deep into the lungs. The emission of black carbon may have significant effects at high latitudes, where it reduces albedo following deposition to ice surfaces. This implies that the anticipated opening of Arctic shipping routes as the sea ice retreats may lead to a positive feedback through black carbon deposition on the ice

The fate of the materials discharged in Ship Plumes depends on both transport processes in the atmosphere, and also transformation reactions. These, together with information on the emission sources (i.e. ships) determine the extent to which these materials are deposited to the sea surface, or transported to the terrestrial atmosphere. Marine and coastal atmospheric circulation systems will have a strong impact on the deposition, atmospheric dispersion and transport. Specific features of the marine atmosphere need to be considered.

A closely related topic, that should be included in a Ship Plumes study, is the use of wet scrubbers that remove SOX in a stream of seawater: in the simplest (open-loop) scrubbers, the effluent is discharged back to the surface water. These scrubbers are currently being installed within sulphur emission control areas (SECA), which encompass some northern hemisphere coastal waters. In these areas, the maximum allowed sulphur content of marine fuel was reduced from 1% to 0.1% in January 2015. Since this change results in a doubling of fuel costs, it has become attractive to use scrubbers so that cheap, high-sulphur fuel can be used without breaching the limits on SOX emission. However, little is known about the chemical composition of the effluent and its consequences for the marine environment.

During the meeting, all participants introduced themselves and provided a short summary of their research interests, which covered a broad range of atmospheric and marine science. A list of participants, together with email addresses and research interests, has been compiled. There was broad agreement that development of an integrated research programme on Ship Plumes would not only be scientifically exciting, but would also have significant societal implications: SOLAS science can play an important role in providing the scientific basis for future regulations. This led to a discussion of the need to develop collaboration with researchers in areas such as economics, law and social sciences, and also of the need to engage the attention of the public at large, approaches that fit well within the Future Earth concept.

However, it was concluded that the first priority is to identify the scientific questions and challenges, as a basis for developing wider collaborations.

Possible specific regions of interest were also considered. It was pointed out that the Arctic could be an important study area. Climate change is expected to lead to an opening of Arctic shipping routes, bringing a significant change in the distribution of Ship Plumes. The retreat of sea ice is already changing the Arctic environment: understanding the consequences of adding Ship Plumes with their cocktail of nutrients such as N and Fe, together with toxicants and black carbon, presents both an exciting scientific challenge and a question of substantial societal relevance. Other regions of relevance are shipping hot-spots regions (strongly trafficked regions in the vicinity of large harbours) and the protection regions (SECA…), where changes in the emission patterns are expected.

On a show of hands, 23 participants expressed strong interest in attending a workshop to further develop the basis for an integrated programme on Ship Plumes within SOLAS. Such a workshop would need additional invited participants to cover areas of expertise not represented at the meeting (e.g. ship traffic analysis, marine engineering).

During a planned **SOLAS workshop** (26-27 October, Brussels, Belgium) on `SOLAS and society` one of three topics to be discussed will be `The shipping industry and air-sea interactions`.

Also a **separate workshop** on ship plumes is currently planned to take place in Sweden, but no firm date has been set at this time.

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 Ocean 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 CO_2 Atlas (SOCAT) is a largely volunteer, international activity by the marine carbon community, with more than 100 contributors to assemble surface ocean carbon dioxide (CO_2) data in a uniform, quality-controlled format. Version 1 was made public in 2011, version 2 in 2013 and the latest version (version 3) was released at the SOLAS Open Science Conference 2015.

A one-day workshop on SOCAT and SOCOM (Surface Ocean pCO_2 Mapping Intercomparison) took place at the SOLAS Open Science Conference 2015. A report of this meeting is attached below (provided by Dorothee Bakker):

The Surface Ocean CO_2 Atlas (SOCAT) and the Surface Ocean pCO_2 Mapping Intercomparison (SOCOM) held a joint event in Kiel on 7 September 2015, in conjunction with the SOLAS (Surface Ocean - Lower Atmosphere Study) Open Science Conference. The 54 participants from 18 countries included SOCAT data providers, data managers, quality controllers, users, SOCOM contributors and science programme managers.

The Surface Ocean CO_2 Atlas provides quality controlled and documented, synthesis fCO_2 (fugacity of carbon dioxide) data products for the global oceans and coastal seas. SOCAT was initiated in 2007, as the need for a publicly available, surface ocean CO_2 data synthesis product was recognized.

SOCAT Version 3 was released at the Kiel event. Version 3 has 14.5 million surface water fCO_2 values collected between 1958 and 2014. New features include 4.4 million additional fCO_2 values, extension of the data set, inclusion of fCO_2 data from well calibrated sensors and alternative platforms, a new data set flag of E, accuracy criteria for all fCO_2 values, automated data checks, and powerful visualisation tools in the interactive Cruise Data Viewer.

A system for automated data upload to SOCAT was formally launched. This automation system integrates data upload, data submission and quality control on a single platform, thereby enabling annual SOCAT releases from Version 4 onwards. Version 4 deadlines for data submission and quality control are 31 January and 31 March 2016, respectively. Version 4 will be released on 30 June 2016.

SOCAT data products enable detection of changes in the ocean carbon sink, quantification of ocean acidification and model validation. Numerous research publications and scientific reports have used and cited SOCAT, as listed on the website (http://www.socat.info/publications.html). These include high-impact reports and over 100 peer-reviewed, scientific publications. The SOCAT and SOCOM Event included discussion of additional surface water parameters, data set flags, collaboration with the Global Carbon Project and the data usage policy. The long-term sustainability and funding of SOCAT were discussed, as well as the need to strengthen SOCAT impact at policy level.

The Surface Ocean pCO_2 Mapping Intercomparison (http://www.bgc-jena.mpg.de/SOCOM/) is a comparison of data-based air-sea CO_2 flux estimates, many of them using SOCAT. Different methods are applied for interpolating sparse pCO_2 (partial pressure of CO_2) data in time and space. Approaches include interpolation, regression and model-based regression or tuning. The SOCOM initiative aims to quantify uncertainties and to identify common features in the surface ocean pCO_2 mapping methods. The event enabled presentation of SOCOM science and discussion on SOCOM progress.

Members of the SOCAT and SOCOM communities expressed a strong wish to continue the collaboration between both projects, to mutual advantage.

Dorothee Bakker, Chair of the SOCAT global group, was recognised for her outstanding contribution to the SOCAT community with an award presented at the SOLAS Open Science Conference.

A full report of the SOCAT and SOCOM Event will be posted on the SOCAT and SOCOM websites.

***WG2-Interior Ocean.** Chair: Nicolas Gruber (Switzerland)
WG2's recent activities focused on analysing the carbon data from hydrographic surveys to determine change in the oceans' anthropogenic CO_2 content since the 1990s. The preliminary results from the first decade of GO-SHIP were presented in a review paper. The WG will finalize the results on the basis of GLODAPv2, the quality-controlled database released in January 2016 for CO_2-relevant biogeochemical and physical parameters from 724 scientific cruises covering the global ocean.

WG2 also contributed to the joint GO-SHIP/Argo/IOCCP "Sustained ocean observing for the next decade" meeting in Galway, Ireland http://www.gaic2015.org.

They continue to support the development and application of biogeochemical sensors on Argo floats. Recently, they contributed to the draft BGC-Argo Implementation Plan and will report on it to the Argo steering team in March 2016. WG2 is likely to engage fully in the data synthesis and integration on a global/basin-scale.

***WG3-Ocean Acidification.** Chair: Jim Orr (France)
The last annual meeting of the SIOA working group took place in May 2016 in conjunction with the symposium on The Ocean in a High-CO_2 World (Hobart, Australia, 3-6 May 2016). The meeting was supported financially by SOLAS and IMBER. The chair of the SIOA working group is Jim Orr.

Following is a short update on changes in SIOA membership (provided by Jim Orr):
Five SIOA members are rotating off and 4 new members are rotating on (lists below). For a smooth transition, they are striving for a bit of overlap. For instance, Fred Gazeau (new) has been working with Jean-Pierre Gattuso for some months in order to take over leadership on the international database for ocean acidification data. Furthermore, all members, new and old, have been invited to attend the Hobart meeting.

Former Members (rotating OFF):

- Jim Barry (USA), served 2009-2016
- Jelle Bijma (Germany), served 2009-2016
- Jean-Pierre Gattuso (France), served 2009-2016
- Yukihiro Nojiri (Japan), served 2009-2016
- Ulf Riebesell (Germany), served 2009-2016

New Members (rotating ON):

- Frédéric Gazeau, started late 2015 Laboratoire d'Océanographie de Villefranche CNRS-UPMC, France
- Hans Pörtner, started late 2015 Alfred Wegener Institute, Germany
- Kim Currie <kim.currie@niwa.co.nz>, starts in 2016 (Hobart) Research Centre for Oceanography University of Otago, New Zealand
- Kristy Kroeker, starts in 2016 (Hobart meeting) Ecology and Evolutionary Biology University of California, Santa Cruz, USA

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. There is an OA-ICC web site (https://www.iaea.org/ocean-acidification/page.php?page=2181) and a news stream (https://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.

A training course on `Best practices in ocean acidification research` took place on 19-23 October 2015 in Xiamen, China. The training course was organized by the OA-ICC and the State Key Laboratory of Marine Environmental

Science, Xiamen University, Xiamen, China. The training course sought to train early-career scientists and researchers from IAEA Asian Member States entering the ocean acidification field. The end goal was to assist them to be able to set up pertinent experiments to avoid typical pitfalls and ensure comparability with other studies.
Twenty eight scientists from 10 IAEA Asian Member States participated in the course, which aimed to provide an introduction to both monitoring and experimental ocean acidification studies, with special focus on methods and potential pitfalls. It also looked to encourage networking and familiarize participants with existing international cooperation opportunities and resources in the field of ocean acidification.

Another training course on `Studying ocean acidification and its effects on marine ecosystems` took place on 2-6 November 2015 in Cape Town, South Africa. The training course was organized by the OA-ICC with the support of the University of Cape Town and the Council for Scientific and Industrial Research (CSIR). The course was open to 26 trainees from IAEA Member States in Africa. Priority was given to early-career scientists beginning to work in the field of ocean acidification.

The purpose of the course was to train early-career scientists and researchers from IAEA African Member States entering the ocean acidification field, with the goal to assist them in becoming able to measure ocean acidification and to set up pertinent experiments, avoiding typical pitfalls and ensuring comparability with other studies. It also sought to increase networking among scientists working on ocean acidification in Africa.

The 3rd Global Ocean Acidification Observing Network (GOA-ON) Science Workshop was held in Hobart, Australia, following the 4th International Symposium on the Oceans in a High-CO_2 World. GOA-ON is guiding the development of an integrated network for the detection and attribution of ocean acidification and ecosystem response, and has engaged with over one hundred participants from 30 nations to formulate its Requirements and Governance Plan. GOA-ON has also served to focus funding bodies and international research programs to integrate within a shared vision that extends from the coastal to open ocean domains.

OA-ICC provided travel grants for four participants from developing countries to the SOLAS Open Science Conference 2015.

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 ongoing effort. Scientists can help expanding the SOLAS Metadata base by completing a simple template available at http://tinyurl.com/328zjr5 and email it to solas@geomar.de.

I.e. **Task teams**

SOLAS/IGAC Task Team: Halogens in the Troposphere (HitT)
The primary objective of the SOLAS/IGAC Halogens in the Troposphere task team (HitT) is to determine and quantify the importance of reactive halogen compounds in tropospheric chemistry and climate forcing. The goal of HitT is to facilitate international collaboration between laboratory, field, and model activities regarding tropospheric halogen chemistry especially in the following domains: polar regions, salt lakes, marine boundary layer (both remote and coastal), volcanoes, free troposphere, and urban areas.The SOLAS community was deeply saddened by the unexpected death of the co-leader of the team Roland von Glasow in September 2015.
SOLAS SSC member Alfonso Saiz-Lopez and Lucy Carpenter are currently working on a proposal for a new "Activity" that will build from the HitT task team. The proposal writing has taken longer than expected, but it is hoped to be completed this summer.

During the EGU meeting in 2016 a `Halogens in the Troposphere` session took place. This session had a total of 20 presentations (6 orals + 14 posters) comprising a good mix of laboratory, field, and modelling results and expanding from the tropics to the polar regions. The session was well attended, by about 90 people, and everyone suggested to continue having the session in next year´s EGU.

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).

SOLAS-Japan or ADOES-Japan do not have its own grant at present. Most of the members are now working for IMBER, GEOTRACES and a new big program called OMIX (Ocean Mixing Processes; see http://omix.aori.u-tokyo.ac.jp/en/).

Fortunately, many researchers are continuing SOLAS science under their projects. ADOES would like to discuss to collaborate with the IOC/WESTPAC and Future Earth in the near future.

