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SCOR Proceedings, Volume 53  
REPORT OF THE 2017 ANNUAL SCOR MEETING

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# **43<sup>nd</sup> SCOR EXECUTIVE COMMITTEE MEETING**

Cape Town, South Africa

4-6 September 2017

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## **1.0 OPENING**

### **1.1 Opening Remarks and Administrative Arrangement**

Participants were welcomed by SCOR President Marie-Alexandrine Sicre on behalf of SCOR and by local host John Compton on behalf of the South African SCOR Committee. A moment of silence was observed for 7 individuals who died during the past year and had been involved in SCOR activities: Ralph Cicerone, Paul Harrison, Mike Lucas, James O'Brien, Graham Shimmield, Theodore Smayda, and Torben Wolff. The South African SCOR Committee hosted an afternoon session of presentations by South African students and scientists in memory of Mike Lucas. Following the moment of silence, participants introduced themselves.

### **1.2 Approval of the Agenda**

Additions or modifications to the agenda as distributed may be suggested prior to approval of the final version. Marie-Alexandrine Sicre noted changes in the agenda from the version distributed in the background book, to accommodate presenters' schedules, and the changes were approved.

### **1.3 Report of the President of SCOR**

The President briefly reviewed her activities for SCOR since the 2016 SCOR Annual Meeting in Sopot, Poland. In addition to the normal activities related to the management of SCOR, extra time was required to prepare and participate in the UN Ocean Conference, participate in G7 science activities, and assist Future Earth in the development of the Ocean Knowledge-Action Network. Sicre and Ed Urban participated in the IOC General Assembly in June 2017, and met with the ICSU Science Director and the French SCOR Committee while Urban was in Paris for the IOC Assembly. Sicre also participated in a meeting of the French IIOE-2 Committee at that time.

### **1.4 Report of SCOR Executive Director**

The SCOR Executive Director, Ed Urban, reported on his activities for SCOR since the 2016 SCOR Annual Meeting, and on the current condition of SCOR. SCOR's finances are in good shape. There has been some extra pressure on SCOR dues this year in several countries, but it seems that the budgeted dues level will be achieved. SCOR working groups have had good visibility and five groups will be meeting in conjunction with Ocean Sciences 2018, which could give extra visibility to these groups. The large-scale projects are making good progress, as will be reported later in the meeting. In terms of visibility for SCOR, there will be a SCOR booth at Ocean Sciences 2018. The number of Twitter followers doubled during the year. There was a good response to the questionnaire about SCOR communication approaches. The response to the ICSU review was completed by the SCOR Executive Committee and Executive Director,

reviewed by national SCOR committees, and sent to ICSU. The percentage of female participation in SCOR activities has continued to increase and participation of scientists from developing countries remained stable. The SCOR Executive Committee is discussing how to bring early-career scientists into working groups.

### **1.5 Appointment of an *ad hoc* Finance Committee**

The SCOR Constitution requires that a Finance Committee be appointed at every SCOR Annual Meeting. It must consist of at least three members of SCOR who are not members of the Executive Committee. The Finance Committee reviewed the administration of SCOR finances during the previous fiscal year and the current year, and proposed a budget for 2018 activities and dues for 2019. Marie-Alexandrine Sire announced that members of the 2017 Finance Committee are Annalisa Griffa (Italy), Jorma Kuperinen (Finland), Sinjae Yoo (Korea), and Jing Zhang (Japan). The Committee will report to the meeting under agenda item **8.3**.

### **1.6 2018 Elections for SCOR Officers**

The SCOR Secretary and all three Vice-President positions will be open for nominations for the 2018 elections. Peter Burkill asked for volunteers to serve on the Nominating Committee.

## **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.

#### **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 2016 SCOR meeting for another year to complete its second publication. The group has reported that the second paper from the group is close to being finished. This review paper is entitled “Hydrothermal energy transfer and organic carbon production on the deep-seafloor”, by N. Le Bris, P.A. LokaBharathi, M. Yücel, A. Das, and the SCOR WG135. The paper will be submitted to *Frontiers in Marine Science* by end of October 2017. There was discussion about whether to disband the group now or wait until the second paper is completed. It was decided that the group should be continued for now and informed that it will be disbanded automatically in 12 months.

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

Corina Brussaard reported on the group. Its final workshop 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](http://www.eforams.org/img_auth.php/e/ed/SCORWG138_Catalina_2nd_circular.pdf)). The group’s progress toward fulfilling its terms of reference are as follows:



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

The WG 138 efforts allowed the community working on genetic studies on planktonic foraminifera to produce a comprehensive synthesis of existing genetic resources (Morard et al., 2015), to devise a scheme for implementing stable nomenclature to distinguish among taxa genetically (Morard et al., 2016) and to provide a comprehensive synthesis and analysis of methods used to obtain genetic information from single-cell extractions (Weiner et al., 2016). In addition, WG 138 facilitated the development of a new comprehensive database on the distribution of species identified by their shells in surface sediments (Siccha and Kucera, 2017).<sup>1</sup>

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

An advanced draft version of a revised taxonomy, including essential formal taxonomic amendments (Spezzaferri et al., 2015), now exists and includes an identification key that has passed several rounds of review (including during the Catalina meeting) and is already starting to be used (cited and implemented in, for example, Meilland J., Fabri-Ruiz S., Koubbi P., LoMonaco C., Cotte C., Hosie G.W., Sanchez S., and Howa H. 2016. Planktonic foraminiferal biogeography in the Indian sector of the Southern Ocean: Contribution from CPR data. *Deep-Sea Research I* 110:75–89.

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

An online resource has been developed associated with the synthesis of data on single-cell DNA extraction and sequencing of planktonic foraminifera: <http://pfr2.sb-roscoff.fr/>.

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

Jelle Bijma and Michal Kucera pursued the envisaged eBook project with Copernicus in the form of two meetings at the headquarters of Copernicus. This project is progressing slower than expected.

Meeting participants decided to continue the group for another year, but to automatically disband the group in 12 months with a letter from SCOR encouraging the group to finish its E-book.

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<sup>1</sup>Siccha, M., and Kucera, M. 2017. ForCenS, a curated database of planktonic foraminifera census counts in marine surface sediment samples. *Sci. Data* 4:170109, doi: 10.1038/sdata.2017.109.

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

Colin Devey reported that WG 139 was granted an extension for an additional year at the 2016 SCOR Annual Meeting to complete on-going activities. The first is the special issue of *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 special issue was published in 2015 in *Marine Chemistry* (issue 173). WG 139 activities are expected to continue in the coming year, including continued progress on the best practices manual for ligand measurements, and completion of speciation analyses on intercalibration samples collected from the Gulf of Mexico and Southern Ocean. Devey noted that the group has been very productive. They would like to set-up a best-practice protocol, although they have experienced operational complications with sending samples. Meeting participants approved an extension, with an update in 6 months.

Status of terms of reference:

#### **1. To inform the Ocean Sciences community of this WG and related objectives via a widely distributed publication in *Eos* or analogous journal.**

The initiation of this SCOR Working Group, including the terms of reference and overall objectives of this working group, was announced in two publications in 2012:

S.G. Sander, K.N. Buck, and M.C. Lohan. 26 June 2012. Improving understanding of organic metal-binding ligands in the ocean. *Eos*, 93(26): 244.

K.N. Buck, M.C. Lohan, and S.G. Sander. July 2012. Metal-binding organic ligands. *IUPAC Chemistry International*, 34(4): 23.

#### **2. To summarize published results on all aspects of metal-binding ligands in the oceans (e.g., distributions, chemical structure, sources, sinks, stability constants), and to contribute to the organic ligand database for use in biogeochemical models and for those working in the field (including results from ongoing GEOTRACES, SOLAS and CLIVAR efforts). The summary will be included in a review paper published after year 2, as well as in the database on the proposed website.**

Databases for metal-binding ligand measurements have been compiled by members of the working group for cobalt (Mak Saito), copper (Jim Moffett), iron (Alessandro Tagliabue) and zinc (Maeve Lohan). The iron-binding ligand database is the most developed and an additional database for the raw titration data (Micha Rijkenberg) used to calculate iron-binding ligands has also been initiated. A compilation review of iron-binding ligands based on these databases was published in the *Frontiers in Marine Science* special issue for this working group (<http://journal.frontiersin.org/article/10.3389/fmars.2016.00221/full>).

- 3. To expand upon the ligand intercalibration programme, initiated by GEOTRACES, to evaluate key analytical issues with currently employed methodologies and determine how to best link ongoing efforts in trace metal and organic geochemistry to assess natural metal-binding ligands.**

A large intercalibration of the interpretation techniques routinely used for determining ligand concentrations and conditional stability constants from titration data was conducted, and results were published in the first WG 139 special issue (Pizeta et al. 2015). Powerful new interpretation tools developed by participants in this working group were also presented in the special issue and evaluated in the intercalibration, all of which are now freely available to download from the SCOR WG 139 website (<http://neon.otago.ac.nz/research/scor/achievements.html>).

For field-based intercalibration efforts, large volumes of filtered seawater have been collected for this purpose from the Gulf of Mexico and from the Southern Ocean, initial analyses of these samples for dissolved metals are underway, and samples for ligand analyses will be made available to the community in late summer 2017.

A manual detailing intercalibration results and best practices for measurements is in the planning stages. This manual is expected to be continually updated and will be made publicly available online at the SCOR WG 139 website.

- 4. To identify how best to incorporate published and future data into biogeochemical models.**

The working group discussed several aspects of incorporating ligands into models, including how analysts can provide ligand concentrations, their sources and sinks and complexation kinetics such as the variability in conditional stability constants of iron, how to distinguish between different iron-binding ligand classes, and whether trace metals compete for the same class of ligands. A paper published by Volker and Tagliabue (2015) in first special issue examined how organic iron-binding ligands could be represented in a biogeochemical ocean model. This effort is ongoing and will be part of a new SCOR Working Group, WG151: Iron Model Intercomparison Project.

- 5. To debate the nature of sampling strategies and experimental approaches employed in laboratory and field efforts from different communities in workshops and meeting discussions to foster cross-fertilization of ideas across groups, capitalize on joint expertise between specialties and ultimately enhance our understanding of the links between the provenance, fate, distribution, and chemistry and biological functions of these organic metal-binding ligands in the oceans.**

This working group met annually from 2012-2016, coinciding with the February Ocean/Aquatic Sciences Meetings. Notes from each of these meetings are posted on the WG 139 website. The co-chairs of this Working Group have also chaired a special session related to the working group at each of the conferences in 2012-2016. A Town Hall Meeting during the 2014 Ocean Sciences meeting was attended by 47 people and served to highlight accomplishments of the working group to date and to engage broader community participation in working group activities. These

meetings have fostered discussions on the need for improved modeling of trace-metal speciation in seawater and have led to a new SCOR Working Group, WG145: Modeling Chemical Speciation in Seawater to Meet 21<sup>st</sup> Century Needs. Several members of SCOR WG 139 are also members of WG 145 and the new model will incorporate trace metal-organic ligand interactions across marine environments.