In 2015, the ADOES China and Japan team had several cruises and some symposia jointly with other projects in China and Japan.

- A West Pacific cruise was conducted from 21 March to April 26, 2016 by R/V *Dongfanghong-2* for air-sea interaction studies, including on-board incubation experiments on the influences of dust and haze addition on the surface ocean primary production.
- The KS-15-6 cruise: 25 June–6 July 2015, East China Sea, the Okinawa Trough and Philippine Sea for seawater and aerosol samplings collaborated with GEOTRACES-Japan.
- The KH-15-3 cruise: 14 October–4 November 2015, East China Sea for seawater and aerosol sampling and iron dissolution experiment collaborated with GEOTRACES-Japan
- The KH-15-4 cruise: 6-26 November 2015, upstream of Kuroshio region for aerosol sampling and a bubble bursting experiment collaborated with IMBER-Japan
- An international symposium was hosted by Ocean University of China on 26-28 July 2015 at Qingdao, China for aerosol pollution, deposition and impacts in land and ocean environment.
- Two national symposia were organized in collaboration with IMBER-Japan at AORI (Atmosphere and Ocean Research Institute), at the University of Tokyo on 18-19 February 2016 and with GEOTRACES-Japan on 28-29 March.

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 global scales by bringing together the laboratory, field, and modeling communities. The co-chairs are V. Faye McNeill (Columbia University, USA) and Thorsten Bartels-Rausch (Paul Scherrer Institut, Switzerland).

In late 2015, IGAC withdrew its sponsorship of AICI/OASIS with instructions to review the needs of the community, regroup, and propose a new activity.

The Ocean–Atmosphere–Sea Ice–Snowpack (OASIS) program was created in 2002 to bring together an international group of multidisciplinary field researchers, laboratory scientists, and modelers to study chemical and physical interactions and exchange processes between the title reservoirs, with a primary focus on the impact on tropospheric chemistry and climate feedbacks.

Efforts by the group have now been focused on regrouping and will probably continue in this vein for the next year. The first phase of the current plan is to solicit feedback from the AICI/OASIS community regarding research priorities and needs. To this end, the group will hold town hall meetings at the IGAC, Goldschmidt, and AGU meetings, and issue an online survey. After this, a science committee will be formed to create a new proposal based on the community feedback and the successes and lessons learned from AICI/OASIS. Meanwhile, the group is also planning an interdisciplinary polar science meeting in Switzerland for 2017.

I.f. **SOLAS Open Science Conference 2015**

The SOLAS Open Science Conference 2015 was held in Kiel, Germany on 7-11 September at the Christian-Albrechts-Universität zu Kiel bringing together over 260 scientists from 35 countries to learn and discuss about the latest developments on biogeochemical-physical air-sea interactions and processes. During plenary talks, discussion sessions and poster presentations participants were able to learn and exchange about cutting-edge research in the field and present their own findings. On Monday 7 September special site events took place as part of the conference:

- An all-day meeting of the Surface Ocean CO_2 Atlas (SOCAT) and the Surface Ocean pCO_2 Mapping Intercomparison (SOCOM) community was attended by around 50 scientists with the highlight of launching SOCAT version 3. For her dedicated work with SOCAT, Dorothee Bakker received a reward during the conference banquet.
- The German contribution to SOLAS, the Surface Ocean Processes in the Anthropocene (SOPRAN) project also held its final meeting and published a brochure containing important scientific highlights of the last 9 years.
- To strengthen the SOLAS commitment towards capacity building the workshop `The ABC of presenting: Audience-friendly, Brief and Clear` for early-career scientists was organized. This workshop was held over two days and helped early-career scientists to further develop their presentations skills.
- On the last day of the conference, a small `Nordic SOLAS` meeting took place to introduce the visions of Swedish SOLAS and discuss an expansion of the network to include scientists from all Nordic countries.

Poster sessions turned out to be particularly popular and successful during the OSC. Even the already extended time slot in the late afternoon seemed not to provide enough time. In all, 9 students won student poster awards (Panassa Essowe, Leonie Esters, Margaux Gourdal, Sinnika Lennartz, Mingshuang Sun, Precious Mongwe, Camille Richon, Tianfeng Guo and Alex Zavarsky).

The local organising committee (LOC) was 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).

Structurally, the SOLAS OSC15 took place in conjunction with two major events 1) the SOPRAN final meeting and 2) 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 was composed of the SSC and one member of the LOC. 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.

The layout of the conference was slightly changed from previous conferences as SOLAS invited 9 keynote speakers and selected 22 other speakers from the poster abstracts pool. Among the 22 speakers, 6 were from developing countries and 11 were early-career scientists. Here is a detailed overlook of the plenary session, discussion session and poster session topics and speakers etc.:

Tuesday 8 September

lenary Session theme: Air-sea interface and fluxes of mass and energy
This session is dedicated to oceanic and atmospheric processes, driven for instance by waves, bubbles or surfactants, which act upon the air-sea interface and serve to regulate the fluxes of mass and energy between the coupled ocean-atmosphere system.

Overview keynote speaker: *Bernd Jähne* (University of Heidelberg, Germany) Talk title: Physics of the air-sea interface and fluxes of mass and energy
Speakers:

- *Ruo-Shan Tseng* (China - Taipei): Air-sea momentum transfer and near-surface currents under high winds and tropical cyclones
- *Tom Bell* (UK): Quantifying the effect of bubbles upon air-sea gas exchange
- *David Ho* (USA): Air-sea gas exchange in the North Atlantic: GasEx-98 revisited

Plenary Session theme: Interconnections between aerosols, clouds and ecosystems
This session is dedicated to the interconnections between aerosols, clouds, and marine ecosystems and the understanding of the system they form as a whole, in which change in one component is manifested in another.

Overview keynote speaker: *Karine Sellegri* (University Blaise Pascal, France)
Talk title: Marine aerosol emissions related to the seawater biogeochemical composition
Speakers:

- *Avirup Sen* (India): Chemical characterization of ambient atmospheric aerosols over different environments of India and the adjoining oceans during the winter and summer monsoons - 2014: Implications of a Coordinated Campaign
- *Poonam Tyagi* (Japan): Soil microorganisms and terrestrial plant metabolites in marine aerosols from the western North Pacific Rim: one-year observation of hydroxy fatty acids over Gosan site, Jeju Island)
- *Rafel Simo* (Spain): Highlights of the Pegaso cruise: plankton-emission of trace gases and aerosols in the Southern Ocean

Discussion Sessions
I: Towards joint SOLAS-CliC activities on sea-ice biogeochemistry Convener: *Lisa Miller*
II: Microbial life at the air-sea interface Convener: *Christian Stolle*
III: Differences between marginal areas and open ocean- Baltic Sea example Convener: *Jacek Piskozub*

Poster Session
Atmospheric deposition and ocean biogeochemistry Integrated topics
Ocean biogeochemistry control on atmospheric chemistry

Wednesday 9 September

Plenary Session theme: SOLAS science and society

This session is dedicated to SOLAS research with socially relevance and to activities, which have a direct impact on society, such as air quality, human health, marine resources and climate regulation.

Speakers:

- *Hans Joachim Schellnhuber* (Germany): Sustaining the Seven Seas
- *Philip Boyd* (Australia): Geoengineering the planet: from geochemistry to geopolitics
- *Lucia M. Fanning* (Canada): Assessing science-policy linkages in regional and global ocean governance arrangements for fisheries, pollution and biodiversity
- *David Turner* (Sweden): Ship plumes

Plenary Session theme: Integrated topics

This session is dedicated to oceanic systems where integrated studies are required and urgent. They are regional, high sensitivity and high-priority systems, such as for instance the upwelling systems, sea ice and coastal waters.

Speakers:

- *Anna Rutgersson* (Sweden): The role of upwelling systems for air-sea exchange in marginal seas
- *Andrew Reed* (USA): Vertical Spatial Variability of Denitrification in the Eastern Tropical North Pacific Oxygen Minimum Zone
- *Leticia Cotrim da Cunha* (Brazil): Acidification through eutrophication- an example from an urban coastal ecosystem in SE Brazil)
- - *Sebastien Moreau* (Belgium): The role of sea ice in the carbon cycle of polar seas: 1D to 3D modelling)

Discussion Sessions

I: Atmospheric deposition, ocean biogeochemistry and climate change
Convener: *Zongbo Shi*
II: Relationship between wind speed and gas exchange over the ocean: which parameterization should I use?
Convener: *Rik Wanninkhof*
III: Priorities and integrated programs for the study of eastern boundary upwelling systems Convener: *Francisco Chavez*

Poster Session

Greenhouse gases and the oceans
Interconnections between aerosols, clouds & ecosystems

Thursday 10 September

Plenary Session theme: Greenhouse gases and the oceans

This session is dedicated to the most significant long-lived greenhouse gases, such as CO_2, CH_4 and N_2O and their natural cycles in the oceans and troposphere, which interact with anthropogenic inputs and lead to climatic feedback and environmental impacts.

Overview keynote speaker: *Ute Schuster* (University of Exeter, UK) Talk title: Greenhouse gases and the oceans

Speakers:

- *Chao Zhang* (China): Diagnosing CO_2 fluxes in a River-dominated Ocean Margin (RiOMar): the East China Sea off the Changjiang estuary
- *Damian Arévalo-Martínez* (Germany): Nitrous oxide emissions from eastern boundary ecosystems: Case studies from Peru and Benguela upwelling regions
- *Sayaka Yasunaka* (Japan): Mapping of the air-sea CO_2 flux in the Arctic: basin-wide distribution and seasonal to interannual variability

Plenary Session theme: Ocean biogeochemical control on atmospheric chemistry

This session is dedicated to the ocean emissions of aerosols and reactive gases, such as organic and oxygenated organic compounds, and sulphur-, nitrogen- and halogen-containing compounds and their impacts on atmospheric photochemistry, air quality and stratospheric ozone.

Overview keynote speaker: *Elliot Atlas* (University of Miami, USA) Talk title: Ocean Biogeochemical Controls on Atmospheric Chemistry

Speakers:

- *Sarah Lawson* (Australia): Unexplained organic trace gases over temperate Southern hemisphere oceans
- *Liselotte Tinel* (France): Shining light on the air-sea interface: investigating the photochemical production of functionalized VOC
- *Susann Tegtmeier* (Germany): The future role of oceanic halogen compounds for the stratosphere

Discussion Sessions

I: Future air-sea gas transfer laboratory experiments
Convener: *Bernd Jähne*
II: Nutrients supply to Southern Ocean surface
Convener: *Remi Losno*
III: SOLAS research into the effects of potential geoengineering
Convener: *Cliff Law*

IV: Ship Plumes Convener: *David Turner*

Poster Session
Air-sea exchange and fluxes of mass and energy Outside of the box ideas
SOLAS science and society

Friday 11 September

Plenary Session theme: 'Outside the box' ideas
This session is dedicated to ideas, initiatives, and experiments that are not yet part of SOLAS. This can be a new perspective on continuing projects, a promising new technique, a pressing societal need or a completely new direction in SOLAS science. Surprise the programme committee with the unexpected!

Speakers:

- *Doug Wallace* (Canada): Dorado/Dolphin: a unique semi-submersible autonomous vehicle for SOLAS science
- *Miriam Gonzalez* (Germany): Comparing the effects of different climate engineering techniques on ocean acidification
- *Marcelo Santini* (Brazil): Using oceanographic data collected by southern elephant seals (*Mirounga leonina*) to infer the sea-ice formation rate on the vicinity of the Wilkins Ice Shelf in 2008
- - *Miri Trainic* (Israel): The effect of phytoplankton ecology on aerosol emission: a case study of coccolith ejection into the air from the coccolithophore Emiliania Huxleyi)

Plenary Session theme: Atmospheric deposition and ocean biogeochemistry
This session is dedicated to the broad range of particles of continental origin the ocean receives from the atmosphere. Atmospheric deposition impacts vast regions of the oceans and result from both natural processes and human activities.

Overview keynote speaker: *Keith Moore* (University of California, USA) Talk title: Atmospheric Deposition and Ocean Biogeochemistry

Speakers:

- *Kamana Yadav* (India): Variations in source and chemical composition of dust during 2010 and 2012 winter in the west coast of India
- *Kathrin Wuttig* (Australia): Bioavailability of iron to N_2 fixers under the Saharian dust plume)
- *Bärbel Langmann* (Germany): On the long-time fertilisation of the surface ocean by volcanic ash)

Reports of the discussion sessions and other events can be found on the SOLAS website at http://www.solas-int.org/solas-events.html

I.g. **SOLAS 2015-2025: Science Plan and Organisation**
As mentioned in previous reports, SOLAS celebrated its 10-year anniversary in 2014. In 2013, SOLAS began an effort to define research themes of importance for SOLAS research over the next decade and prepared a new science plan for the next phase of the project until 2025.
Reviewer comments were taken into account and addressed in the second half of 2015 and early 2016 with the revised version of the science plan and a letter to the referees addressing all comments were submitted to the sponsors by mid-March 2016.