- 6. To recommend future approaches to ligand biogeochemistry in a designated symposium, including ongoing GEOTRACES field efforts (i.e., regional surveys and process studies), integration of CLE-ACSV and organic geochemistry techniques, and the need for rapid incorporation of this research in biogeochemical models. Such future recommendations will also be included in the aforementioned downloadable manual. It will also include a series of recommended downloadable digital products on multiple platforms for interpreting ACSV data.**

A final two-day symposium was held for SCOR WG 139 in Sibenik, Croatia in April 2015. This symposium was open to the broader scientific community and was used as a platform to recommend future approaches to ligand measurements and highlight results from intercalibration and field activities. A total of 51 people attended the symposium, including 24 students and postdoctoral fellows, who were each allotted time to present their research results in the field of ligand biogeochemistry. Twenty of the 51 symposium attendees also participated in a training workshop held the day before the symposium. This workshop was held at the Martinska Marine Station in Sibenik, and consisted of hands-on training in analyzing samples for metal-binding ligands and in using the state-of-the-art interpretation techniques developed (in part) through the activities of the working group.

- 7. To establish a webpage for this SCOR working group, to promote a forum for discussion of ideas and results in form of a blog, soliciting input from the trace metal biogeochemistry, organic geochemistry and modelling communities and provide a platform to propose special sessions on trace metal-binding ligands at international meetings such as Ocean Sciences, AGU and/or EGU.**

A website has been created for this SCOR working group (<http://neon.otago.ac.nz/research/scor/>). An email list for the WG members and another for those interested in following the working group's activities is hosted at the Bermuda Institute of Ocean Sciences ([scorwg139members@bios.edu](mailto:scorwg139members@bios.edu) and [scorwg139all@bios.edu](mailto:scorwg139all@bios.edu)). The 'all' email list for this SCOR WG currently has 188 followers and will remain active for continued use in discussing accomplishments and activities of the working group.

- 8. To produce conclusions resulting from the outcome of the above objectives in the form of a Website, a journal special issue or book, and a report to SCOR.**

A website for this SCOR WG has been created and is currently being maintained at the University of Otago (<http://neon.otago.ac.nz/research/scor/>). The first special issue resulting from this WG's activities was published in July 2015 in *Marine Chemistry*, and included 28 research articles plus an editorial (<http://www.sciencedirect.com/science/journal/03044203/173>). The second special issue was published in *Frontiers in Marine Science/Chemistry* in June

2017 with a total of 21 research articles and an additional editorial (<http://journal.frontiersin.org/researchtopic/3981/organic-ligands-a-key-control-on-trace-metal-biogeochemistry-in-the-ocean#articles>). This second special issue will be published as an open-access e-book in summer 2017 and will be made available from the SCOR WG 139 Website.

#### **2.1.4 WG 141 on Sea-Surface Microlayers**

Peter Burkill reported on this group. A subset of the group conducted a multi-disciplinary sea-surface microlayer (SML) research cruise on the R/V *Falkor* (Schmidt Ocean Institute) in 2016. The cruise started in Darwin, Australia and finished in Guam, sampling the SML and underlying water at more than 17 stations, performing on-board ship experiments and aerial ROV deployments. The cruise was used as a “hands-on” teaching platform for several Ph.D. students and allowed for the continued refinement of the group’s ‘Guide to best practices to study the ocean’s surface’ (see TOR 1). See <https://schmidtoccean.org/cruise/study-of-the-sea-surface-microlayer/>. Two review papers resulted from the group’s work this year<sup>2</sup> and a special issue of *Elementa: Science of the Anthropocene* has been opened (see <https://collections.elementascience.org/sea-surface-microlayer>). A post-cruise meeting was held in August 2017 to compare the multi-disciplinary data sets and to develop an integrated understanding of the SML and the role of the SML in global-scale processes. Part of the meeting considered the refinement of the ‘Guide to best practices to study the ocean’s surface’ based on sampling experiences from the cruise and any updates to the best practice sampling document will be made if needed.

Progress has been good; the status of the terms of reference is as follows:

- 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. The ‘Guide to best practices to study the ocean’s surface’ was published online in September 2014. To ensure that the document will be accessible beyond the lifetime of the SCOR SML WG, the document will be held by the Plymouth Marine Science Electronic Repository (managed by the Marine Biological Association), ensuring a permanent and free download link. <http://plymseas.ac.uk/6523/>.

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<sup>2</sup>Anja Engel, Hermann W. Bange, Michael Cunliffe, Susannah M. Burrows, Gernot Friedrichs, Luisa Galgani, Hartmut Herrmann, Norbert Hertkorn, Martin Johnson, Peter S. Liss, Patricia K. Quinn, Markus Schartau, Alexander Soloviev, Christian Stolle, Robert C. Upstill-Goddard, Manuela van Pinxteren & Birthe Zäncker (2017) The Ocean’s Vital Skin: Toward an Integrated Understanding of the Sea Surface Microlayer. *Frontiers in Marine Science* 4:165. doi: 10.3389/fmars.2017.00165  
Wurl O, Ekau W, Landing WM, Zappa CJ. Sea surface microlayer in a changing ocean – A perspective. *Elem Sci Anth.* 2017;5:31. DOI: <http://doi.org/10.1525/elementa.228>

- 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 opinion/position paper in a peer-reviewed journal and will support future international projects concerning the SML and ocean change.**

PARTIALLY COMPLETE. The recent publication including members of the SCOR SML WG in *Frontiers in Marine Science* fulfills TOR 2. A second short communication published in the upcoming special issue in the journal *Elementa: Science of the Anthropocene* will complete TOR 2.

- 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 working group has been engaged in several major meetings;

- Special session at Ocean Sciences Meeting 2016 in New Orleans 'Linking the Ocean with the Atmosphere - Exploring the Importance of the Ocean-Atmosphere Interface and Near Surface Waters in Global Scale Processes' (February 2016).
- Session at Surface-Ocean/Lower Atmosphere Study (SOLAS) Open Science Conference in Kiel, Germany on 'Microbial life at the air-sea interface' (September 2015).
- The Ocean Surface Microlayer and Biogeochemical Feedbacks in the Earth System conference, GEOMAR/ Kiel University, Germany (July 2015).

- 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.**

IN PROGRESS. The special issue in the journal *Elementa: Science of the Anthropocene* deadline for submission of manuscripts was the 14 March 2017; 13 papers are under review now.

Burkill recommended approving a one-year extension. A one-year "no cost extension" of the group was approved.

#### **2.1.5 WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders**

Peter Burkill reported on WG 142. The group is preparing a manuscript (Bittig et al., in preparation) that summarizes the protocols for successful operation of oxygen sensors on profiling floats. The efforts of WG 142 are being successfully transferred to a broader community, including operators of gliders. The group has also played a seminal role in planning for a global array of Biogeochemical-Argo floats, as well as the development of data processing protocols for the Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) profiling float array. The next meeting of the WG is tentatively set for the Argo Data Management Team meeting in Hamburg, Germany during late November 2017. A focus of this

meeting would be passing much of the Working Groups findings on to the Argo Data Management Team.

Of the groups four terms of reference, two have been completed, one almost completed, and one in progress:

- 1. Summarize and assess the current status of biogeochemical sensor technology with particular emphasis on float-/glider-readiness (pressure and temperature dependence, long-term stability, calibration accuracy, measurements time constant, etc.).**

The Working Group activities have been remarkably successful in influencing community understanding of the role of air oxygen calibration. This includes a publication that summarizes the improvements of air oxygen calibrations on a large array of U.S, and Canadian profiling floats (Johnson, Kenneth S., Joshua N. Plant, Stephen C. Riser and Denis Gilbert. 2015. Air oxygen calibration of oxygen optodes on a profiling float array. *Journal of Atmospheric and Oceanic Technology* 32:2160-2172), as well as publications summarized in the 2016 report. The publication by Bittig et al. will bring the Working Group's effort on oxygen sensors to completion.

- 2. Develop pre- and post-deployment quality control metrics and procedures for oxygen and other biogeochemical sensors deployed on floats and gliders providing a research-quality synthesis data product.**

These metrics are encapsulated in the Bittig (2015, 2016) recommendations and further expanded on in the Bittig (in preparation) manuscript.

- 3. Collaborate with Argo and other data centers to implement these procedures in their standard routines.**

Working Group members have attended every Argo Data Management Team meeting since 2012 and reported on Working Group findings. These reports have shaped the ADMT document, "Processing Argo Oxygen Data at the Data Assembly Center Level".

- 4. Disseminate procedures widely to ensure rapid adoption in the community. Develop ideas for capacity building in this context.**

The Working Group activities have been highlighted in several publications (Biogeochemical-Argo Planning Group, 2016; Bittig et al., in prep., Johnson and Claustre, 2016; Johnson et al., 2017), as well as numerous presentations.

There has been good progress, so meeting participants approved a "no-cost extension" for the group to complete its work.

#### **2.1.6 WG 143 on Dissolved N<sub>2</sub>O and CH<sub>4</sub> measurements: Working towards a global network of ocean time series measurements of N<sub>2</sub>O and CH<sub>4</sub>**



John Turner reported on this group's work. The group produced a technical report on *The Production of Methane and Nitrous Oxide Gas Standards* (see [http://www.scor-int.org/Publications/SCOR\\_WG\\_143\\_Technical\\_Report.pdf](http://www.scor-int.org/Publications/SCOR_WG_143_Technical_Report.pdf)). The planned activities for the coming year are to (1) conduct data synthesis and manuscript writing for the intercomparison of methane and nitrous oxide in seawater and (2) complete the cruise report for the Baltic Sea expedition (see <https://www.io-warnemuende.de/message/items/tracking-down-the-greenhouse-gases-methane-co-iow-heads-a-method-standardization-expedition.html>). The group plans to hold its final meeting in conjunction with the Ocean Sciences Meeting in February 2018 in Portland, Oregon, USA.

Turner reported that the group is very active seems to be making good progress:

**1. Conduct an intercalibration exercise between the time series programs (for methane and nitrous oxide)**

This is completed, with data analysis and publication pending. The group has conducted three intercomparison exercises of discrete seawater samples and one intercomparison of underway equilibrator systems. It is receiving the data for the most recent intercomparisons and will start formally analyzing the data next month when at least half the datasets will have been received.

**2. Establish the appropriate standards to be used by the scientific community**

This is completed and the Technical Report is posted at [http://www.scor-int.org/Publications/SCOR\\_WG\\_143\\_Technical\\_Report.pdf](http://www.scor-int.org/Publications/SCOR_WG_143_Technical_Report.pdf). Gas standards have been manufactured by John Bullister at NOAA PMEL and distributed to twelve groups around the globe. Every recipient is working with other scientists in their countries to cross-calibrate their own standards, where necessary.

**3. Recommend the analytical reporting procedures to be used for N<sub>2</sub>O and CH<sub>4</sub>**

An outcome of Term of Reference #1 will include best practice recommendations for sample collection and analysis as well as data reporting. This activity has not occurred yet, but will be completed by the end of 2017.

**4. Establish framework for an N<sub>2</sub>O/CH<sub>4</sub> ocean time series network and write a global oceanic N<sub>2</sub>O/CH<sub>4</sub> summary paper for publication in an open-access journal.**

This task is still pending. The GEOMAR group (H. Bange, A. Kock, D. Arevalo) will take the lead for this. Manuscript writing will start when the terms of references 1-3 are completed. Potential open-access journals for publication of the SCOR WG overview paper include *Biogeosciences*, *Ocean Science*, *Frontiers in Marine Science*, or *Environmental Research Letters*.



Further, SCOR WG 143-related articles that include results of the group's work include the following:

- A manuscript about the MEMENTO database is currently being written by Annette Kock for submission to *Earth System Science Data*.
- An overview article about the application of cavity-enhanced absorption spectroscopy for measurements of dissolved trace gases (including N<sub>2</sub>O and CH<sub>4</sub>) in ocean science is currently in preparation for the open-access journals *Ocean Science* or *Frontiers in Marine Science*.

Their cruise report is not done yet, so Turner will ask the group to submit the cruise report when it is completed.

#### **2.1.7 WG 144 on Microbial Community Responses to Ocean Deoxygenation**

Patricia Miloslavich reported on WG 144's progress. WG 144 held a symposium in Goa, India, at the National Institute of Oceanography during 2–5 December 2016. The group is producing a special issue from the symposium, in *Deep-Sea Research II* (DSR II). N. Ramaiah, Sean Crowe, Virginia Edgcomb and Bess Ward will be the editors. So far, nine manuscripts have been submitted and are under review and it is expected there will be about 15 papers in the special issue. DSR II estimates the time from initial submission to publication to be about 1.5 years, so the special issue should be published sometime in 2018. A tentative list of authors and titles, compiled at the time of the symposium, is given in the WG report.

The proposed cruise on the R/V *Falkor* was not approved (beyond their original terms of reference) and they were unable to raise funding for their proposed meeting in Chile, which would have been the 4<sup>th</sup> meeting of the group. The group did convene three good workshops, and have conducted training in relation to their first meeting and cruise, and capacity building in relation to their symposium in India, involving many early-career scientists. They have a white paper documenting methods and a special issue of *Deep-Sea Research* from the Goa symposium. Meeting participants decided to disband the group after the special issue is published.

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

Marie-Alexandrine Sicre reported on the group's progress. The group published a paper on its work.<sup>3</sup> A second SurveyMonkey questionnaire, aimed at users outside the academic community, was launched in April 2017 and gathered 57 additional responses. Members of the group were successful in obtaining funding from NERC and NSF for a research project, starting in July 2017, to develop a full characterization of the chemistry of TRIS buffers in artificial seawater over the full range of relevant salinities and temperatures. Measurements in the United States and United Kingdom will be complemented by measurements carried out at GEOMAR (Kiel, Germany) and at the French, German and Japanese national standards laboratories. An analysis and summary of the results of both SurveyMonkey questionnaires will be prepared for

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<sup>3</sup>Turner, D.R., E.P. Achterberg, C.-T.A. Chen, S.L. Clegg, V. Hatje, M.T. Maldonado, S.G. Sander, C.M.G. van den Berg, M. Wells. 2016. Toward a Quality-Controlled and Accessible Pitzer Model for Seawater and Related Systems. *Frontiers in Marine Science* 3: doi:10.3389/fmars.2016.00139.

publication. The next WG meeting is planned for February 2018 in conjunction with the Ocean Sciences Meeting.

Progress on the group's terms of reference is as follows:

- 1. To document the current status, and basis in laboratory measurements, of Pitzer models of seawater and estuarine water focusing on the chemistry of ocean acidification and micronutrient trace metals (including, but not limited to, Fe, Cu, Mn, Cd, and Zn). Current capabilities and limitations for oceanographic and biogeochemical calculations will be defined, and future needs established. Important gaps in knowledge, which should have high priority for new measurements, will be identified. The components to be covered will include the seawater electrolytes, the selected trace metals, and buffer solutions and key organic ligands such as those used in CLE-CSV titrations.**

The Working Group's review has been published in *Frontiers in Marine Science*.

- 2. To publish the results of the first term of reference in the refereed scientific literature, and to introduce the conclusions and recommendations to the oceanographic community at a "town hall" event or special session at an international ocean sciences meeting.**

The Working Group's overview of current model status and development needs has been published. The WG's plans were presented at a Town Hall meeting at Ocean Sciences 2016, where the WG also co-sponsored a session.

- 3. To specify the functions and capability for a web-based modelling tool that will make chemical speciation calculations easily accessible for a wide range of applications in oceanography research and teaching, and thus improve understanding and spread best practice in modelling.**

The Working Group considers that the functionality should be based on user's needs, and has therefore taken steps to consult with user communities. User needs were discussed at the 2016 Town Hall, and were followed up by a SurveyMonkey questionnaire aimed at academic users (thanks to Ed Urban for help with this). A second SurveyMonkey survey aimed at users outside the academic community was distributed in April 2017.

- 4. To implement the web-based tool for chemical speciation calculations, based upon the specification developed in the third term of reference which will also be used to obtain external funding to develop the programs, documentation, and site.**

This term of reference involves significant effort, both in program code development, and in new measurements. External funding has now been secured through the NERC/NSF grant described above.

The group request to reallocate the funding from their 2017 meeting to hold a meeting in 2018. The request was approved and it will be discussed next year where the WG stands and how to move forward.

#### **2.1.9 WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5)**

Denise Smythe-Wright reported on the group's progress. The working group will meet after the background papers for the SCOR meeting were completed. The group held its second training workshop in August 2017, in conjunction with the Goldschmidt conference in Paris, France.<sup>4</sup>

#### **2.1.10 WG 147: Towards comparability of global oceanic nutrient data (COMPONUT)**

Raymond Roman (University of Cape Town), a Full Member of WG 147, reported on the progress and plans of the group, which has a busy year ahead. In relation to the group's terms of reference, Roman reported that the following has been achieved:

- 1. To establish mechanisms to ensure comparability of oceanic nutrient data in collaboration with International organisations such as ICES and PICES.**

WG 147 collaborated with JAMSTEC and started to provide SI-traceable CRMs of nutrients to the global community since November 2016. SCOR-JAMSTEC CRMs cover the full range of nutrients concentration from Atlantic low to Pacific high by five lots of CRMs. These CRMs have not been ordered and used as much as expected from the survey of nutrient analysts that was done before the CRMs were produced. Members of the group are collecting two additional batches of Atlantic Ocean seawater, from deep and mid-depth waters, for CRM production.

- 2. To assess the homogeneity and stability of currently available RMs/CRMs: Are current producers achieving a level of precision within and between laboratories which is comparable to or better than 1%.**

Results of 2015 intercalibration exercise confirmed that the homogeneity of currently available KANSO CRMs should be better than 1%.

- 3. Standardise data handling procedures for use of CRMs:**

No specific progress has been achieved during this period. A part of this ToR will be included in the updated GO-SHIP nutrients manual, discussed in ToR #6.

- 4. Provide training in analytical protocols and best practice through regular global inter-comparison studies**

In 2012 there was a workshop dedicated to phosphate analysis, the results of which were published. As part of the working group outputs there will be a nutrient training workshop organized through WG 147 at NIOZ in Nov. 2017, which is specifically for scientists from developing countries, followed by a specialist workshop on silicate analysis. We have received 234 applications for participation; about 10 participants can be funded through the SCOR and

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<sup>4</sup><http://www.whoi.edu/CMER/news-and-events>

POGO support for developing country scientists. Information about the workshop can be found at <https://www.nioz.nl/en/education/marine-studies/scor-pogo-international-training-workshop-for-nutrient-analysis-2017>).

#### **5. To continue the series of International Intercalibration exercises**

The report of the 2015 intercalibration exercise is already published. An invitation letter will be sent soon to about 90 global laboratories who are working in oceanic waters for the 2017/2018 intercalibration exercise, to be organized in collaboration with IOCCP.

#### **6. Update the GO-SHIP nutrient measurement manual, originally a product of the IOC-ICES Study Group on Nutrients. (Hydes et al 2010)**

WG 147 has drafted a new manual, which is an update of the 2010 GO-SHIP nutrient measurement manual, and this draft was sent to group members for comments in April 2017. Group members are continuing this work to finalize the manual update in early 2018.

In conjunction with the 2018 Ocean Sciences Meeting in Portland, Oregon, WG 147 has submitted a proposal for a special session on “Biogeochemistry and Nutrients in open ocean waters: Sustainable Ocean Observations and Time Series Efforts” and will hold the final meeting of the group. The group asked permission to use its 2017 meeting funds for its planned meeting in February 2018, which was approved.

#### **2.1.11 WG 148 on International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)**

Katherine Hutchinson, a Ph.D. student at the University of Cape Town and Associate Member of the group, reported on the group’s progress. The basic purpose of IQuOD is to produce and freely distribute the highest quality, most complete and consistent historical ocean temperature global database. It will maximize the quality, consistency and completeness of the long-term global subsurface ocean temperature database. Subsurface ocean temperature is considered an Essential Ocean Variable and Essential Climate Variable.

Progress toward the group’s terms of reference is as follows:

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

As part of the first IQuOD interim product (v0.1), “first cut” algorithms for unknown XBTs were created, building on from Cowley et al. (2013) and recoded into open-source Python (Palmer et al. submitted to *J. Atm. Oc. Tech.*)

- 2. To evaluate and document the most effective combination of automated quality control (AutoQC) procedures for temperature profile observations. International collaboration will be required for the design and coordination of benchmarking experiments using high quality reference datasets.**

Automated quality control tests from the international community were implemented on IQuOD's github repository, high-quality reference datasets were made available, the benchmarking code is ready, and preliminary software was developed for performance metrics.

- 3. To establish and implement a set of optimal automated quality control procedures, by reaching international community consensus and using the knowledge gained in the benchmarking tests from ToR-2 (above); to produce and publish a reference guide for best practices in automated quality control of ocean temperature profiles; and to develop and freely distribute an open-source quality control software toolkit to promote wide and rapid adoption of best practices by the oceanographic community.**

Optimal automated quality control tests based on international community consensus plus software toolkit and reference guide. (Planned for 2017-2018/2019-2020)

- 4. To examine and document the feasibility of machine learning and other novel computational methods for enhanced quality control, to potentially minimize labor costs associated with human expert quality control procedures.**

Machine learning feasibility for expert quality control: Prototype web-based site in development and preliminary applications for bottom hit events in XBTs developed

- 5. To develop, implement and document internationally agreed best practice methods for assignment of uncertainty estimates to each temperature observation.**

“First cut” made at assigning random error to each discrete observation (Cowley et al. draft in preparation).