The full title of the document is: SOLAS 2015-2025: Science plan and Organisation Linking ocean-atmosphere interactions with climate and people

Table of contents:

For further details of the procedure followed to produce the new science plan please refer to the report of last year. The revised version of the Science Plan is available on the SOLAS website at http://www.solas-int.org/about/future_solas.html. As a next step an implementation document will be produced by the SOLAS SSC and IPO.

I.h. **Engagement with Future Earth: Research for Global Sustainability**

In October 2015, SOLAS signed a `Memorandum of Understanding` with Future Earth. Since the Future Earth Global Hubs are in place, SOLAS has regular communication with the officers on various topics and is following webinars on all kind of Future Earth-related topics.

SOLAS has shown great interest and support to establish a Future Earth Knowledge Action Network (KAN) on the Ocean. Future Earth's Knowledge-Action Networks are hoped to be prime mechanism for delivering the future Earth research strategy. Knowledge-Action Networks are collaborative frameworks that facilitate highly integrative sustainability research. Their aim is to generate the multifaceted knowledge needed to inform solutions for complex societal issues.
Knowledge-Action Networks build on the broad range and diversity of specialist expertise represented in the large community of researchers and practitioners associated with Future Earth, for example, in Research Projects, Fast-Tack Initiatives and Clusters, and endorsed and associated organisations, projects, and individuals that are part of the Future Earth Open Network.

The objectives of the Knowledge-Action Networks are to:

- identify and respond to society's needs for scientific knowledge to successfully undertake the transformation to sustainability
- generate integrated knowledge that is relevant to decision-makers
- develop and cultivate research that is solution-driven, inter- and trans-disciplinary
- add value to research that is or has been carried out already

Currently, the process of establishing the Ocean KAN has not been laid out entirely by Future Earth to interested core projects. SOLAS is involved in all communications regarding the issue and the SOLAS SSC chair is part of the development team of the Ocean KAN. In early May, Peter Liss was named co-leader of the Ocean KAN.

During a Future Earth core project meeting in Bern in late June 2016 an extra day of meeting has been allocated for further establishing the Ocean KAN.

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

Following the momentum of a meeting that took place in March 2015, co-organised by SCOR in Kiel, Germany, SOLAS has started an effort to develop cross-projects topics. During the SOLAS open Science Conference some representatives of involved programmes met for an afternoon discussion on this subject. Different views on how to proceed on this issue were mentioned. Some key extracts of the meeting minutes are below:

Cross projects/programmes topics of marine sciences

Véronique Garçon gave a brief introduction providing background information and describing the non-exhaustive list of cross-project topics identified over the last 6 months by various projects, on which a Knowledge Action Network (KAN) Oceans could focus. Véronique stressed that not all the topics presented neatly fit into the Future Earth vision as they emphasise fundamental science rather than stakeholders' involvement but that a KAN could provide a pathway for merging competencies and resources to achieve both fundamental science and the Future Earth vision. She concluded that core projects and KAN-Oceans need to co-exist and mutually benefit each other.
Her presentation included some slides provided by ecoSERVICES and GEOTRACES. David Turner added that GEOTRACES, besides proposing the topic on deep-sea mining, is also interested in the topics of Extreme events in Eastern Boundary Upwelling systems and Changes in the Arctic: threat or opportunity?

Bob Duce, then briefly presented GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection), its WG38 on 'The Atmospheric Input of Chemicals to the Ocean' and the two new topics to be developed in the coming years:

- Impact of Ocean Acidification on Fluxes of Atmospheric non-CO_2 Climate-Active Species;
- Changing Atmospheric Nutrient Solubility.

The discussion started.

Martin Visbeck and David Carlson reminded that WCRP is already doing co-design and co-production, for instance with climate services and IPCC. It was suggested that questions for KAN-Oceans should be limited to those that are too complex and/or broad for a single project to address. It was also suggested that 'upstream' stakeholders be consulted for the research that interests them, and/or they can provide the questions KAN-Oceans should be addressing, e.g. IPCC, who identify the issues and uncertainties that prevent better climate predictions. Currently, the discussion is internal to the academic research sector, which decides what are the 'most interesting' questions for the global community. This idea that KAN-Oceans needs to focus on upstream research are shared by WCRP and CLIVAR.

Peter Liss mentioned that IGBP has been functioning differently from WCRP and is now ending. Future Earth offers a home for the core projects in a new way, with the additional angle of looking into what society needs scientifically, as well as fundamental sciences. KAN-Oceans offers the opportunity to work on big societal issues in addition to what the core projects are doing, to deliver on their existing science plans. He also reminded the group that there are practical funding possibilities too. Future Earth provides a framework, and a dialogue needs to take place between scientific groups and Future Earth about what they wish to do together.
Martin Visbeck commented that core projects currently have very little, if any, visibility or participation in some of the big current endeavours, such as the World Ocean Assessment about to be released, and this needs to change. Martin gave examples of 3 dialogues that should take place and develop beyond the first contact and that should be listed in the cross-projects topics of marine sciences:

- interaction with the World Ocean Assessment;
- interaction with UNEP;

- interaction with the Seabed Authority.

Martin Visbeck noted the rationale and outcome of the meeting of some ocean related core projects that took place in March 2015, in Kiel, Germany and added that according to Future Earth, the KAN-Oceans could include all ocean-related projects, not only Future Earth core projects, if that is what the ocean community wishes. Returning to the modus operandi for KAN-Oceans, Peter Liss noted it was important to start with the question and determine a structure appropriate to answer the question and not the other way round. It was noted that scientists are so good at dividing themselves, it is not difficult for the relevance of science to be lost in the bigger schemes. There are many acronyms [projects] with an oceans interest/focus, but what have they actually contributed in a co-design mode? Limiting factors are a lack of enthusiasm from some and funding to embrace new challenges. Challenges need to be framed in a way that is not sector specific, e.g., "How to get enough protein to feed 10 billion people?" is a question to which all disciplines could contribute, A central theme is to lift ideas beyond the normal science rhetoric.

Peter Liss re-emphasised that however the question is framed, it should be the science question that leads and looks beyond existing science. An additional benefit is that such an approach is going to position KAN-Oceans to be able to access different (new) sources of funding. This led to a discussion about how KAN-Oceans could be organised to draw scientists together. Phil Boyd thought it would be useful to know what are the Grand Challenges.

Martin Le Tissier replied that all big bodies have some. Although IGBP did overall very good research, an area identified with hindsight where more efficient work could have been done was the interaction/collaboration between projects, both internal to IGBP, as well as with other GEC projects.

Martin Le Tissier shared Peter's proposition that instead of thinking of how to operationalise things, we should concentrate on identifying which topics we can work on together.

Martin Visbeck noted the few large topics proposed at the meeting in March in Kiel, suggesting that they could be the topics of the KAN-Oceans:

- Ocean discovery
- Ocean solutions
- Ocean 2100
- Ocean extremes
- Ocean pollution
- Ocean governance

Bob Duce expressed the view that he is unsure if the network concept including the 6 large topics mentioned by Martin Visbeck are fitting what Future Earth is offering with the KAN-Oceans.
A round table solicited everyone's views on how to move forward. Phil Boyd summarised that the KAN-Oceans should capture scientific excellence and enthusiasm, the ability to act on grand challenges, and delivery of science to society, and that the sum should be greater than the parts. What is still needed is how to jump through hoops to get to the big questions?

Lisa Miller thought that it would be beneficial to have workshops, preferably with the appropriate stakeholders involved in the workshop agenda and planning.

A document providing a summary of the efforts led by SOLAS trying to come up with a list of possible topics across core projects inside and outside ex-IGBP that could fit Future Earth agenda (easily associated for co-design with stakeholders) has been written. The ultimate intention of this document is to foster interactions between international projects on co-designed and co-produced knowledge in marine sciences.

The idea behind this approach is to start with a couple of topics, learn how to do the co-design and co-production of knowledge with the help of Future Earth.

The topics listed are:

- Extreme events in EBUS
- Atmospheric chemistry services
- Changes in the Arctic: threat or opportunity
- Environmental consequence of resource exploitation in the deep-sea
- 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. SOLAS visit to NASA and NSF in Washington D.C.

A SOLAS delegation composed of Brian Ward and Emmanuel Boss travelled to Washington D.C. in January 2016 to visit representatives of the National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) to present and discuss SOLAS research priorities and goals in view of funding requests by SOLAS to NSF and NASA.

At NSF, a SOLAS presentation was given to about 15 NSF programme managers and some additional meetings were arranged with:

- Henrietta Edmonds, who will take over as the new Chemical Oceanography Programme manager from Don Rice. Don is the programme manager who has supported SOLAS through SCOR.
- Kelly Falkner, who is the Geosciences Division Director.
- Don Rice and Sylvia Edgerton (Atmospheric Chemistry).

At NASA, a meeting with Paula Bontempi and Barry Leifer took place and a SOLAS presentation was given. Another meeting with Jack Kaye (Associate Director for Research of the Earth Science Division (ESD) and Hal Marring (Radiation Sciences Program Manager) was also arranged.

II.b. SOLAS @ Ocean Sciences Meeting

Through the support of SCOR, SOLAS was presented at a shared booth at the Ocean Sciences Meeting 2016 in New Orleans in February 2016. The new SOLAS flyer was presented to the public for the first time. Also a banner summarizing the SOLAS project was placed at the booth.

II.c. Collaboration with ESA

After the completion of the OceanFlux project, ESA mentioned that it is very high interested in continuing the collaboration with SOLAS, though additional funding depending on its interest.

As an outcome of the topical conference on "Earth Observation for Ocean-Atmosphere Interactions Science 2014 - Responding to the new scientific challenges of SOLAS" a detailed report has been written and was revised by SOLAS. This report served as a basis for a synthesis document `ESA-SOLAS Earth Observations and SOLAS science priorities`. This document provided to ESA will be submitted to their programmatic review.

Also a SOLAS/ESA workshop will take place in late June 2016 (see II.e.).

II.d. 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.

The 24th PICES Annual Meeting (PICES-2015) was held from October 14 to 25, 2015, in Qingdao, China, under the theme `Change and Sustainability of the North Pacific`. Unfortunately, the budget of SOLAS did not allow SOLAS to send a representative at the meeting.

II.e. SOLAS workshops on Remote Sensing and SOLAS and Society

SOLAS is funding two important workshops in June and October 2016. The first workshop will be a SOLAS/ESA workshop on `concurrent remote-sensing inversions of ocean and atmosphere` to take place at the ESA facilities in Frascati, Italy on 13-15 June. Three main questions will be addressed during the workshop:

- What are the benefits and drawbacks of having sensors focused on the ocean and atmosphere (or both) on the same platform/constellation?
- Holistic inversion* – is it time to invert ocean, atmosphere and clouds together? What is the advantage of doing so? Polar orbiting vs. Geostationary satellites. Use of ancillary data in inversions.
- Data accessibility – How can we maximize the availability of data and inversion products to the community?

Workshop conveners are SOLAS SSC members Ilan Koren and Emmanuel Boss.

A second workshop to take place in Brussels, Belgium in late October on `SOLAS and society` will concentrate on the following three issues:

- Carbon valuation
- Law/policy across the air-sea interface
- Shipping and emissions/effluents

Workshop conveners are Christa Marandino (GEOMAR) and Erik van Doorn (University of Kiel).

II.f. SOLAS communication

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

SOLASNews newsletter (NL): emailed to ~2,400 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 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 18 is currently planned for publication in late summer 2016.

E-bulletins: sent to over 2,400 SOLAS scientists roughly 5-8 times per year; 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 that informs on the outline of the new science plan.

Twitter account; The IPO created a SOLAS Twitter account. Posting regular SOLAS updates is planned to begin in the second half of 2016.

II.g. SOLAS national networks

Twenty-nine nations are part of the SOLAS network. Each has a representative (see list below).

Australia: Sarah Lawson and Andrew Bowie
Belgium: Nathalie Gypens
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: Christa Marandino and Hartmut Herrmann (NEW)
India: VVSS Sarma
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
Southern Africa: Carl Palmer
Sweden: Katarina Abrahamsson
Turkey: Baris Saglihoglu and Mustafa Koçak
UK: Tom Bell
USA: Rachel Stanley (NEW)

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 April 2016, 23 reports were received and will soon be posted on the SOLAS website. The information contained in the reports has been/are a great source of information for the IPO to report to sponsors, but also to facilitate the coordination job and to redistribute the results and progress from some nations to the rest of the SOLAS community via the Newsletters and the website. This year the information provided through the reports will also be used to create an implementation plan for the new SOLAS science plan.