- 6. To freely disseminate (interim) versions of the IQuOD global temperature profile database (and added-value products) as it evolves over the next 3 years, in user-friendly file formats.**

Distribution via U.S. NCEI, UK MetOffice, Japanese BODC, French Coriolis, and Australian IMOS (currently in verification phase at NCEI)

- 7. To share knowledge and transfer skills in instrumentation, regional oceanography, quality control procedures and data stewardship with international scientists in both developed and developing nations.**

Knowledge transfer activities centered on the 1<sup>st</sup> SCOR WG 148 workshop. The group plans to transfer lessons learned using outreach activities through CLIVAR and IRD. They plan to educate and develop skills, especially in developing countries.

Since the 2016 SCOR annual meeting, the group has held 6 video conference meetings among members of the group and 1 in-person meeting, on 3-7 October 2016 in Tokyo, Japan. The group

is planning to hold its 2018 meeting on 16-18 April 2018 in Oostende, Belgium. The major objectives of the meeting will be to conduct an AutoQC benchmarking exercise; refine i-metadata, uncertainty and duplicates flagging, coordinate machine learning activities, and discuss potential outreach activities. In addition, a session on “Scientific data rescue of ocean data with a focus on climate analysis” was proposed for the 2018 Ocean Sciences meeting in February 2018, in Portland, Oregon, USA.

In terms of publications, the following are available:

- IQuOD Web site (see [www.iquod.org](http://www.iquod.org))
- A Github software repository, with Automated Quality Control (50 tests from various international groups), Wodpy, and Machine learning for XBT data (in development) (see <https://github.com/IQuOD>)
- Workshop reports (1<sup>st</sup> SCOR-IQuOD WG 148 report at [http://www.iquod.org/documents/iquod\\_4thWkshp\\_meeting\\_report\\_final.pdf](http://www.iquod.org/documents/iquod_4thWkshp_meeting_report_final.pdf))
- One peer-reviewed article has been submitted on “An algorithm for classifying unknown expendable bathythermograph (XBT) instruments based on existing meta data” and another one, on observational uncertainties, is in preparation.

Sergey Shapovalov commented that the Associate Member from Russia did not know that he had been appointed. It will be important for the future to compile email lists of all working group members and to send appointment letters to all of them. Meeting participants approved funding for the group to meet in 2018.

#### **2.1.12 WG 149 on Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?**

Patricia Miloslavich reported on the progress of WG 149. The group is making good progress on fulfilling its terms of reference:

- 1. Assess the current status of emerging research themes 1-3 by reviewing the literature to assess the dominant research foci, their relative coverage, and identify any major gaps and/or limitations. Publish this review in an open-access peer-reviewed journal.**

The group has finalized the figures and most of the text (now in a penultimate draft for a Research Review for *Global Change Biology* (a pre-submission enquiry in late 2016 showed that the journal was interested). The review is entitled “Experimental approaches to assess the biological ramifications of multiple drivers of global ocean change.” The manuscript will be submitted by mid-August 2017.

- 2. Raise awareness across different scientific communities (evolutionary experimental biologists, ecologists, physiologists, chemists, modelers) to initiate better alignment and integration of research efforts.**

The manuscript mentioned for ToR1 has 10 sub-sections, which integrate many of the above themes in ToR 2. WG 149 comprises expertise across all of the above themes and so they were

able to incorporate state-of-the-art knowledge about each theme and how best to link them. Furthermore, WG 149 members are publicizing the holistic approach being taken by WG 149 within their own communities.

**3. Co-ordinate thematic transdisciplinary sessions to attract and assemble experts from other fields such as paleoceanography and marine ecotoxicology to learn from the successful approaches their fields have developed to address multiple drivers.**

In the past 12 months, the group has set up reciprocal links to a wide range of other projects that are tackling aspects of changing ocean biological systems (<https://scor149-ocean.com/partners/>). The partners include the fisheries-based Nereus Program - Predicting Future Oceans and the IOC GO<sub>2</sub>NE program on hypoxia. The group also recently featured an end-to-end foodweb paper on its website (<https://scor149-ocean.com/#meetings-section>) to again try to learn more from other research fields. The group has a successful working relationship with the IMBeR project and recently submitted a joint session with IMBER entitled “Multiple stressors at multiple scales” to the 4<sup>th</sup> Symposium on the Effects of Climate Change on the World’s Oceans (June 2018 in Washington D.C.). The list of accepted sessions will be available in early August 2017.

**4. Develop a multi-driver Best-Practice Guide (BPG, or other tools) as one potentially valuable way to help this research field move forward in a cohesive manner.**

The group has taken a three-tiered approach to develop a Web-based best practice resource that will be made available to the global community by summer 2018: (1) initial decision support to navigate through this complex research topic via flow charts and questionnaires; (2) a “Virtual Marine Scientist” experimental design tutorial to assist researchers with the selection and refinement of the most suitable design for their research question(s) and locale(s); and (3) a series of Webinars by field-leading scientists to enable researchers to further hone their skillsets. A course book that provides links among each of these three strands, along with other information, will also be available as an open-access pdf. Strands 1 and 3 will be developed intersessionally, with Fabricius and Havenhand leading strand 1; Strand 2 being led by Boyd, Dupont, Vichi and Collins; Strand 3 by McGraw and Gehlen. The pdf “course book” is being structured by Boyd, Gattuso and Riebesell.

**5. Mentor early career scientists in the design process for complex multiple driver manipulation experiments, familiarize them with Best Practice Guide (BPG), and teach them practical methodologies for the analysis of their experimental findings.**

The International Atomic Energy Agency (IAEA), through the Ocean Acidification – International Coordination Center (OA-ICC), will fund a further workshop in Monaco in mid-2018. This workshop will be used to roll out the multiple drivers BPG to early-career scientists. As the group did in 2017, it will hold its 3<sup>rd</sup> annual workshop several days after this Monaco workshop which will maximize WG participation in this hands-on training event on how to get the most from the Web-based BPG.

The group also plans to roll out the BPG in North America in mid-July at the early-career Gordon Research Seminar which precedes the Ocean Global Change Gordon Research

Conference. Members of WG 149 will be encouraged to publicize the BPG at events in their countries. For example, Boyd will give a presentation on the principles behind the BPG at the 5<sup>th</sup> annual Ocean Acidification workshop in September in Hobart, Australia. Christina McGraw gave a similar presentation at the recently held New Zealand 10<sup>th</sup> annual Ocean Acidification workshop.

Miloslavich recommended funding for the group to meet in 2018, which was approved.

### **2.1.13 WG 150 on Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)**

Sandy Thomalla, a Full Member from the University of Cape Town, reported on the progress of the group. The chair of WG 150 published an article in *Eos* informing the community about the group and its first meeting.<sup>5</sup> WG 150 will carry out intercalibrations between in situ camera systems, LOPC, and backscatter sensors during the UK COMICS cruises (<http://comics.ac.uk/>) in the Southern Ocean in November-December 2017 and in the Benguela in April-May 2018. The group is planning an international “autumn school”, likely hosted at the National Oceanography Centre, Southampton, in late 2018. During the year, the group will finalize its list of essential variables and publish these freely available online, and will decide on a public depository and publish the first set of example data and codes. The group will host a dedicated session during the Ocean Science Meeting in February 2018 in Portland, Oregon to promote TOMCAT’s work and to advertise the autumn school, and will hold its next WG meeting there.

#### **1. Review current devices that optically measure particles, and document the capabilities and limitations of each device.**

The group reviewed and discussed existing devices during its meeting in September 2016 and is now documenting and discussing their capabilities and limitations within the literature review, which will serve as a benchmark for future optical work.

#### **2. Make vocabularies more transparent and interoperable using international standards.**

The group compiled a list of key terms and essential variables and is working on formal definitions now. The group is currently looking into ways of making these freely accessible via a wiki.

#### **3. Define key parameters for interpretation of optical information, and recommend which optical measurements are useful for characterizing particle type, interactions and export.**

As above. The group discussed the key variables, but will refine its recommendations within the literature review and in the future. This will include an effort to secure funding for dedicated modelling and the organization of autumn schools to disseminate this knowledge.

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<sup>5</sup> <https://eos.org/meeting-reports/optical-sensors-can-shed-light-on-particle-dynamics-in-the-ocean>



- 4. Evaluate various techniques and algorithms for the conversion of optical observation into particle type, size, concentration, mass, composition, and fluxes, and recommend ways of improving our understanding of the relationships between these properties.**

The group will focus on this step after it retrieves the calibration data (target summer/autumn 2018).

- 5. Promote sharing of software examples and codes, placed on a public repository.**

As above. The group will focus on this step after it retrieves the calibration data (target summer/autumn 2018).

- 6. Improve the visibility and usage of data by hosting an inventory of published datasets.**

The group is currently discussing the options with the British Oceanographic Data Centre and potential need for financial support. In addition, group members promote TOMCAT during conferences and meetings and have received increasing interest.

The group is still missing one Full Member from a developing country; they are trying to identify an appropriate person, but also welcomed nominations from SCOR.

#### **2.1.14 WG 151: Iron Model Intercomparison Project (FeMIP)**

Alessandro Tagliabue, a co-chair of WG 151 and a Nominated Member from the UK SCOR Committee, reported on the group's progress. During the coming year, the group will proceed with Objective 1 (collating information about the three main processes identified as being most important in models of iron cycling: external input, biological cycling, and speciation/scavenging) and Objective 2 (testing cases for model skill metrics for the different platforms). Results from Objectives 1 and 2 will be presented at the Feb. 2018 meeting of WG 151 and publicized during a Town Hall session during Ocean Sciences 2018. The outcome of Objective 1 is planned to be a publication and the release of code for different process closures. The outcome of Objective 2 is planned to be a release of evaluation tools and consensus values via the website, plus a companion paper. Champions and preliminary plans will be developed for Objectives 3 and 4 during the kick-off meeting of the working group in Feb. 2018. The group is running models and busy developing reference standard for models; there is the potential for capacity building in terms of using reference standards. The group is trying to communicate without email using [www.slack.com](http://www.slack.com).

#### **2.1.15 WG 152 on Measuring Essential Climate Variables in Sea Ice (ECV-Ice)**

John Turner reported on the progress of WG 152, and noted that the group is on track. Two virtual meetings are planned for summer/fall 2017, to discuss planning of the upcoming intercalibration experiments as part of TOR #1 and the next in-person meeting, in June 2018, in conjunction with BEPSII, MOSAiC and CATCH during the 2018 SCAR/IASC POLAR 2018 Conference, in Davos, Switzerland. At the meeting, WG 152 members and others will review progress on the group's Terms of Reference (present the data collations (TR #2); pursue the

elaboration of intercalibration experiments (TR #1 and #3), including reviewing results of primary production experiment in Saroma; and finalize plans for a gas concentration experiment at UEA. The intercalibration experiment on gas concentrations will be conducted at the UEA ice-tank facility in summer 2017. EUROCHAMP 2020 funding will be available for this intercalibration experiment. The funding will cover travel expenses for 1-3 international participants, and the costs of operating the facility. At least one ice growth experiment (~10 days) will be run. If feasible, a second experiment at a different temperature will be conducted.

**1. Publish synthetic reviews compiled from measurements demonstrating large, unresolved discrepancies.**

The group has started to collect various datasets (raw data, methodologies and associated protocols for data correction, instruments, and sampling design) for each target parameter (sea ice-air CO<sub>2</sub> flux, ocean-air CO<sub>2</sub> fluxes in the seasonal ice zone, primary production, light transmission, etc.) from the global polar sea-ice and ocean research communities. Planned reviews include the following:

- Sea ice-air gas fluxes. Coordinating lead authors: D. Nomura and B. Else. Data are currently being collated, to be presented during the next annual meeting.
- Air-sea gas flux parameterizations in the marginal ice zone. Coordinating lead authors: B. Loose and B. Else. Data are currently being collated, to be presented during the next annual meeting.
- Primary production. Coordinating lead authors: F. Fripiat, M. Fernandez-Méndez and C.J. Mundy. Data are currently being collated, to be presented during the next annual meeting.
- Light transmission through sea ice. Coordinating lead author: J. Ehn. A plan to collate available data will be discussed during the upcoming year.

**2. Design and coordinate intercalibration experiments to evaluate different methods for key parameters.**

The group has started to seek funding for various intercalibration experiments (gas concentrations, primary production, trace metals, etc.).

Gas concentrations

- Date: summer 2018
- Location: University of East Anglia (UEA) ice tank facility
- Participants: B. Delille (lead), M. Kotovich, L. Miller, B. Else, M. Thomas, J. France, D. Nomura, A. Fransson, K. Amrahamsson, E. Damm, J. Verdugo, C. Uhlig, J.-L. Tison, etc.

The purpose is to compare all the techniques available to measure gas concentration in sea ice (sampling, processing, storage, analysis): peepers, sackholes, ice crushing, equilibrating method, melting-refreezing method, bulk melt for DIC/TA. N<sub>2</sub>O, CH<sub>4</sub>, and CO<sub>2</sub> will be tested, but with a special emphasis on pCO<sub>2</sub>.

EUROCHAMP 2020 transnational access funding is available to cover facility access and travel for 1-3 international participants. Additional funding is being pursued for more participants.

#### Primary production

- Date: Spring 2019
- Location: Cambridge Bay (Canada)
- Participants: Brent Else (co-lead), F. Fripiat (co-lead), J. Stefels, M. Van Leeuwe, J. Bowman, C.J. Mundy, J.-M. Rintala, M. Fernandez-Mendez, F. Deman, A.-J. Cavagna, D. Nomura, etc.

The purpose of this experiment is to compare all the techniques available to measure primary production (GPP, NPP, NCP) in sea ice: biomass/chl-a accumulation, under-ice eddy covariance, under-ice microelectrodes, isotopic tracer incubations ( $^{14}\text{C}$  &  $^{13}\text{C}$ ),  $\text{O}_2\text{:Ar}$  ratio, PI curve, and PAM fluorescence. The group 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, they will determine how to collect a representative in-situ sea-ice microbial community and to ensure tracer homogenization within the brine network prior to incubation (e.g., direct vs. buffered melting). The experiment could be extended to include other inter-calibrations. Other suggested intercalibration include bacterial production, DNA/RNA, bacterial abundance, light measurements, nutrients, biomass, taxonomy, storage of ice cores for later analysis. A special emphasis will be also dedicated to solve the nutrient-chlorophyll paradox in productive sea ice, although the number of participants will need to be limited to avoid logistical problems.

#### Trace metals

- Date: Fall 2017 and follow up in 2019
- Location: Ross Sea (PIPERS voyage) and TBD
- People involved: D. Lannuzel and A. Aguilar-Islas (co-leads), J. de Jong, etc.

The purpose is to test the existing methods and devices to sample, process, store, and analyze trace metal concentrations in sea ice. An initial experiment will most likely take place in the Ross Sea during a voyage in austral fall 2017. Duplicate cores will be collected using three different coring devices. Based on the results from this first experiment, the group will decide where and when the next phase of the experiment will take place.

### **3. 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.**

Because we were not able to identify opportunities for true international intercalibrations, we have not yet begun to focus on this activity. New technologies will be tested alongside conventional techniques for calibration.

#### **4. Create a guide of best practices for biological and biogeochemical studies in the sea-ice environment.**

The group will create a guide of best practices hosted on the ECV-Ice website as a living document. The first entry will be the Miller et al. (2015) methodological review from SCOR WG 140, and the results of additional methods evaluations and intercalibrations will be added as they become available.

Funding was approved for the 2018 meeting of the working group.

## **2.2 Working Group Proposals**

### **2.2.1 Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs (P-OBS)**

Peter Burkill presented a summary of the proposal and comments on it from national SCOR committees. The Netherlands SCOR Committee expressed that the proposed work of this group would have very broad application, although it is not clear what has been done and what has not. The proposal is overambitious, although the topic relevant for SCOR. They ranked the proposal as “do not fund” before the meeting, but after hearing the discussions, changed their ranking to “may fund”. The Japanese SCOR Committee thought that the terms of reference were too vague and unclear, and that it was not ready for funding, although it was nice that so many women were proposed as Full Members. The Korean SCOR Committee thought that the scientific problem is important, but what the group would do about it is not clear. Are they compiling or setting up new methodologies? The UK SCOR Committee thought the proposal ambitious and wondered whether the group could deliver within the time and financial constraints for SCOR working groups. They also suggested having someone from the Continuous Plankton Recorder (CPR) among the Full Members. The Finnish SCOR Committee ranked the proposal as “must fund”, as the work of this group will be useful and valuable. Their only concern is that coastal seas should be removed from the proposal if they will not include them in the scope of the group. Ed Urban added that global surveys have a difficult time extending into coastal seas because of sampling restrictions in national EEZs, so it is not surprising that they would not be considered by the group. The South African SCOR Committee rated the proposal as “may fund” because it has a worthy objective, but no new science. There is already a lot on this topic going on and the plan of integration not clear. They fear that the result will be just another report and an overview without clearly impacting observations. The proposal includes modelling, but only one modeler is listed. The Italian SCOR Committee was in favor of funding this proposal because it deals with an important problem and is very timely. It is important to determine how to integrate new biological measurements into existing observing systems. The group has already contacted GO-SHIP, for example. It will be important to integrate these observations with GOOS. The Russian SCOR Committee stated that this is an important problem and the issue is timely. The China-Beijing SCOR Committee felt that the working group is very important. IAPSO was very supportive and thought it was a good proposal. They were surprised that the Full Membership is predominantly female and the Associate Membership is predominantly male. The group should take advantage of the wealth of biological data collected by FerryBox systems. IABO supported this proposal as a “dream come true” for biologists. There is no standardization of methods and

data thus far, so this activity offers a great opportunity to integrate disciplines and different activities going on. It has the potential to be a “game changer”.

During the discussion period that followed, Sinjae Yoo asked for a better explanation of what the group would achieve. Peter Burkill replied that it would explore new technologies that could be placed on ships/observation platforms. Maria van Leeuwe agreed that the group could make progress, but how much with the time and budget of a SCOR working group? The Netherlands SCOR Committee did not think the proposal merited a “must fund” because it is too ambitious. Peter Burkill responded that the UK SCOR Committee was also polarized, with some of the same issues raised. The terms of reference are very diffuse and it is questionable whether they can be achieved within the scope of a SCOR working group. What about the historical data aspect in the working group, particularly related to CPR data? The Italian SCOR Committee agreed that the terms of reference are all quite vague, but the really important point is to find a problem that is relevant and address it with the right group of people.

### **2.2.2 Eastern boundary upwelling systems (EBUS): diversity, coupled dynamics and sensitivity to climate change**

Sergey Shapovalov, the SCOR Executive Committee monitor for the proposal, summarized the plans of the group and the comments from national SCOR Committees. At last year’s SCOR meeting, there were two proposals on upwelling. SCOR did not approve either proposal and asked that the two groups of proponents work together to create a single merged proposal, if they wished, which they did. Most countries consider this topic timely, considering that upwelling areas are very productive. Overall, the comments were that the terms of reference are very ambitious, widespread, and rather vague. In terms of membership, South Americans are included, but Asian scientists are largely missing, despite interest in the topic. There were concerns about finding funding for the proposed Summer School and Open Science Conference, and to meet capacity building plans. No countries rated the proposal as “do not fund”.

Following this summary, national SCOR representatives and others present at the meeting had an opportunity to give comments about the proposal. The Japanese SCOR Committee was happy to see synthesis of the two proposals from the 2016 SCOR annual meeting. Upwelling is an extremely timely topic and requires a highly interdisciplinary approach. The terms of reference were not well organized. They should include an ocean-atmosphere interactions expert in the membership. The Netherlands SCOR Committee considered the proposal very timely, a high priority, and liked the proposal very much. IABO ranked the proposal as second in the group of five proposals. This topic is a priority for SCOR, but needs more biological input. The terms of reference were good up to a point, but the proposal is still incomplete (it included physical oceanography and modelling, but limited integration of biological data). Biology should be included more. The Finnish SCOR Committee ranked the proposal as “must Fund” and was also pleased to see the merging of the two proposals from the 2016 SCOR meeting. They made a lot of detailed comments in their written response to the proposal, but overall incorporation of the atmospheric sciences would be very much appreciated. The Italian SCOR Committee liked the proposal, but ranked it as “may fund”. They appreciated the timeliness of the topic, but in particular appreciated the proposed summer school. They were concerned about the terms of reference being very wide and not very clear about the target(s) of the activities and products. The U.S. SCOR Committee found the proposal to be timely and a priority for research and for

SCOR, and ranked it a “must fund”. A SCOR working group would be a good mechanism for this topic, and data mining and capacity-building activities are appropriate for SCOR. The terms of reference are appropriate, but may be too ambitious to complete in the timeframe of a SCOR working group. Partnership with CLIVAR is important. The South African SCOR Committee ranked the proposal as its second “must fund”. The upwelling topic is important. A collaborative international effort in relation to climate change is essential and covers Northern and Southern hemisphere ecosystems. The proposed membership was generally good, but the gender balance (3 out of 10 were female) was poor. The proposed capacity building included a summer school (a successful element in other working groups) and was considered a very positive aspect of the proposal. The Korean SCOR Committee agreed with the Japanese SCOR Committee that more Asian members would be essential, and they could be particularly helpful if the Sumatra upwelling system were added. It is timely to have such a working group to synthesize information about eastern upwelling systems and based on that we can identify, what area to investigate further. The UK SCOR Committee ranked this proposal as a “may fund”. The proposed work is ambitious. The terms of reference were not convincing in what they would deliver and for whom. Asian membership is needed. The science part of the proposal is part of the SOLAS Science Plan and thus should be done by SOLAS. IAPSO ranked the proposal as “may fund” and its socio-economic exercise was unclear. The China-Beijing SCOR Committee ranked the proposal as “may fund”. It is a good area to study the interactive processes among land, ocean and atmosphere at the regional scale, but they were concerned that the topic may be too regional. The IOC representative was very excited about the proposal because it is such a timely topic. He suggested that links be made between this working group and science activities within IOC, such as ocean acidification and oxygenation projects.