(All the reports received during the reporting period are available in an Addendum to this report; see http://www.scor-int.org/Annual%20Meetings/2016GM/2016_SOLAS_National_Reports.pdf)

II.h. ***Endorsed projects***

Over the reporting period, SOLAS endorsed the project NAAMES - North Atlantic Aerosols and Marine Ecosystems Study and the International Carbon Dioxide Conference to be held summer 2017 in Interlaken.

Information about support letter and endorsement are accessible on the website, along with the endorsement submission form.

II.i. **SOLAS article on `Scientific synthesis and contribution to Earth system science`**

A SOLAS article titled `SOLAS: Scientific synthesis and contribution to Earth system science` by Emilie Brévière et al., was published in *Anthropocene* in December 2015.
The article is available at: http://www.sciencedirect.com/science/article/pii/S2213305415300187

Abstract:
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 (IGBP) 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, which has led to the launch of 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.

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 interim executive officer, Stefan Kontradowitz (substituting for Emilie Brévière during her maternity leave). The funding for a second staff position (project officer) ended in January 2016. Emilie Brévière will be back as executive officer by 1 October. Due to some leftover funds provided by IGBP it will be possible to keep Stefan Kontradowitz in the IPO until December 2016 or January 2017.

GEOMAR provides office space and funds the executive officer salary since 1 February 2011 until December 2020. As per today unfortunately, no other funding opportunity for securing the second position could be found.

APPENDIX 8
GEOTRACES

GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2015/2016

1 June 2015 to 30 April 2016

1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

The SSC membership (listed above) includes 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; internal cycles of the elements in the ocean; 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

GEOTRACES continues to work diligently and enthusiastically, enjoying a very successful implementation. Its cruise field programme has now 84 GEOTRACES cruises (including 11 International Polar Year cruises) with 946 section stations completed and about 678 peer-reviewed papers published.

2.1 Status of GEOTRACES field programme

During the past reporting year, GEOTRACES has successfully completed most of the expeditions of the international Arctic GEOTRACES Programme. This includes 4 section cruises (from Canada, USA and Germany). One more Arctic cruise (from Germany) will be undertaken in summer 2016. In addition, one German cruise in the southeastern Atlantic Ocean was successfully concluded. The Atlantic Ocean basin now has remarkable coverage.

In complement to the GEOTRACES Ocean sections cruises, 8 process study cruises have also been completed. The GEOTRACES field programme is progressing excellently.

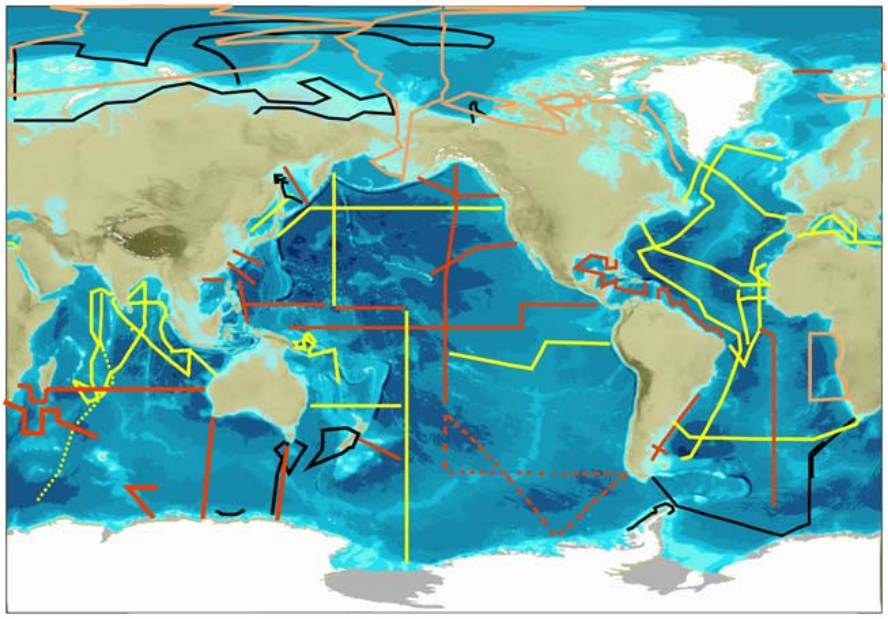

Figure 1: *Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey. In orange: Sections completed during the past year. In red: Planned Sections.*

An updated version of this map can be found on the GEOTRACES home page <http://www.geotraces.org>.

This year, one special field programme event merits to be highlighted. On the 7 September 2015, two cruises from the international Arctic GEOTRACES Programme, on the U.S. Coast Guard Cutter *Healy* and the German ship *RV Polarstern,* rendezvoused at the North Pole, having a memorable opportunity to occupy the same sampling station.

When the Standards and Intercalibration Committee created the idea of the crossover station—where two different GEOTRACES transect cruises occupy the same sampling station and subsequently compare their TEI data to facilitate intercalibration—they never imagined that two ships would be at the North Pole at the same time! They were both rafted up to the same ice floe and scientists could simply walk to visit each other's ships, labs, and share experiences and knowledge.

Figure 2: USCGC Healy and RV Polarstern at the North Pole ©Stefan Hendricks.
Source: blogs.helmholtz.de.

2.2 GEOTRACES Intermediate Data Products

The GEOTRACES community is working hard to prepare the next Intermediate Data Product (IDP), which will be released at the 2017 Goldschmidt Meeting (13-18 August 2017, Paris, France). The Intermediate Data Product 2017 (IDP2017) is being built upon the feedback received from the IDP2014 survey that collected 262 answers (the results were described in last year's report to SCOR).

To ensure timely release of the IDP2017, a clear procedure and timelines for data submission and review were established and communicated broadly (see data management section in this report for further details).

Promoting the use of IDP2014 data

While working on the next IDP, GEOTRACES is continuing its efforts to publicise the IDP2014, promote its use and intensify collaboration of GEOTRACES with the broader ocean research community. To this end, a Town Hall was held at Ocean Sciences Meeting 2016 (21-26 February 2016, New Orleans, Louisiana). The Town Hall session on "**Opportunities to Strengthen Your Science (and Proposals) using GEOTRACES Data**" **(**1) informed the community about strategies to access, download and manipulate data from IDP2014 and provided preliminary information about IDP2017; (2) sought feedback from users of IDP2014 to improve IDP2017 and make it as user-friendly as possible; and (3) presented the outcome of the first Iron-Model Intercomparison Project (FeMIP), in

which comparison to GEOTRACES data allowed an unprecedented assessment of model performance.

Figure 3: GEOTRACES Town Hall Meeting at Ocean Sciences 2016.

Furthermore, the IDP2014 was also presented at the booth that SCOR had at the Exhibition Hall of the Ocean Sciences Meeting. At the booth, a GEOTRACES banner introducing the IDP2014 was displayed; promotional postcards of eGEOTRACES Atlas 3D scenes were distributed; and SSC members and IPO staff were available to inform visitors about the IDP2014 and the GEOTRACES Programme.

Figure 4: SCOR booth at Ocean Sciences 2016.

2.3 GEOTRACES Publications

During the reporting period, 130 new papers have been added to the GEOTRACES peer-reviewed papers database (http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers). In total the database includes 678 publications so far.

The following three special issues were published since the 2015 SCOR meeting, and two more are in preparation:

Marine Chemistry (Volume 177, Part 1, Pages 1-202, December 2015)
Biogeochemistry of trace elements and their isotopes
Edited by Rob Middag, Claudine Stirling, Alessandro Tagliabue and Jingfeng Wu
http://www.sciencedirect.com/science/journal/03044203/177/supp/P1

Marine Chemistry (Volume 177, Part 3, Pages 409-582, December 2015)
Cycles of metals and carbon in the oceans - A tribute to the work stimulated by Hein de Baar
Edited by Loes J.A. Gerringa, Micha J.A. Rijkenberg, Patrick Laan and Klaas R. Timmermans
http://www.sciencedirect.com/science/journal/03044203/177/part/P3

Biogeosciences, special issue (Volumes 11 and 12)
KEOPS2: Kerguelen Ocean and Plateau Study 2
Edited by S. Blain, I. Obernosterer, B. Queguiner, T. Trull, and G. Herndl
http://www.biogeosciences.net/special_issue164.html

Also, several publicity articles have been published in news magazines or journals in the past year. For example:

Turner, D., & Urban, E. (2016). GEOTRACES: High-Quality Marine Analytical Chemistry on a Global Scale. Chemistry International, 38(1), 16–17. doi:10.1515/ci-2016-0108 (Open Access)

A complete list of the publicity articles is available here: http://www.geotraces.org/outreach/publicity-documents.

2.4 GEOTRACES Science highlights

The GEOTRACES International Project Office regularly edits highlights of published articles, which are posted in the website (http://www.geotraces.org/science/science-highlight) and in the electronic newsletter (http://www.geotraces.org/outreach/geotraces-enewsletter). Among the numerous highlights published since last year's report, we selected those which bring scientific messages related to the coupling (or not) of TEIs with nutrients: Zn and Si on the one hand, and the Cd and PO_4 paradigm on the other hand. High-resolution measurements conducted in the framework of GEOTRACES cruises are questioning well-established paradigms, such as the famous Cd/PO_4 relationship classically used in paleoceanography. These high-resolution data are also confirming that a significant fraction of Al is released by sediments to the ocean.

Decoupling between dissolved zinc and silicon in the North Atlantic Ocean driven by mixing of end members

Roshan and Wu (2015, see reference below) reveal that the correlation between dissolved zinc (Zn) and silicon (Si) is relatively weak in the North Atlantic Ocean (GA03 US section). They use the results of an Optimum Multi-Parameter Water Mass Analysis to establish which parameter is mainly controlling the Zn distribution. Surprisingly, they present evidence that remineralization might have an insignificant effect on the zinc distribution in this region. They conclude that dissolved zinc in the North Atlantic Ocean is mainly controlled by water mass mixing, although some water mass end-members exhibit deviations in the Zn-Si correlation as, for example, the Mediterranean Outflow Waters. Unexpectedly large Zn inputs of hydrothermal origin are also perturbing the expected relationships.

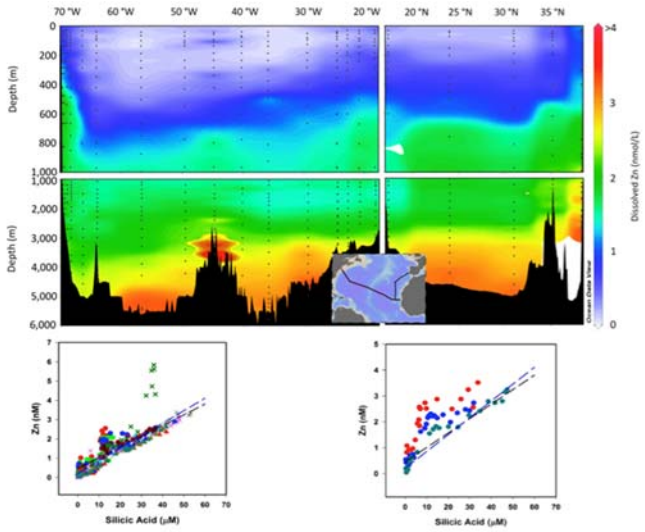

Figure 5: *The Top panel shows the distribution of dissolved Zn along the GA03. Bottom panel shows the Zn-Si relationship for the zonal (left) and meridional (right) transect. Disappearance of a linear correlation is evident, particularly for the meridional transect where the Mediterranean waters have a great influence.*

Reference:

Roshan, S., & Wu, J. (2015). Water mass mixing: The dominant control on the zinc distribution in the North Atlantic Ocean. Global Biogeochemical Cycles, 29(7), 1060–1074. doi:10.1002/2014GB005026

Changing the cadmium : phosphorus paradigm?

The well-established strong linear relationship linking dissolved cadmium (Cd) and phosphorus (P) concentrations in seawater is at the origin of the attraction of Cd as a proxy for PO_4 in the paleocean. However, exploring the dissolved Cd and PO_4 distributions in the ocean, Quay and co-workers (2015, see reference below) show that the Cd/P of particles exported from the surface ocean doubles in high-nutrient low chlorophyll (HNLC) regions. They also demonstrate that Cd/PO_4 variations in the surface ocean and deep sea depend on Cd/P of degraded particles. Using a box model, they present evidence that past changes in HNLC conditions would change the Cd-PO_4 relationship in deep sea, which has to be considered in paleo-reconstructions.

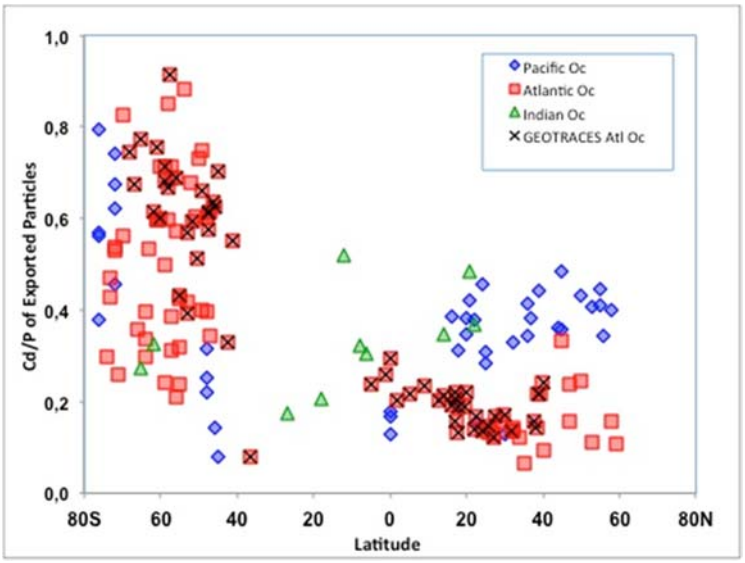

Figure 6: *The meridional and interbasin trends in the estimated Cd/P ratio of particles exported from the surface ocean. The Cd/P of exported particles is a primary factor controlling the spatial variations of dissolved Cd/P in the surface ocean and in the deep sea where particles are degraded.*

Reference:
Quay, P., Cullen, J., Landing, W., & Morton, P. (2015). Processes controlling the distributions of Cd and PO_4 in the ocean. Global Biogeochemical Cycles, 29(6), 830–841. doi:10.1002/2014GB004998

Impressive set of data reveal new features on the modern cadmium–phosphate relationship

Xie and co-authors (2015, see reference below) report vertical profiles of dissolved cadmium (Cd) in the western South Atlantic Ocean (GEOTRACES section GA02), which show nutrient-like distributions similar to those of the macronutrient phosphate (PO4). A close look at the data reveal

- In the surface ocean, preferential uptake of Cd over PO_4 by phytoplankton occurs along the transect, regardless of ambient iron (Fe) concentrations, suggesting Fe availability is not critical for biological Cd utilization in the southwest Atlantic;
- In addition, horizontal advection of Cd-depleted low-oxygen waters originating from the Angola Basin and brought across the Atlantic Ocean via the Benguela and Equatorial currents imparts a Cd-depleted signature to equatorial intermediate waters distinguishing them from southerly intermediate waters.
- This new dataset provides further evidence that Subantarctic Mode Water plays an important role in generating the non-linearity of the global Cd-PO_4 correlation.

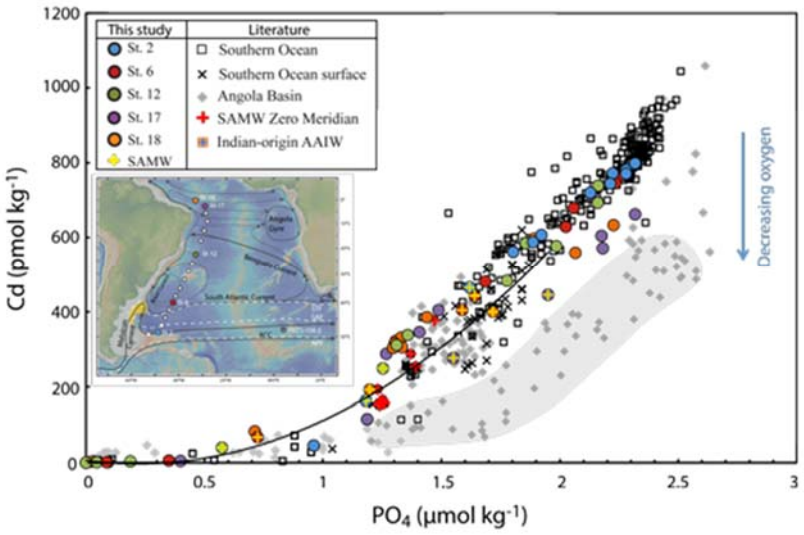

Figure 7: *Evaluation of Cd–PO_4 systematics using new data from GEOTRACES GA02 Leg 3 (colored circles; see inset for location) and literature data (Southern Ocean: Abouchami et al., 2014; Baars et al., 2014; Boyé et al., 2012; Xue et al., 2013; Indian Ocean: Vu and Sohrin, 2013; Angola Basin: Waeles et al., 2013) at the scale of the South Atlantic Basin. The Cd–PO_4 relationship for samples with PO_4 >1.3 µmol kg^{-1} in this study exhibits two parallel linear correlations. The influence of low-oxygen waters originating in the Angola Basin (grey shading) is noticeable in intermediate waters at the equatorial stations. The clear kink at PO_4 ~ 1.3 µmol kg^{-1} in the South Atlantic is attributed to northward flowing, nutrient-rich Subantarctic Mode Water.*

Reference:
Xie, R. C., Galer, S. J. G., Abouchami, W., Rijkenberg, M. J. A., De Jong, J., de Baar, H. J. W., & Andreae, M. O. (2015). The cadmium–phosphate relationship in the western South Atlantic — The importance of mode and intermediate waters on the global systematics. Marine Chemistry, 177, 110–123. doi:10.1016/j.marchem.2015.06.011

Large fluxes of dissolved aluminium exported from the coast to the ocean

In the Eastern China Sea (ECS), the continental shelf serves as an important source of dissolved aluminium (DAl) for the overlaying waters via resuspension of sediments and benthic fluxes. This was demonstrated by Ren et al. (2015, see reference below), who identified cross-shelf transport in the subsurface water over the ECS. The DAl export from the 100 m isobath is 1.67 x 10^{10} g yr^{-1}.

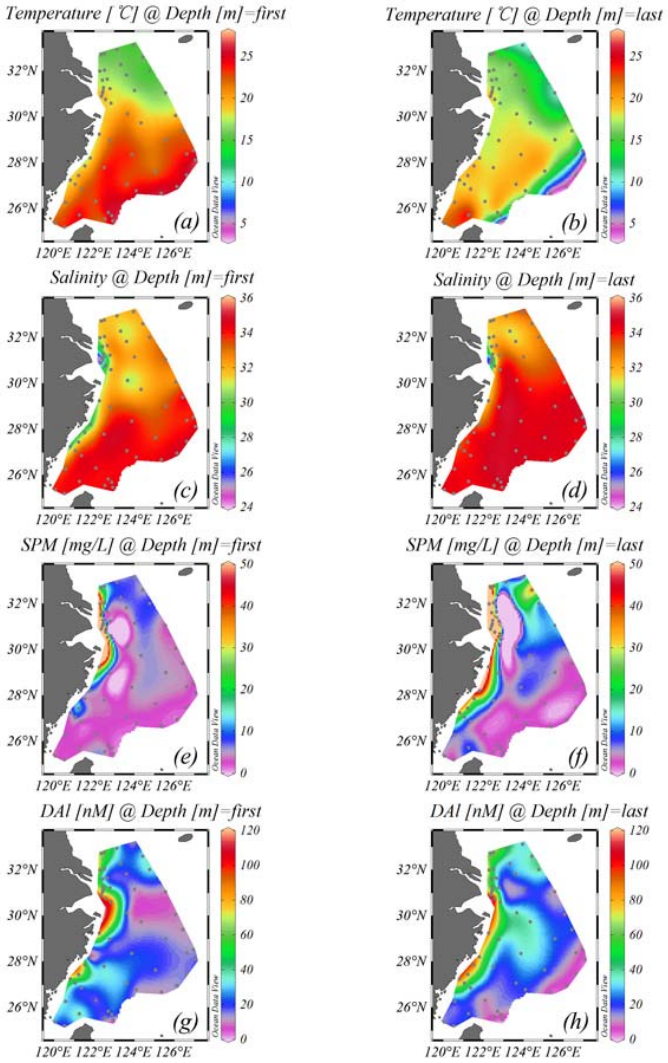

Figure 8: *Horizontal distributions of temperature, salinity, SPM (mg/L), and dissolved Al (nM) in the surface water (a, c, e, g) and bottom water (b, d, f, h, with water depth ranging from 13 m to 1200 m) of the East China Sea. Changjiang Diluted Water (CDW) expanded southeastward in the surface, and was restricted to the coastal area by the incursion of Kuroshio Waters (KW). The incursion of Kuroshio Subsurface Water (KSSW) in the bottom layer can reach 30°N near the Changjiang Estuary. The concentration of dissolved Al decreased gradually from the coastal area to the central shelf, and then decreased sharply at the shelf break. The bottom layer had higher concentrations of dissolved Al than in the surface layer in the coastal and middle shelf, consistent with their higher concentrations of SPM.*

Thanks to the Kuroshio current, more than half of this Al is transported northward within the region enclosed by the 100 m and 200 m isobaths to the Japan Sea/East Sea. The remaining flux is transported out of the shelf across the 200 m isobath. This highlights the importance of coastal processes and subsurface cross-shelf transport as a source of dissolved trace elements to the open ocean.

Reference:

Ren, J.-L., Xuan, J.-L., Wang, Z.-W., Huang, D., & Zhang, J. (2015). Cross-shelf transport of terrestrial Al enhanced by the transition of northeasterly to southwesterly monsoon wind over the East China Sea. Journal of Geophysical Research: Oceans, 120(7), 5054–5073. doi:10.1002/2014JC010655

Multiple controls on the dissolved aluminium fate in the western Atlantic Ocean

Thanks to the most impressive set of dissolved aluminium (Al) and silicon (Si) data ever published in the Atlantic Ocean, Middag and co-workers (2015, see reference below) are thoroughly scanning the processes determining their oceanic distributions. They reveal that i) atmospheric inputs are affecting only the surface and subsurface waters; ii) there is an elusive but obvious coupling between Si-containing biogenic particles and Al; iii) scavenging is occurring faster than the horizontal advective transports, preventing the use of Al as quantitative water mass tracer; and iv) not observed at a basin-wide scale before, suspended sediments are a significant source for dissolved Al in the deep waters.

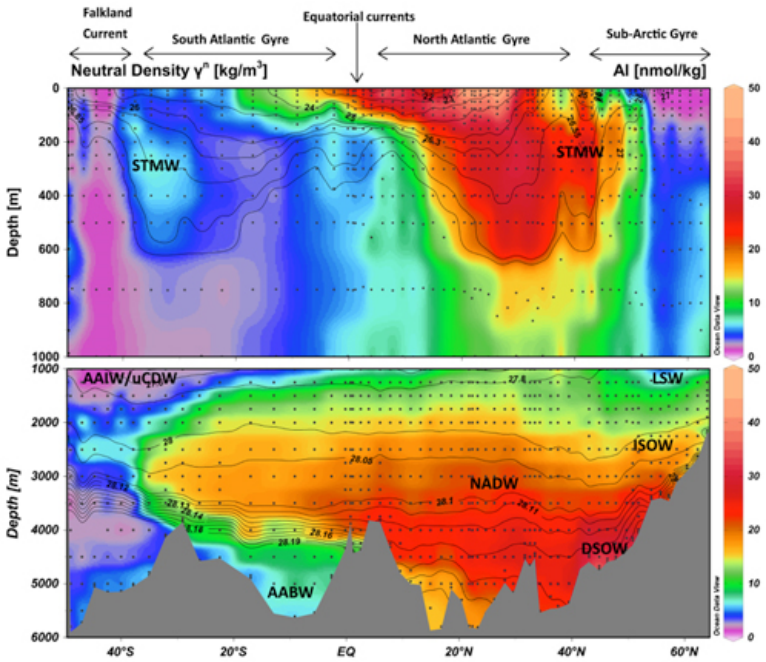

Figure 9: *The distribution of Aluminium (Al) is depicted in colour scale overlain with neutral density isopycnals and main water masses labelled for the upper 1000m and the deep ocean. The effects on the Al concentrations of sediment resuspension in the deep ocean and atmospheric deposition in the surface ocean are clearly visible.*

Reference:

Middag, R., van Hulten, M. M. P., Van Aken, H. M., Rijkenberg, M. J. A., Gerringa, L. J. A., Laan, P., & de Baar, H. J. W. (2015). Dissolved aluminium in the ocean conveyor of the West Atlantic Ocean: Effects of the biological cycle, scavenging, sediment resuspension and hydrography. Marine Chemistry. doi:10.1016/j.marchem.2015.02.015

3. Activities

3.1 GEOTRACES intercalibration activities

The Standards & Intercalibration (S&I) Committee is currently composed of Karen Casciotti, Peter Croot, Tina van de Flierdt, Walter Geibert, Lars-Eric Heimbürger, Maeve Lohan, and Hélène Planquette (who joined since the last reporting period). Greg Cutter has stepped down from the committee and we thank him for all his efforts. Walter Geibert is now a co-chair, together with Maeve Lohan. Since its meeting in Galway, Ireland in January 2015, a virtual meeting was held in January 2016, and a three-day in-person meeting took place at Stanford University from 27 to 29 April 2016. The committee is in constant communication via email and through a shared online resource.