### **2.2.3 International Network for the Study of How Organisms Respond to Environmental change (INSHORE)**

Patricia Miloslavich summarized the proposal and the comments from national SCOR committees. This was the third submission of some form of this proposal. Substantial feedback was provided by national committees. Environmental change involves more human activities than would be the focus of this group. There was no information about how database would be maintained. Why would the focus be on the 10 mussel species and how could the results be extrapolated more widely? Why would the mussel life cycle not be taken into account? A slight majority of respondents ranked the proposal as “do not fund” and none ranked it as “must fund”.

During the discussion, the IABO representative was disappointed that the proposal was extremely narrow, even in terms of biology. Peter Burkill also thought the proposal was very narrow and probably not a good choice for SCOR. There were no other comments during the discussion.

### **2.2.4 Expanding Regional Application of Dynamic Ocean Management (ERADOM)**

Colin Devey summarized the working group proposal and comments from national SCOR committees. The consensus was that the activities described were neither ocean science nor relevant to SCOR, as it is focused on management. The proposed activity is not suited for a SCOR working group approach. The terms of reference are vague and there are no managers in the proposed membership. The proposal is better suited to ICES, PICES, the UN, or some other

intergovernmental organization. A large majority of national SCOR committees ranked the proposal as “do not fund”.

In the roundtable discussion at the SCOR meeting, the Japanese SCOR Committee ranked the proposal as “do not fund”, although this type of activity it is necessary for sustainable use of the ocean. This is not the type of ocean science that SCOR supports. The Netherlands SCOR Committee asked if this would have been suitable for SCOR if the terms of reference were stronger. The replies were that SCOR has a focus more on core oceanography. This proposal is not really social science either, really more an application of management techniques. But, SCOR might fund a working group proposal focused on natural science, but including social science, although these have not fared well in previous SCOR meetings. The SCOR Executive Committee would have to decide whether to reserve some working group funding for this type of proposal.

### **2.2.5 Floating Litter and its Oceanic Transport Analysis and Modelling (FLOTSAM)**

David Halpern provided a summary of the proposal and of the comments from national SCOR committees. There was enthusiasm for the new topic. The expertise and geographical balances are good, but the gender balance is poor. Most national committees rated the proposal as “must fund”, with none ranking it as “do not fund.”

The Finnish SCOR Committee offered to suggest additional members from Finland who are experts on microplastics. The Japanese SCOR Committee noted that this topic is very timely on a global scale. Biological, ecological, and social scientists could be added and there are women working on this topic. The proposal is well written. The membership is biased toward physical oceanography; it should also include some other disciplines and coastal ocean scientists. More concrete plans for capacity building are needed. The Italian SCOR Committee ranked this proposal as their first choice because this is an emerging topic that needs to be addressed in a scientific way, and this proposal does that. The gender balance is an issue. As noted previously, the proposal is focused on physical aspects. Adding other topics might make the proposal too broad and it is important to get more information on circulation, velocity, and other physical factors. Corina Brussaard added that transport of plastic litter downward involves biology, so more biology should be included. The South African SCOR Committee found the proposal to be innovative, visible, globally significant, and scientifically sound. They noted the gender balance issue and suggested an early-career scientist from South Africa as an Associate Member to help bring in the interactions of physics and biology. The capacity-building plans are a bit vague and generic. The Russian SCOR Committee noted that plastic pollution is a global problem and SCOR can deliver results to different parties and gain good visibility. This would be the first time that SCOR addressed this topic. The terms of reference are good. It may be more difficult than for other topics to find members from developing countries. The Netherlands SCOR Committee agreed that the plastic pollution topic is very timely. The UK SCOR Committee thought the proposal was timely and it was good to see the focus purely on physics since this is unique and so far the focus of plastic litter has been more on biology. The terms of reference are good. There are a lot of policy implications and it is not clear how the group will interact with policymakers. The Continuous Plankton Recorder (CPR) database could be useful. The Chinese SCOR Committee ranked this proposal as “must fund” because it is very timely and an important topic. The Korean SCOR Committee also ranked this proposal as its top choice. The U.S. SCOR

Committee noted that NASA is interested to use remote sensing for plastics detection and commented that marine plastics is an important issue. Few women are included in the proposed membership, but are few in the field with a focus on physics from which to choose (there are quite a few women working on biology). They rated the proposal as a high “must fund.” IABO thought that the proposal should include more management options and a societal viewpoint; a focus on solutions is missing. IOC stated that this is a very important topic and there is a working group within GESAMP working on microplastic, weathering, etc. If a SCOR group is funded, it would be good to have these groups interact.

### Ranking of proposals

Following the discussion and review of ratings from national SCOR committees submitted before the meeting, it was noted that three of the five proposals had no “do not fund” rankings. The Finance Committee was asked to provide advice on the second day of the meeting whether SCOR could afford to support three new working groups in 2018. The Finance Committee was concerned that there would be a risk with funding three working groups, in case all the funds were spent by each group and it might only be possible to fund one new working group next year. Ed Urban commented that there was a definite risk, but also noted that, on average, working groups spend only about 75% of their budgets each year and this should be even more likely in 2018 because so many of the groups will meet in conjunction with Ocean Sciences 2018. Peter Burkill added that working groups are a core focus of SCOR and there are three really good working groups, so we should be willing to fund all three. The main argument against doing this is that we only had five proposals in total, so the success rate (60%) is relatively high.

Corina Brussaard asked about the risk of countries not paying their dues in 2018? Ed replied that the dues level received this year is higher than budgeted because the budget each year assumes that not all dues will be collected. Toshio Yamagata and Colin supported Peter Burkill’s recommendation to fund all three groups. Yamagata noted that there is a risk that the high success rate this year will stimulate more proposals next year and then we might only be able to fund one group. David Halpern agreed that it would not look good if we can only support one group in 2018; SCOR should fund two new working groups each year. Jorma Kuparinen noted that SCOR advised two groups to merge their proposals last year (both proposals had ranked pretty well). This merged proposal is ranked two or three this year. David suggested that, if we were to select only two proposals, we should do that independent of their rankings prior to the meeting, taking into account such arguments. Colin noted that SCOR’s reserves grow and decline with the decision whether we fund two or three groups per year. The Finance Committee noted that we have a larger discretionary budget so the 15,000 USD per year for another group is not relative to 100,000 USD that we must keep in reserve, but relative to about 600,000 USD in total. Alessandro Tagliabue recommended funding the top three proposals because they do not have any “do not fund” rankings. Marie-Alexandrine Sicre asked how the research in the EBUS proposal will be covered by CLIVAR/SOLAS/IMBeR. Will there be duplicated science or really something different?

Ed reminded participants that the approval at this meeting is provisional; final approval requires changes to membership and/or terms of reference that may be requested by SCOR. The Chinese SCOR Committee noted that SCOR asks national committees for a maximum of two “must



funds” and now we might approve three, which seems strange. It is not good to risk only being able to fund one group next year. Denise Smythe-Wright suggested that we should perhaps change our communication to national committees to ask whether the science is fundable and then rank the fundable proposals. Maria van Leeuwe noted that we seem to be confused about the arguments nations may use for ‘may fund’ rankings because national committees were asked to limit their “must funds” to two proposals and not because the science in the “may fund” proposals is not good enough. It was decided to vote on whether to fund three proposals. Fourteen national SCOR committees and affiliated organizations were eligible to vote. The vote was 10 in favor of funding three proposals, 3 against, and 1 abstention. So the final decision was to fund three working groups: FLOTSAM, P-OBS and EBUS.

### **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 through SCOR. 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/Future Earth Integrated Marine Biosphere Research (IMBeR) project**

Peter Burkill presented PowerPoint slides prepared by Carol Robinson, the IMBeR chair. 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 the project. The *IMBeR Science Plan/Implementation Strategy* (SPIS) has been reviewed and reviewers’ comments have been responded to by IMBeR. IMBeR is supported by a 17-member Scientific Steering Committee and an International Project Office in Bergen, Norway and a Regional Project Office in Shanghai, China. The IMBeR mission is “to promote integrated marine research and enable capabilities for developing and implementing ocean sustainability options within and across the natural and social sciences, and communicate relevant information and knowledge needed by society to secure sustainable, productive and healthy oceans.” IMBeR’s research goal is “to understand, quantify and compare historic and present structure and functioning of linked ocean and human systems to predict and project changes including developing scenarios and options for securing or transitioning towards ocean sustainability.” IMBeR is aligning all its activities and SSC expertise to the SPIS, created a new name and logo, has updated its website and communication strategy, and is establishing an early-career researcher network. The name of the project was changed to “Integrated Marine Biosphere Research” project.

Burkill presented IMBeR's Grand Challenges and Innovation Challenges:

- **Grand Challenge I: Understanding and quantifying the state and variability of marine ecosystems.** Implementation activities include comparative analyses of polar ecosystems, understanding the structure of polar food webs, IMBeR's contributions to the second International Indian Ocean Expedition (IIOE-2) through the Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) activity, international research undertaken by IMBeR's Climate Impacts on Oceanic Top Predators (CLIOTOP) regional activity, efforts to plan a trans-disciplinary research project to address key challenges on Arctic continental shelves arising from rapid climate change, and contributions related to ocean acidification research and observations.
- **Grand Challenge II: Improving scenarios, predictions and projections of future ocean-human systems at multiple scales.** Implementation activities include a session at the IMBeR Imbizo 5 on multiple stressors of ocean ecosystems and work of CLIOTOP to build policy-relevant scenarios for global oceanic ecosystems and fisheries.
- **Grand Challenge III: Improving and achieving sustainable ocean governance.** Implementation activities include work of IMBeR's Integrating Climate and Ecosystem Dynamics (ICED) activity with the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) in the Southern Ocean, the Committee on Environmental Protection (CEP) and the International Whaling Commission (IWC). IMBeR scientists were involved in generating a special issue that considers the role of biodiversity in sustaining the value of ecosystems to humanity.<sup>6</sup>
- **Innovation Challenge I: Understanding the role of metabolic diversity and evolution in marine biogeochemical cycling and ocean ecosystem processes.**
- **Innovation Challenge II: To contribute to the development of a global ocean ecosystem observational and modelling network that provides ecosystem essential ocean variables (eEOVs) and to improve marine data and information management.**
- **Innovation Challenge III: To advance understanding of ecological feedbacks in the earth system.**
- **Innovation Challenge IV: To advance and improve the use of social science data for ocean management, decision making and policy development**

IMBER will hold its [5<sup>th</sup> Imbizo open science meeting](#) in Woods Hole, Massachusetts, USA in October 2017, its 6<sup>th</sup> CLIMECO summer school in Yogyakarta, Indonesia in August 2018, and its [second Open Science Conference](#) in Brest, France in 2019. Funding for the IMBER International Project Office in Bergen, Norway and its Regional Project Office in Shanghai, China have been extended to 2020. IMBER is in the process of selecting a new Executive Officer.