The main task of the committee in the past year was preparing for IDP2017 and ensuring the submission of data to be intercalibrated well in advance of the completion of the data product. The improvements of the submission procedure from the last reporting period are working well and we are pleased with the response from the community. The committee has provided details on requirements for different types of cruises and parameters, which made the intercalibration process more transparent for data submitters. In addition, a new flowchart of the submission procedure was designed and put on the website (http://www.geotraces.org/dp/intermediate-data-product-2017/steps-to-ensure-that-your-data-are-in-idp2017). This better description of the process, combined with regular reminders, individual letters, and written instructions for specific parameters, all contributed to receiving a large number of S&I reports from the analysts from the Atlantic and Pacific oceans. The submission of data for approval has been split into three deadlines, of which the second has now passed. While the submission of reports for data intercalibration can take place at any time before the final deadline, early submission is encouraged so that the committee can resolve issues before the final meeting for approval.

The S&I Committee received approximately 200 datasets from the Atlantic, 50 from the Pacific, 2 from the Indian Ocean, 6 from past IPY cruises, 8 from process studies and 4 GEOTRACES-compliant datasets for the April deadline. During the April meeting of the S&I Committee, all datasets were introduced by the assigned committee members, and discussed by the full committee. Several intercalibration reports were of outstanding quality, providing excellent detail on intercalibration procedures, which was seen as a clear improvement to submissions for the 2014 IDP. There are some remaining issues with some sections where no data have been submitted, or very little data. A particular issue has been the hydrography and nutrient datasets.

Some data in IDP2014 was not intercalibrated due to late submissions and lack of crossover stations. Because all data to appear in IDP2017 must be intercalibrated, we have therefore contacted all data generators whose data were not intercalibrated for IDP2014 and asked for a report to be submitted for IDP2017. We have received many of these reports, but some have not yet been submitted, and the S&I Committee will contact these analysts once more. Elemental co-ordinators, who have been contributing substantially to GEOTRACES by producing reference materials, standards, and organising intercalibration studies, play a key role in ensuring good data quality and improving the abilities of the communities. The existing list of elemental co-ordinators on the web page has been re-assessed, and all elemental co-ordinators contacted to ask if they wished to continue in this role. The responses were overwhelmingly positive, and only a few changes are required. The committee points out in this context that it is critical to involve the S&I Committee in decisions that have a potential influence on the choice, the availability and the characterization of reference materials, as this is our main tool to ensure consistent data sets.

The S&I Committee also discussed how analyses of consensus materials should be archived and distributed in the future. This discussion is on-going and it includes defining committee interaction with elemental co-ordinators, defining how values should be published, the level of anonymity required, and how consensus values can be updated in a manner that is transparent to the community.

The committee is in the process of re-designing the web page and obtaining a dedicated email address (sic@geotraces.org) to make electronic interaction with the S&I Committee more transparent.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanography Data Centre (BODC), with the head office located in Liverpool; the GEOTRACES Data Manager (Abby Bull) is based at the BODC office in Southampton, UK. 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/metadata submissions
- maintaining and modifying GDAC web pages 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 & Intercalibration Committee to ensure that issues/questions relating to GEOTRACES and its progress 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/ metadata for the IDP2017

BODC has recently assigned extra resources to the GEOTRACES Project in order to aid and provide support to Abby, focusing entirely on processing data to be included in the IDP2017. When the GEOTRACES Project expects to experience busy periods (i.e., from Summer 2016 – May 2017) this extra resource will be invaluable.

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

Working with the IPO
The IPO continues to offer support to GDAC when required. The IPO continues to help GDAC stay up to date with new cruises, as well as providing reminders of when certain people should be contacted in order to extract various information at relevant times.

Working with BCO-DMO
GDAC and BCO-DMO have worked closely together over the past year. GDAC has liaised with BCO-DMO about how they can offer support and decrease the data processing time from GDAC's point of view via the use of the GDAC metadata template/methodology form. Communication is regular and BCO-DMO informs GDAC when new U.S. GEOTRACES data are submitted, as well as providing an estimated data processing time. Working with BCO-DMO has also helped to streamline data submission and processing procedures.

GDAC website updates
The GDAC basic delivery mechanism has been removed from the GDAC website as it was not being used. GEOTRACES would like to see an interactive map re-established on the GDAC website rather than the static maps, however, this will consume resources and is therefore not a current priority. All basin maps have been updated and pre/post cruise metadata forms added to the information section about each cruise situated below the basin maps. Contact information of each Chief Scientist/GEOTRACES Scientist for each cruise have also been included on these pages.

DMC/SSC meeting – July 2015
The DMC/ SSC meeting in July 2015, Vancouver, was the first opportunity for Abby to meet most of the key GEOTRACES participants and country representatives. At the DMC meeting, Abby presented various data management areas. These included:

1. Summary of the GEOTRACES transition process from Ed Mawji to Abby Bull
2. A break-down of GEOTRACES data visits since being in position
3. Information and highlights on version 2 of the IDP2014
4. A GDAC website report
5. A process study update
6. A comparison/ interpretation of version 1 and version 2 IDP download statistics

The DMC meeting also focused on the agreement of IDP2017 data and S&I Committee submission deadlines. These are as follows:

S & I/ data deadlines	S & I approval	Anticipated large amounts of data submitted to GDAC	Significance
1 November 2015	January 2016	January – February 2016	Earliest deadline
1 April 2016	May 2016	April – June 2016	Data guaranteed to be in IDP2017
1 December 2016	March 2017	December 2016 – March 2017	Final deadline – data not guaranteed to be in IDP2017

All data for IDP2017 need to be submitted to Reiner Schlitzer by end of May 2017.

The 1 November deadline saw very little data submitted to GDAC and the S&I Committee (Nd and REE data from 4 cruises). This was expected, however, given the 3 deadlines. On the other hand, the guaranteed 1 April deadline experienced an increase in data/intercalibration report submission of around 50 GEOTRACES datasets. At this moment in time, GDAC has received 271 datasets, which are currently being processed and 93 which are completed and 'Reiner ready'. Abby is expecting a steady stream of data to be submitted over the course of the summer in the lead up to and after the DMC/SSC meeting in September 2016.

Maeve Lohan and Greg Cutter (as co-chairs of the S&I Committee) and Abby have put together a document which allows us to determine which analysts have sent both data and intercalibration reports, only sent data, or only intercalibration reports. In the latter 2 situations, communication is required in order to encourage data or intercalibration report submission. This document allows us to keep on top of what has been received and what still needs chasing for data to be successfully included in the IDP2017. This document will also detail approval so Abby is aware of what data have been intercalibrated and what data require further work. This, in turn, alerts Abby whether data values need to be changed in the GDAC database.

A flowchart, created as a joint effort of the S&I Committee, GDAC and the IPO, details how scientists can ensure that their GEOTRACES data are present in the IDP2017. The flowchart illustrates 2 parallel pathways – data submission to GDAC, and the intercalibration process for the dataset via the S&I Committee. Both pathways must be followed (*which can be done concurrently*) in order to have data included in the IDP2017. This flowchart can be accessed on the following GDAC web page :
http://www.bodc.ac.uk/geotraces/data/submission/intermediate_data_product/

BioGEOTRACES meeting – November 2015
BioGEOTRACES discussions at the SSC meeting highlighted the need for a BioGEOTRACES workshop involving GEOTRACES and BioGEOTRACES researchers, as well as GDAC, in order to decide how to prepare for the submission of biological parameters for inclusion in the IDP2017.

A BioGEOTRACES meeting was held in November 2015 at Woods Hole, Massachusetts. It was decided that in order for BioGEOTRACES data to be included in the IDP2017 the following procedure would be followed:

1. GDAC to provide a metadata form to BioGEOTRACES participants so that scientists are aware of what information is required.
2. BioGEOTRACES scientists to provide GDAC example datasets with accompanying metadata so GDAC can provide feedback.
3. Guaranteed IDP2017 submission deadline on 1 April 2016 for BioGEOTRACES data.

4. Maite Maldonado to provide recommendations for methodologies and intercalibration protocols/efforts for each BioGEOTRACES parameter that has been chosen to be included in the IDP2017.

GDAC has provided feedback on example BioGEOTRACES datasets that were submitted and used biological data management resources at BODC for support and expertise. Only 'element quotas of individual phytoplankton cells' were submitted by the guaranteed IDP2017 deadline. GEOTRACES datasets will still continue to be prioritised over BioGEOTRACES datasets.

GDAC data wiki page
One change to note since July 2015 is that there is now a wiki page which details the number of outstanding, received, and processed datasets (those ready for the IDP2017). This tool has proved to be invaluable in regard to tracking outstanding data and monitoring the throughput of data into the BODC system so priorities are more easily defined and work efforts/extra resource can be targeted as required. This wiki page (https://wiki.ceh.ac.uk/display/GDM/GEOTRACES+IDP17+Progress) is updated at the end of every month so changes can be easily identified, and pressure can be applied where needed. Through the use of this tool it is hoped we will see a steady stream of data submitted to GDAC rather than a large submission close to the final deadline (December 2016), therefore lifting a potential burden from the GDAC data manager. Through the use of the wiki page, updates can be discussed further with the DMC co-chairs.

Data overview
The data management of the GEOTRACES programme is a large undertaking, with a total of 84 associated cruises (including all cruise legs; this takes into account all section cruises, process studies and compliant data), and 64 sections/studies. More than 800 scientists have taken part in the GEOTRACES cruises, with 15 different nations having run a major GEOTRACES IPY/section/process study cruise.

The 2015/2016 period has witnessed the submission of outstanding data, with metadata becoming more forthcoming. It has been recognised that a way of encouraging PIs to submit their data to GDAC more readily is to use the IDP2017 as an incentive.

Summary of completed GEOTRACES cruises to date:

Section cruises	**IPY cruises**	**Process studies**	**Compliant data**
31 cruises (including all legs) with 23 sections	11	35 (including all legs) with 23 studies	5

Summary of GEOTRACES cruises which have taken place in 2015/2016:
This year the International GEOTRACES Arctic research programme was focused on field efforts from the United States, Canada and Germany. Four Arctic cruises were planned, funded, and took place between July and October 2015. The German **section** cruise (M121 (GA08)) focused on the SE Atlantic with cruise dates of 22 November-28 December 2015. Other cruises which took place were **Process Study** cruises, and are as follows:

- Japanese cruise (KH15-3 – GPpr12) in the East China Sea – October–November 2015
- Netherlands cruise (PE401 ViciFe – GApr05) in the Black Sea – August–September 2015
- German cruise (SO245 UltraPac– GPpr09) in the ultra-oligotrophic South Pacific – December 2015–January 2016
- Australian cruises (K-axis - GIpr06) and (HEOBI GIpr05) – both in the Indian sector of the Southern Ocean – January–March 2016
- Canadian cruise (LineP- 2015-10 - GPpr07) in the Pacific Ocean – August-September 2015
- UK cruise (Shelf Seas – DY033 - GApr04 leg 3) in the Celtic Sea – July–August 2015

Summary of GEOTRACES cruises to take place in 2016/2017:

Process Studies
- **ViciFe** – Netherlands - Arctic Pelagia – Summer 2016 – further information to be provided shortly.
- **SOSCEx II** – South Africa – (PI: Pedro Montero)

- **Peacetime** – France – (PI: Dr Guieu Cecile) – of which further information will be provided shortly.

Section cruises
- **GN05 – GRIFF** – Germany (PI: Torsten Kanzow) – Arctic Ocean – 19/07/2016 – 09/09/2016

In summary
The collection and processing of data to be included in the IDP2017 will be the focal point of GDAC's data activities over the coming year.

In summary, GDAC is receiving more and more data/metadata via the use of the metadata templates. Scientists are consulting the GDAC web pages before submitting, which is an indication that this part of the data submission process is improving. The methodology information is crucial when it comes to assigning BODC parameter codes, instrumentation, and writing documentation for the user.

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
The following outreach activities merit to be reported:

- GEOTRACES Outreach web page
  The IPO has continued to compile and make available on the GEOTRACES Outreach web page educational and outreach materials. This year, a remarkable effort was invested in outreach for the GEOTRACES International Arctic Programme. This includes:

  - 17 cruise blogs
  - 58 videos
  - participation of a PolarTREC science teacher on board the U.S. expedition who posted over 65 blogs to the PolarTREC website (www.polartrec.com/expeditions/us-arctic-geotraces/journals)
  - the "Float the Boat" programme (programme designed to involve students and public with an Arctic research on the U.S. *Healy* where over 1,300 boats on the ice were deployed as drifters to track the ice movement across the Arctic: http://floatboat.org
  - radio interviews
  - Educational outreach to U.S. Coast Guard personnel

    - outreach to local populations who depend on the Arctic Ocean for their livelihood (U.S. researchers put together a package for presentation at Kawerak Conference (31 May-4 June, 2015, Alaska) and presented GEOTRACES at the meeting for rural natives.

- GEOTRACES eNewsletter Special Issue devoted to Outreach activities
  In order to provide visibility to the numerous GEOTRACES outreach activities, the IPO published a special issue of the e-Newsletter devoted to outreach. This issue was published and broadly distributed coincidently with the opening of the COP21 conference on climate change (30 November 2015), to reinforce the message that GEOTRACES research is closely linked to climate change. The special issue is available here:
  http://www.geotraces.org/index.php?option=com_acymailing&ctrl=archive&task=view&mailid=501&key=pEtJKupG&tmpl=component
  After the release of the special issue, the IPO sought feedback from the GEOTRACES SSC members, end users and experts in communication and outreach. Feedback received was positive and very encouraging.

- Booth at Ocean Sciences Meeting 2016
  The IPO helped SCOR in coordinating, setting and staffing the SCOR booth at Ocean Sciences Meeting (21-26 February 2016, New Orleans, LA, USA). This year SCOR invited GEOTRACES, SOLAS, IMBER and SOOS international projects. For this booth, the IPO prepared several ad-hoc materials, including:

    - A new roll-up banner introducing the GEOTRACES programme, the IDP2014 and a selected science highlight.
    - A set of 4 postcards showing 4 different eGEOTRACES Atlas 3D scenes. The aim of these postcards was to attract visitors at the booth at the same time as helping to promote and give visibility to the GEOTRACES products.
    - A video display documenting scientific activities of several SCOR-sponsored projects. This video is available here: https://youtu.be/lx1cnNx2dhY.

- Goldschmidt 2015
  A new poster introducing GEOTRACES and the Intermediate Data Product was presented at the Goldschmidt 2015 meeting (16 - 21 August 2015, Prague, Czech Republic).

In addition, this year we would like to highlight the following tasks:

- GEOTRACES website:
  After the major overhaul done last year, the IPO has continued to improve the GEOTRACES website (<http://www.geotraces.org>) and fix several bugs of the new template. In addition, three upgrades have been done. As an example of new features, the GDAC cruise programme is now embedded in the IPO website so that there exists one cruise programme in both websites, facilitating navigation through them.

- IDP2017 Flowchart
  As initiative of the IPO, a flowchart describing the process to follow in order to ensure that data are in IDP2017, has been created as a joint effort of the S&I Committee, GDAC and the IPO. This flowchart is available on both the GDAC and the IPO websites:
  http://www.geotraces.org/dp/intermediate-data-product-2017/steps-to-ensure-that-your-data-are-in-idp2017

- Meeting and Workshop organisation
  The IPO has been solicited to assist at a different level in the following meetings and workshops: 2016 SSC and DMC meetings; Goldschmidt 2016 Workshop “Exploring GEOTRACES Data with ODV”; Ocean Sciences Meeting Town Hall “Opportunities to Strengthen Your Science (and Proposals) using GEOTRACES Data"; Workshop “Biochemical cycling of trace elements within the ocean: A synthesis workshop”, Workshop “Biogeochemical studies in the Siberian Shelf”; “GEOTRACES Royal Society coupled workshop and meeting”. Please read section “GEOTRACES Workshops” for further information about these workshops.

- Funding
  A new agreement has been concluded within the sponsors of the GEOTRACES IPO. From now on, the University Paul Sabatier replaces the Centre National de la Recherche Scientifique (CNRS) in the financial management of the agreement. Attaining this new agreement has required a substantial time investment from both the IPO science director and the executive officer. In addition, since the IPO is hosting the 2016 SSC and DMC meetings, additional funding has been secured through the University Paul Sabatier.

- Some statistics
  25 new highlights published (105 in total)
  5 eNewsletter published (bimonthly newsletter, 20 in total)
  130 new peer-reviewed papers included in the GEOTRACES Publication Database (678 in total)
  179 new articles published on the GEOTRACES website (from them 35 jobs/student positions)
  140 announcements sent through the GEOTRACES mailing list
  110 new posts on Facebook and 281 likes (top post reach 1,556)
  70 new tweets and 211 followers
  81 new subscribers on the GEOTRACES website

3.4 GEOTRACES Workshops

Coupled meeting and workshop to discuss and synthesise findings from the GEOTRACES programme, 7–10 December 2015, UK.

This meeting was organised in two parts, with two different venues: the first part (#1 below, a Royal Society Scientific Discussion Meeting) was dedicated to a broad audience, the goal being to give an overview of the up-to-date research in marine biogeochemistry and the role of ocean trace-element cycling in Earth systems. The second part was a workshop (#2) occurring in Buckinghamshire (Chicheley Hall). Plenary sessions and small group meetings alternated. The different workshops discussed and synthesised the present knowledge of 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. Poster sessions allowed discussions around the most recent results.

All the authors were requested to submit a paper in a dedicated issue of *Philosophical Transactions A* of the Royal Society.

1) The biological and climatic impacts of ocean trace-element chemistry, 7–8 December 2015, The Royal Society, London, UK.
For further information (recorded audio presentations are available):
https://royalsociety.org/events/2015/12/ocean-chemistry/

2) 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/

Biogeochemical studies in the Siberian Shelf Seas, 27–28 January, Kiel, Germany.

The aim of this workshop, supported by IASC, TRANSDRIFT (System Laptev Sea) and GEOTRACES, was to bring together various groups working on biogeochemical cycles in the Siberian shelf seas and explore possibilities of cooperation. As a result, two possibilities emerged for cooperation with Russia in the field of tracer studies: (1) the participation of a GEOTRACES scientist in the Russian 2017 Expedition to the Barents, Kara Laptev Seas; and (2) GEOTRACES scientists are encouraged to host a Russia student/scientist on a GEOTRACES cruise or lab, with support from SCOR.

Forthcoming:

Exploring GEOTRACES data with Ocean Data View (Goldschmidt 2016 Workshop), 26 June 2016, Yokohama, Japan.

This hands-on workshop will teach standard and advanced ODV methods for the exploration and scientific analysis of environmental data. The GEOTRACES Intermediate Data Product 2014 (IDP2014) will be used as example dataset. Participants will learn how to create publication-ready maps, property-property plots and sections, and how to apply simple or advanced station and sample filters. In addition, an overview over the wide range of derived variables available in ODV will be given and a number of variables often needed in geochemical research will be described and applied. This includes aggregation, interpolation, unit conversion, differentiation and integration. The workshop will start with presentations of general software concepts and capabilities, followed by hands-on sessions for the creation of specific plot types and scientific discussion rounds explaining the findings. Participants are encouraged to bring their own laptop computer with ODV (http://odv.awi.de/) and the IDP2014 dataset (http://www.bodc.ac.uk/geotraces/data/idp2014/) already installed. For further information: http://www.geotraces.org/meetings/geotraces-events/eventdetail/263/-/exploring-geotraces-data-with-ocean-data-view

Joint GEOTRACES/OCB Workshop: "Biogeochemical cycling of trace elements within the ocean: A synthesis workshop", 1–4 August 2016, Lamont-Doherty Earth Observatory, Palisades, New York, USA.

The workshop will launch a synthesis initiative on the biogeochemical cycling of trace elements and their isotopes within the ocean. The aim is to bring together expertise from GEOTRACES, OCB, and the broader oceanographic community of observationalists and modelers to explore the biological–chemical–physical underpinnings of trace element cycling, including (but not limited to) bioavailability, uptake, scavenging, and regeneration. The workshop will identify a small number of high-priority synthesis objectives that can be achieved over the next decade, exploiting the rapidly expanding set of data from GEOTRACES and related studies. The workshop will also outline strategies to reach those goals, which may include new modeling and observational initiatives. For further information: http://www.geotraces.org/meetings/geotraces-events/eventdetail/254/-/joint-geotraces-ocb-workshop-on-internal-cycling-of-trace-elements

3.5 Special sessions at international conferences featuring GEOTRACES findings

Several special sessions with relevance to GEOTRACES were featured in major international conferences including:

2016 Ocean Sciences Meeting, 21–26 February 2016, New Orleans, Louisiana, USA.
For further information: http://osm.agu.org/2016/

GEOTRACES Town Hall:

*****Town Hall "Opportunities to Strengthen Your Science (and Proposals) using GEOTRACES Data", **Thursday, February 25, 2016: 6:30 PM - 7:30 PM**

GEOTRACES Tutorial:

*****T014: What Controls the Distribution of Dissolved Iron in the Ocean?, **Tuesday, February 23, 2016, 03:30 PM - 04:00 PM**
Primary Chair: Alessandro Tagliabue, University of Liverpool.

GEOTRACES Sessions:

Atmospheric deposition and ocean biogeochemistry
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

**The role of particles in the cycling of trace elements and their isotopes in the ocean
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

*Trace Elements and Isotopes at the Interfaces of the Atlantic Ocean
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

*Trace Metal Bioavailability and Metal-Microorganism Interactions
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

*Trace metal speciation in seawater: measurements, modelling and impact on marine biogeochemistry
Primary Chair: David R. Turner, University of Gothenburg, Gothenburg, Sweden
Chairs: Stan M.G. van den Berg, University of Liverpool, Liverpool, L69, United Kingdom, Sylvia Gertrud Sander, University of Otago, Dunedin, New Zealand, Kristen N. Buck, University of South Florida Tampa, Tampa, FL, United States, Rachel Shelley, LEMAR/UBO, Brest, France, Peter L Morton, Florida State University, Department of Earth, Ocean, and Atmospheric Science, Tallahassee, FL, United States, Christian Schlosser, GEOMAR Helmholtz Centre for Ocean Research Kiel, Chemical Oceanography, Kiel, Germany and Eric P. Achterberg, GEOMAR Helmholtz Centre for Ocean Research Kiel

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-coordinators: 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, Australia, Rob Middag (Univ Otago, New Zealand), James Moffett (Univ. South Carolina, USA)

*02a: Trace Metals in the Ocean: Distributions, Isotopic Variation and Speciation
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://fallmeeting.agu.org/2015/

*GC067: Trace Metal Cycling in the Environment – 40 Years of Advancements
Convenors: Priya Ganguli, Frank Black, Sergio Sanudo-Wilhelmy and Ed Boyle

Forthcoming:
2016 Goldschmidt Meeting, 26 June–1 July, 2016, Yokohama, Japan.
For further information: http://goldschmidt.info/2016/

*12d: Oceanic Cycling of Trace Elements Using Elemental, Isotopic, and Modeling Approaches: Geotracers and Beyond...
Convenors: Tim Conway, Tristan Horner, Jessica Fitzsimmons, Hajime Obata, Catherine Jeandel, Andrew Bowie, Phoebe Lam

*12f: Elemental and Isotopic Marine Biogeochemistry at a Range of Scales: The Global Ocean, Marginal Seas, and Polar Atmosphere–Sea Ice–ocean Systems
Convenors: Susan Little, Daiki Nomura, Gregory de Souza, Markus Frey, Delphine Lannuzel, Jun Nishioka, Patrick Rafter, Martin Vancoppenolle

*16d: Models of Life and Geochemistry: Integrating Large-Scale Datasets into Global Climate Models
Convenors: Seth John, Tatiana Ilyina, Andy Ridgwell

Challenger Society 2016 Conference - Oceans and Climate, 5–8 September 2016, Liverpool, UK.
For further information: https://www.liverpool.ac.uk/challenger-conference-2016/

*__Trace element and isotope exchange at ocean boundaries__
Conveners: Will Homoky (Oxford), Torben Stichel (Southampton) & Susan Little (Imperial)

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 either 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 wth coupling to 6000 m CTD wire
Brazil	Complete	GEOTRACES WATER SAMPLER - 24-bottle sampler for use with modem 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	5000 m conducting Vectran
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,	Powder coated aluminium with titanium pressure	27 x 12-L OTE GO-Flo	8000 m; conducting Kevlar

	winch planned	housings and fittings		
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	13 X 5-L Teflon-lined Niskin-X; 13 X 5GO-Flo	4000 m; 8 mm Kevlar line
Norway	In development	Standard 12 positions CTD Rosette GO	5-L Niskin-X	
Poland	Complete* (although the steel cable)	Powder coated aluminum, SeaBird Rosette	8x 10L GoFlo	3000m, steel conducting cable
Poland	Complete	Single bottle	10l G-FLO X Teflon coated	300m Kevlar
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 - GEOTRACES	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L GO-Flo	8000 m; conducting Kevlar
USA- University of Alaska Fairbanks	Complete	Seabird Rosette. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	No Kevlar line available yet.
USA- Old Dominion University	Complete	Seabird Rosette. SBE-19 plusV2 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 year

While continuing to progress with the field programme, the top priority for next reporting year will be the release of the second **Intermediate Data Product at the Goldschmidt Meeting 2017** (13-18 August 2017, Paris, France). This will require a huge effort from the GEOTRACES community, GDAC, and IPO and, thus, most of the GEOTRACES work will be centred in making the IDP2017 possible, with several meetings to be held.

In addition, GEOTRACES will continue to implement the **GEOTRACES synthesis of results strategy** with (1) a workshop focused on the internal cycling of TEIs within the ocean to be held in August 2016, organised by U.S. GEOTRACES, in collaboration with the Ocean Carbon and Biogeochemistry Programme (OCB) and (2) a workshop centred on geochemical tracers used as paleoceanographic proxies, proposed for 2018. A proposal has been submitted to the Past Global Changes project (PAGES) to explore partnership with them to host the workshop.

Acknowledgements

We offer our special thanks to Ed Urban, who continues to provide tremendous support and valuable advice to the implementation of the GEOTRACES programme.

Written and compiled by:
Ed Boyle and Reiner Schlitzer (Co-Chairs GEOTRACES SSC)
Maeve Lohan and Walter Geibert (Co-Chairs of the GEOTRACES S&I Committee)
Abby Bull (GEOTRACES Data Manager)
Catherine Jeandel (GEOTRACES IPO Science Director)
Elena Masferrer Dodas (GEOTRACES IPO Executive Officer)

May 2016

APPENDIX 9

INTERNATIONAL QUIET OCEAN EXPERIMENT (IQOE)

2016 Annual Report International Quiet Ocean Experiment

Since publication of the Science Plan of the International Quiet Ocean Experiment (IQOE) in 2015, the following actions have taken:

- An IQOE Science Committee was approved by SCOR and the Partnership for Observation of the Global Oceans (POGO)
- The Science Committee met in London, UK in March 2016
- IQOE Co-chairs and Sponsors met in Woods Hole, Massachusetts, USA on 22 July.
- The Science Committee formed 6 working groups to begin implementing the activities of the project
- An IQOE Web site was developed

IQOE Science Committee
The IQOE Science Committee has the major responsibility to direct the science of the project and implement the IQOE Science Plan. The inaugural committee has two co-chairs, one an acoustician and the other bioacoustician. The members include the following:

Co-chairs: George Frisk (USA) and Peter Tyack (UK)

Other Members: Olaf Boebel (Germany), Bishwajit Chakraborty (India), Christ de Jong (The Netherlands), Anthony Hawkins (UK), Jennifer Miksis-Olds (USA), Hanne Sagen (Norway), Jakob Tougaard (Denmark), and Alexander Vedenev (Russia).

Other scientists will be involved in IQOE through working groups (see below) and through endorsement of national scientific activities.

March 2016 IQOE SC Meeting
The IQOE SC held its first meeting in London, UK on 29-31 March to begin its work. The meeting agenda included presentations of all portions of the IQOE Science Plan to ensure that all SC members were familiar with the document. An important part of the meeting was to hear from potential stakeholder organizations based in London, such as the Institute of Marine Engineering, Science & Technology (IMarEST), International Chamber of Shipping, U.S. Office of Naval Research-Global, International Association of Oil & Gas Producers (IOGP), and from Geneva, the Comprehensive Test Ban Treaty Organisation (CTBTO). The meeting also began to make plans for the initial IQOE implementation activities. Six working groups were proposed and the terms of reference and working group membership are being developed (see below).

Meeting of IQOE Co-chairs and Sponsors
The chairs and sponsors of IQOE will meet in Woods Hole, Massachusetts, USA on 22 July 2016. Several co-chairs are in Woods Hole during the summer months, making it a convenient location to meet. The meeting reviews the status of IQOE implementation and discusses fund-raising for the project. [modify after the meeting]

IQOE Working Groups

1. Standards and Intercalibration: Any project that involves more than one investigator, laboratory, or observing system must agree to standard techniques and/or perform intercalibrations among techniques or observations to make it possible to later compare their results. The IQOE will form a subcommittee responsible to recommend best practices for experimentation and observation or, where this is considered undesirable, will determine other means to ensure that results are comparable.
2. Data Management and Data Access: One of the goals of the IQOE will be to create time series of acoustic data in key locations of the global ocean, to provide to policymakers documentation of how sound in the ocean has changed over time. The IQOE will seek to make as many acoustic observations and experimental

results as openly available as possible, and will develop a data management and data access policy for scientists and data centers involved in the project.

3. Arctic Science: The Arctic Ocean is still relatively pristine acoustically. However, with the continuing decrease in ice cover of this basin, oil and gas exploration, shipping, tourism, and other noise-producing activities are increasing. The IQOE will seek to produce an acoustic baseline against which future sound increases can be compared.
4. Measurement of Biodiversity on Coral Reefs with Acoustics: Coral reefs are some of the most biodiverse areas of the global ocean, are important to human society, and are in danger from global change. The biodiversity of reef habitats can be difficult to assess because it requires observations by human divers. However, many reef organisms make sounds that can be measured continuously. This working group will explore the potential to monitor sound on coral reefs continuously to characterize one measure of reef biodiversity.
5. Using Acoustics to Locate Spawning Aggregations of Fish: Many species of fish vocalize. Some vocal species also form dense spawning aggregations in areas that have not always been identified. This working group will assess the potential to use passive acoustics to locate and monitor aggregations of fish such as cod and haddock.
6. Stakeholder Relations: Diverse stakeholder groups have an interest in sounind in the ocean, because their activities produce sound incidentally or produce sound purposely, or because they are concerned about the effects of sound on marine organisms. Other stakeholders collect and archive acoustic data. This working group will help the IQOE Science Committee interact with the various stakeholders to keep them informed, make sure their concerns are addressed, and entrain them as partners in the IQOE.

In addition, the Partnership for Observation of the Global Oceans (POGO) set up a Working Group to Implement IQOE Science Recommendations on Noise Exposure and Broad-Scale Acoustic Monitoring to contribute to IQOE goals. This working group will implement specific elements of the IQOE Science Plan related to (1) approaches to assess the impact of noise exposure and acoustic monitoring methods, (2) means to implement and improve these approaches, and (3) better understanding broad-scale issues related to ocean noise and human influences.

IQOE Web Site

An IQOE Web site has been developed with basic information about the project (see www.iqoe.org). The site includes information about the development of the project, products that have resulted, people who have been involved, and resources for the community, such as links to relevant programs, scientific meetings, and publications. Information about IQOE working groups will be added when available.

Funding

SCOR budgeted US$10,000 for IQOE implementation activities in 2016 and an additional $10,000 from the Monmouth University-Rockefeller University consortium was carried over from 2015. These funds were used primarily to support the March 2016 SSC meeting.

Submitted by Ed Urban, SCOR Executive Director

APPENDIX 10

SECOND INTERNATIONAL INDIAN OCEAN EXPEDITION (IIOE-2)

SCOR, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and the Indian Ocean Global Ocean Observing System (IO-GOOS) launched the Second International Indian Ocean Expedition (IIOE-2) on 4 December 2015. The launch included distribution of the IIOE-2 Science Plan and Implementation Strategy documents (see http://www.iioe-2.incois.gov.in/IIOE-2/Reports.jsp). On the same day, the first cruise of the IIOE-2 left from Goa, India for Mauritius (see http://www.iioe-2.incois.gov.in/IIOE-2/Expedition1.jsp), on ORV *Sagar Nidhi*. The cruise included significant participation of non-Indian scientists demonstrating strong international collaborative leadership.

IIOE-2 Steering Committee

A request for nominations of scientific theme and operational working group chairs was issued through SCOR, IOC, and IO-GOOS. The chairs will comprise the IIOE-2 Steering Committee. The co-sponsors are considering nominations and hope to appoint the committee by the time of the SCOR meeting. Co-sponsors are still discussing how to resource meetings of the Science Committee.

Joint Project Office (JPO)

Two project offices have been set up for IIOE-2; one in Perth, Australia at the IOC regional office, and the other in INCOIS in Hyderabad, India. The two offices are being referred to as the Joint Project Office. Staffing and other costs are provided by national governments and IOC. Ed Urban from SCOR continues to provide support to the project also.

National IIOE-2 Committees

SCOR with the other co-sponsors are encouraging the formation of national IIOE-2 committees, to foster and coordinate national research in the Indian Ocean and promote increased funding for such work. National contributions will provide a strong foundation for the IIOE-2 and national committees have been formed in Australia, Germany, India, South Africa, the UK, and the USA. The U.S. IIOE-2 Committee held a Town Hall session at the Feb. 2016 Ocean Sciences Meeting to provide an update about IIOE-2 progress.

Endorsement Process

The IIOE-2 co-chairs have created an endorsement process to create a process to engage national projects in IIOE-2.

Early-career Scientist Activities

A workshop was held by early-career scientists at the Goa symposium in December. There is a paper underway to report on the recommendations of the workshop. A Facebook page (IIOE 2 Early Careers) as a networking tool.

Communication

An IIOE-2 Web site is available at http://www.iioe-2.incois.gov.in/IIOE-2/index.jsp# and the Indian Ocean Bubble-2 provides updates about the project (see http://www.iioe-2.incois.gov.in/IIOE-2/Bubble.jsp).

Funding

The 2016 SCOR budget approved in at the Goa meeting included US$20,000 for IIOE-2 activities. Australia and India are supporting at least two FTEs for the JPO. IOC and IO-GOOS have yet confirmed their financial support.

APPENDIX 11

2015 Audited SCOR Income and Expenses Statement

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH, INC.
STATEMENT OF ACTIVITIES
YEAR ENDED DECEMBER 31, 2015

UNRESTRICTED NET ASSETS	
SUPPORT AND REVENUE	
Grant and contract revenue	$827,482
Membership dues	$348,888
Meeting registration fees and miscellaneous income	$ 51,286
Interest income	$ 20
TOTAL SUPPORT AND REVENUE	$1,227,676
EXPENSES	
PROGRAM SERVICES	
Scientific programs	$861,553
Travel and subsistence programs	$ 73,198
Other conferences and meetings	$ 41,132
TOTAL PROGRAM SERVICE EXPENSES	$975,883
SUPPORT SERVICES	
Management and general	$293,811
TOTAL EXPENSES	$1,269,694
CHANGE IN UNRESTRICTED NET ASSETS	($ 42,018)
UNRESTRICTED NET ASSETS, beginning of year	$235,828
UNRESTRICTED NET ASSETS, end of year	$193,810

APPENDIX 12

SCOR-Related Meetings (2016-2018)

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)	Xiamen, China
15-17 July	WG 149 on Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?	Waterville Valley, New Hampshire, USA
5-7 September	SCOR General Meeting	Sopot, Poland
12-14 September	WG 150 Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)	Southampton, UK
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)	Qingdao, China
3-7 October	WG 148 on International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)	Tokyo, Japan
24-26 October	SOLAS Scientific Steering Committee	Qingdao, China
2-5 December	WG 144 Symposium on OMZ Microbial Ecology and Biogeochemistry	Goa, India

2017		
27-28 January	IQOE Science Committee	London, UK
2-4 February	IIOE-2 Steering Committee	Perth, Australia
6-7 February	IOCCP Scientific Steering Group	Miami, Florida
28-30 March	GlobalHAB Scientific Steering Committee	Naples, Italy
2-5 April	WG 152 on Measuring Essential Climate Variables in Sea Ice (ECV-Ice)	La Jolla, California, USA
13 April - 12 May	4th African Discovery Camp for Research-based Training Science for the Sustainable Use and Management of Marine Ecosystems and their Resources	Henties Bay, Namibia
23-25 April	IMBeR Scientific Steering Committee	Shanghai, China
11-14 June	SOOS Scientific Steering Committee	Bremerhaven, Germany
15-16 June	WG 149: Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?	Villefranche, France
9-11 August	WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5)	Aix-en-Provence, France
20-25 August	1st GEOTRACES Summer School	Brest, France
4-6 September	SCOR Executive Committee Meeting	Cape Town, South Africa
16-20 September	GEOTRACES Data management Committee and Scientific Steering Committee	Salvador, Brazil
2-5 October	IMBER Imbizo V	Woods Hole, Massachusetts, USA
2018		
February	WG 143: Dissolved N2O and CH4 measurements: Working towards a global network of ocean time series measurements of N2O and CH4	Portland, Oregon, USA
February	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	Portland, Oregon, USA
February	WG 147: Towards Comparability of Global Oceanic Nutrient Data (COMPONUT)	Portland, Oregon, USA
February	WG 150: Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)	Portland, Oregon, USA
11 February	WG 151: Iron Model Intercomparison Project (FeMIP)	Portland, Oregon, USA
April	WG 148: International Quality Controlled Ocean Database:	UK

	Subsurface temperature profiles (IQuOD)	
15-17 June	WG 152 on Measuring Essential Climate Variables in Sea Ice (ECV-Ice)	Davos, Switzerland
3-5 September	SCOR General Meeting	Plymouth, UK