Burkill noted that we should ask IMBeR whether they would be interested in helping implement the INSHORE project, which was not accepted as a new SCOR working group.

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<sup>6</sup> <http://futureearth.org/blog/2017-jul-26/why-we-need-value-biodiversity-anthropocene>

### 3.2 GEOTRACES

Alakendra Roychoudhury and Alessandro Tagliabue presented an update about GEOTRACES, which continues its systematic exploration of the chemistry of the ocean. The major activities for the past year have been preparation of the 2017 Intermediate Data Product, which was released at the 2017 Goldschmidt Meeting on 16 August 2017, in Paris, France. As with the 2014 Intermediate Data Product, graphics of the sections were distributed on memory cards at the Goldschmidt meeting, and will be available at the 2018 Ocean Sciences Meeting. The GEOTRACES statistics as of the time the SCOR meeting were as follows:

- 98 GEOTRACES cruises had been conducted (including 11 International Polar Year cruises).
- 1,024 section stations had been completed.
- 886 peer-reviewed papers had been published.
- 27 Process Studies had been completed, comprised of 41 cruises
- GEOTRACES-compliant data have been submitted from 9 cruises

Planning is underway for Pacific and Indian ocean cruises. Roychoudhury presented the following science highlights:

- **Changing the paradigm on the oceanic iron cycle:** Tagliabue, A., A.R. Bowie, P.W. Boyd, K.N. Buck, K.S. Johnson, and M.S. Saito. 2017. The integral role of iron in ocean biogeochemistry. *Nature* 543(7643):51–59. DOI: <http://dx.doi.org/10.1038/nature21058>.
- **Testament of the efficiency of environmental policies:** Bridgestock, L., T. van de Flierdt, M. Rehkämper, M. Paul, R. Middag, A. Milne, M.C. Lohan, A.R. Baker, R. Chance, R. Khondoker, S. Strekopytov, E. Humphreys-Williams, E.P. Achterberg, M.J.A. Rijkenberg, L.J.A. Gerringa, and H.J.W. de Baar. 2016. Return of naturally sourced Pb to Atlantic surface waters. *Nature Communications* 7:12921. DOI: <http://dx.doi.org/10.1038/ncomms12921>.
- **Oxygen biogeochemistry exerts a strong influence on cobalt cycling:** Hawco, N.J., D.C. Ohnemus, J.A. Resing, B.S. Twining, and M.A. Saito. 2016. A dissolved cobalt plume in the oxygen minimum zone of the eastern tropical South Pacific. *Biogeosciences* 13(20):5697–5717. DOI: <http://dx.doi.org/10.5194/bg-13-5697-2016>.
- **The coupled zinc-silicon cycle paradox illuminated:** Vance, D., S.H. Little, G.F. de Souza, S. Khatiwala, M.C. Lohan, and R. Middag. 2017. Silicon and zinc biogeochemical cycles coupled through the Southern Ocean. *Nature Geoscience*. DOI: <http://dx.doi.org/10.1038/ngeo2890>.

A new database of GEOTRACES publications is available, with an advanced search tool (see <http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers>).

GEOTRACES has a three-pronged synthesis process covering the main scientific goals of GEOTRACES:

1. **Supply and removal of TEI at ocean interfaces:** two Royal Society Scientific Meetings were held, on 7-10 December 2015, which resulted in a special issue of *Philosophical Transactions of the Royal Society A*

2. **Internal cycling of TEIs within the ocean:** A Joint GEOTRACES Ocean Carbon and Biogeochemistry (OCB) program Workshop was held on 1-4 August 2016
3. **Geochemical tracers as paleoceanographic proxies:** GEOTRACES is exploring partnership with the Past Global Changes project (PAGES) for planning a joint workshop.

GEOTRACES is very active and there is lot of interest in the meetings organized. The first GEOTRACES summer school was held on 20-26 August 2017 with 60 students selected from 140 applications, and 20 teaching scientists. The summer school was very well received by participants. SCOR provided support for developing country participants.

New outreach and educational resources have been developed in the past year:

- **GEOTRACES eNewsletter Special Issue** – Discovery Digest: a new type of eNewsletter introduced this year complemented the bi-monthly eNewsletter. The first issue was published in March 2017, devoted to recent discoveries in the oceanic cycle of iron: <http://www.geotraces.org/outreach/geotraces-ene newsletter/listid-12/mailid-768-geotraces-discovery-digest>
- **New video** presenting the GEOTRACES International Program: [https://youtu.be/3\\_pC\\_2eeAtA](https://youtu.be/3_pC_2eeAtA)
- **Children's Book** - Narrated photographic book of the U.S. Expedition to the North Pole: <http://www.healycruisebook.com>

Discover more at: GEOTRACES Outreach webpage <http://www.geotraces.org/outreach>.

Alessandro Tagliabue gave a brief publication about GEOTRACES data management. A very important point is that GEOTRACES manages discrete sample data, CTD sensor data, and aerosol/rain data. There is a quality check before data enter the database. An electronic atlas of data is available as part of the 2017 Intermediate Data Product (IDP-2017) ([www.geotraces.org](http://www.geotraces.org)). Aerosol and rain data are included for the first time in IDP-2017, which are intercalibrated to the same level as the trace metal data. Also new are BioGEOTRACES data, such as HPLC pigment and proteomics data. BioGEOTRACES is a rapidly evolving part of GEOTRACES, which is trying to connect to other initiatives going on related to this topic. Colin Devey, the Executive Committee Reporter for GEOTRACES reported that the Royal Society synthesis workshop generated publications, but some are not open access; how was the decision made? Tagliabue reported that whether or not to pay to make an article open access was decided by the individual contributors, but GEOTRACES paid for a few.

Ed Urban noted that an intermediate product is really a good idea to build visibility for a project, get data into the community early, stimulate new research and cruise ideas, etc.

### 3.3 Surface Ocean – Lower Atmosphere Study (SOLAS)

Veronique Garçon, the chair of the SOLAS SSC, presented an update about the project. At present, SOLAS statistics are as follows:

- There are more than 2,400 scientists in the SOLAS database from more than 75 countries
- SOLAS has national representatives from 30 countries
- The current SOLAS Scientific Steering Committee includes 17 members from 14 countries
- SOLAS has convened 6 Open Science Conferences, with a participation of more than 1,250 scientists
- 6 SOLAS Summer Schools that trained more than 420 young scientists
- SOLAS has distributed more than 100 e-bulletins with SOLAS-relevant information and has published 17 Newsletter issues
- SOLAS has sponsored more than 100 workshops and several hundred publications have resulted from SOLAS-sponsored work.
- The SOLAS Scientific Steering Committee has had four Chairs (Peter Liss, Doug Wallace, Eric Saltzman, and Véronique Garçon) and 44 SSC members. Lisa Miller will begin her term as new SSC Chair from 1 January 2018.

SOLAS has added Future Earth as a co-sponsor, in place of IGBP, and its Phase II *Science Plan and Organisation* (SPO) has been approved by co-sponsors, replacing the SOLAS Science Plan and Implementation Strategy (2004). The new plan forms a solid basis to successfully continue SOLAS for the period 2015-2025. Printed copies are available from the SOLAS IPO. The SOLAS Implementation Strategy details activities and events that directly address SOLAS science and provides information about established working groups and planned developments. SOLAS is working with Future Earth, IMBeR, and other projects to develop an Ocean Knowledge Action Network (KAN). SOLAS is planning its 2018 Summer School for 23 July-3 August 2018 in Cargèse, Corsica, France.

SOLAS is currently advertising for a new Executive Officer, with a deadline of applications of 15 November. It is hoped to have the new person in place by 1 September 2018. Funding will need to be secured to maintain the second staff member after summer 2018. The IPO will be hosted until December 2020 at GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany. GEOMAR is supporting the salary of the Executive Director. SOLAS has opened an Asian SOLAS Bureau in Xiamen University, State Key Lab of Marine Environmental science, China. Dr. Li Li under Prof Minhan Dai's supervision and working with the SOLAS IPO, started work on 1 September 2017 for 3 years, until Sept. 2020.

SOLAS released has version 1 of its live Web-based *Implementation Strategy*, available at <http://www.solas-int.org/activities/implementation.html>. Version 2 is already under preparation.

The SOLAS Core Themes are the following:

1. Greenhouse gases and the oceans
2. Air-sea interface and fluxes of mass and energy
3. Atmospheric deposition and ocean biogeochemistry

4. Interconnections between aerosols, clouds, and marine ecosystems
5. Ocean biogeochemical control of atmospheric chemistry

Studies of the five Core Themes are integrated in three Cross-Cutting Themes to advance understanding of environmental impacts, policy options, and societal developments:

1. Upwelling systems, polar oceans, coastal waters
2. Environmental impacts of geoengineering
3. Science and society

#### Major SOLAS-related Workshops since 2016 SCOR Meeting

- Air-sea Gas Flux; Progress and Future Prospects meeting by the Oceanflux Evolution project & ESA, Brest, France 6-9 September 2016
- Global Ocean Oxygen Network (GO2NE) meeting, IOC-UNESCO, Paris, France, on 7-9 September 2016
- 16<sup>th</sup> SOLAS SSC meeting and SOLAS Asia Symposium days Qingdao, China, on 24-28 October 2016
- SOLAS workshop in Brussels, Belgium on 26-27 October 2016. The topics were (1) Valuing carbon & the ocean's role, (2) Policy across the air-sea interface, and (3) Shipping industry & air-sea interactions
- Ocean Acidification workshop, Dakar, Senegal (West Africa), on 12-20 February 2017, SOLAS, OA-ICC, Future Earth Coasts joint effort
- GESAMP Working Group 38, Norwich, UK, on 27 February- 2 March 2017. This meeting included two workshops: "Changing atmospheric acidity and its impacts on the oceanic solubility of nutrients" and "The impact of ocean acidification on fluxes of non-CO<sub>2</sub> climate active species", sponsored by GESAMP, WMO, NSF, SCOR and SOLAS
- Workshop on Valuing carbon and the oceans' role, Monaco, France, on 30-31 March 2017
- Small Meeting on Air-sea interaction, policy and stewardship, Rome, Italy, on June 14-15, 2017
- BEPSII Meeting in San Diego, USA on 3-5 April 2017. BEPSII is a combined effort by SOLAS & CliC to promote sea-ice biogeochemistry.
- Community Workshop on "Cryosphere and Atmospheric Chemistry", Guyancourt, France, on 19-21 April 2017. (IGAC and SOLAS joint effort)
- Workshop on "Air sea interface and fluxes of mass and energy" in Cargese, France on 15-19 May 2017. WCRP and ESA involvement
- 17<sup>th</sup> SOLAS SSC Meeting, in Bologna, Italy, on 19-21 June 2017.
- SOLAS Session at IAPSO-IAMAS-IAGA Conference. A tribute to Roland von Glasow, in Cape Town, South Africa, on 27 August -1 September. Event Report planned
- GO2NE 3<sup>rd</sup> meeting and IMSOO/VOICE MBARI, USA, on 11-15 September 2017
- International Conference on "Shipping and the environment: From regional to global perspectives, in Gothenburg, Sweden, on 24-25 October 2017 + 26 October: SOLAS shipping workshop.
- International workshop on Marine & Atmospheric sciences in West Africa, Mindelo, Cape Verde, on 12-17 November 2017



### Major SOLAS-related Workshops in 2018

- 2018 AGU Ocean Sciences Meeting, Portland, Oregon, USA, 11-16 February 2018, SOLAS Town Hall Meeting
- SDGs in the Anthropocene Conference, 26-28 February 2018, in Cape Town, South Africa
- SOLAS/NASA/ESA Workshop on Remote Sensing to Study the Ocean-Atmosphere Interface (Future Earth/ESA funding), 13-15 March 2018, Potomac, Maryland, USA
- 18<sup>th</sup> SOLAS SSC Meeting: May 2018, probably Québec City, Canada
- BEPSII Annual Meeting (before SCAR/IASC POLAR 2018 Conference), Davos, Switzerland, 15-17 June 2018
- 7<sup>th</sup> SOLAS Summer School in Cargese, France, 23 July -3 August 2018
- International conference on “Ocean deoxygenation: Drivers and consequences. Past. Present. Future”, SFB754 and GO2NE, 3-7 September 2018, Kiel, Germany
- 2018 joint 14<sup>th</sup> iCACGP Symposium and 15<sup>th</sup> IGAC Science Conference, Takamatsu, Kagawa, Japan, 25-29 September 2018. Followed by parallel workshops on SOLAS Themes 4 and 5

SOLAS has created a series of SOLAS Event Reports (see <http://www.solas-int.org/resources/reports.html>).

SOLAS has been involved in establishing the Ocean Knowledge-Action Network (O-KAN) and preparation of the Belmont Forum Collaborative Research Actions (CRA) call:

- Involvement in the development team (P. Liss, V. Garçon, M. Uematsu)
- Participation in the writing of the Belmont CRA for the Ocean KAN, Bern, June 2016
- Participation to the Oceans Scoping Workshop Brussels, May 2017

Topics where SOLAS involvement could be beneficial to the O-KAN:

1. Building pathways toward the sustainable and equitable use of the ocean,
2. Modifying pathways to account for and minimize the negative impacts of global change on the ocean,
3. Exploring and minimizing the impact of pollution on pathways to ocean sustainability
4. Predicting, mitigating, and responding to ocean disasters to reduce risk

Belmont Forum CRA call for proposals will be out at the end of 2017/early 2018.

Two of the 2017 SCOR working group proposals were endorsed by SOLAS: EBUS and P-OBS.

Garçon noted that there are good interactions between SOLAS and IMBeR. Marie-Alexandrine asked about SOLAS relations with Future Earth. Garçon replied that the O-KAN process was really tough. There is a new Executive Director now for Future Earth and SOLAS will have to see whether interactions change. SOLAS will keep focusing on basic science, but is more open to societal issues now.

### 3.4 SCOR/POGO International Quiet Ocean Experiment (IQOE)

Ed Urban presented an update about the International Quiet Ocean Experiment (IQOE), as its acting Executive Officer. IQOE is supported by SCOR, POGO, and by a partnership between the Urban Coast Institute (Monmouth University, New Jersey USA) and the Program for the Human Environment (The Rockefeller University, New York USA).

IQOE is the first international research project on the topic of ocean acoustics and bioacoustics research, observations, and modeling. Why is an international project needed? IQOE provides a focal point to identify priority questions and promising approaches and brings together a critical mass of resources (expertise, equipment, finances) for observations, standards, and research. IQOE also provides resources for convening, communication, and administration; serves as a champion for standardization and intercalibrations; and demonstrates the importance of ocean acoustics and biological effects to the public, managers, and policymakers.

The motivation for IQOE is that there is a general perception that ambient sound is increasing in the ocean. There are estimates of increases at some frequencies in some places, but we lack a good understanding of changes over time and space. “Peak noise” (at some frequencies) may be possible, because of improvements in technology related to human activities that produce sound in the ocean and changes in economic activity that use the ocean. National laws and regulations have become increasingly strict, following a “precautionary approach” based on a lack of information regarding biological effects of human-made sound. The trend toward precaution is costly for navies, industry, observational science, and management agencies, while not necessarily leading to improved health and survival of marine organisms.

IQOE was developed with the premise that it should not add sound to ocean, relying on passive acoustics. IQOE focuses on ambient sound, comparing noisy and quiet areas, and takes advantage of observational opportunities in areas scheduled or predicted to become quieter or noisier.

IQOE can be described as involving 2 fundamental areas of activity:

1. documenting ambient sound levels in the ocean at frequencies important for marine organisms, including variability over time and space. Ocean sound has received little attention as a global change issue. There is no publicly available “Keeling Curve” for sound in ocean at any location or frequency. The closest are short time series of the Comprehensive Test Ban Treaty Organization (CTBTO), which are not easily available, and some data series published for the U.S. West Coast. This task will involve locating and determining the usefulness (and accessibility) of data held by navies, industry, and others that could be used to document current ambient sound levels and levels going back in time. Efforts are already underway to bring together historic data.
2. bringing together existing information and developing new information on effects of sound on marine organisms. Some scientific syntheses, meta-analyses, and gap analyses related to biological effects have already been performed, but the *IQOE Science Plan* identifies more information that will need to be developed to improve management of sound in the ocean.



The science of IQOE also can be described in terms of 5 fundamental questions:

1. Have human activities affected global ocean soundscape compared with natural changes over time?
2. What are current levels and distribution of anthropogenic sound in the ocean?
3. What are trends in anthropogenic sound levels across the global ocean?
4. What are current effects of anthropogenic sound on important marine animal populations?
5. What are potential future effects of sound on marine life?

In terms of project implementation, the IQOE Science Plan describes the following phases:

1. Laying the foundation (Years 1-3) – underway
  - a. Creating standards for the project
  - b. Deciding the form of data management
  - c. Synthesis and rescue of historic data
2. Pilot projects (Years 4-6) – national projects can be considered pilot projects
3. International Year of the Quiet Ocean (Year 7)
4. Synthesis (Years 8-10)

The responsibility of the IQOE Science Committee (SC) is to design activities to achieve project goals. Its membership must include expertise that broadly covers relevant areas of ocean acoustics and bioacoustics, without having a critical mass of any specific expertise. One mechanism being used by the IQOE SC to fulfil project goals is to create working groups with critical mass on more specific topics. Some working groups crosscut the entire project to provide central functions, such as standardization, data management and access, compiling information about passive observing systems, and providing linkages between IQOE and the Global Ocean Observing System. Other working groups focus on achieving IQOE objectives in particular systems, such as acoustics in biodiversity hotspots and Arctic. The current IQOE working groups include the following:

- IQOE WG on Standardization
- IQOE WG on Acoustic Measurement of Ocean Biodiversity Hotspots
- IQOE WG on Data Management and Access
- IQOE WG on Arctic Acoustic Environment
- POGO IQOE WG

IQOE's Science Committee was formed in early 2016 and met for the second time in London, UK in January 2017. Work has proceeded this year on forming working groups and getting them activated. POGO has been funding an IQOE-related working group for the past two years, which has proposed an acoustic Essential Ocean Variable for the Global Ocean Observing System and is working on an online database of passive acoustic observing systems (see <http://www.iqoe.org/systems>). The IQOE Website is being re-designed and will be launched later this year (see [www.iqoe.org](http://www.iqoe.org)). Funding is being provided for IQOE activities by a consortium of Monmouth University and Rockefeller University in the United States. A proposal has been

submitted to a national government for placement of an IQOE International Project Office at an institutional member of POGO.

Meeting participants approved 2018 funding for IQOE.

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

Peter Burkill provided an update about IIOE-2, as one of its co-chairs. He started by reminding meeting participants that IIOE-2's mission is "to advance our understanding of the Indian Ocean and its role in the Earth System in order to enable informed decisions in support of sustainable development and the well-being of humankind". IIOE-2 is delivered through combining the resources of IOC (an intergovernmental UNESCO agency) with IOGOOS (regional observational network) and SCOR (a non-governmental research-focused organization). IIOE-2's guiding reference books are the *IQOE Science Plan* and *IQOE Implementation Strategy*. Burkill presented the IIOE-2 Science Committee structure and composition. Six countries currently have national committees for IIOE-2: Australia, France, Germany, India, UK, and USA. Ten additional countries are participating in IIOE-2, but do not have national committees: Bangladesh, China, Indonesia, Japan, Kenya, Korea, Madagascar, Norway, Russia, and South Africa.

The Science Committee for the IIOE-2 held its first meeting in Perth, Australia in January 2017. SCOR supported one chair of each of the Science Themes to attend the meeting. The second meeting will be held in Indonesia in March 2018. IIOE-2 is co-sponsoring a session on "The Second International Indian Ocean Expedition (IIOE-2) and Related Oceanic and Coupled Atmospheric Research in the Indian Ocean" at the IAPSO-IAMAS-IGA conference immediately before the SCOR annual meeting.

Burkill concluded by stating that the project is very vibrant and will extend well beyond the originally thought ending date of 2020. He requested US\$25,000 for the next meeting of the IIOE-2 Science Committee in 2018 (in Indonesia) to allow participation by one chair of each Science Theme and the chair of the working group on Science and Research. Ed Urban made that point that the project also needs national funding to carry out its plans, in addition to other sources of funding. SCOR approved the requested support.

## **4.0 INFRASTRUCTURAL ACTIVITIES**

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

David Halpern, the Reporter for IOCCP, provided an update prepared by Maciej Telszewski, the IOCCP Director. IOCCP plays an important role in the Global Ocean Acidification Observing Network (GOA-ON) through participation of two SSG members Richard Feely and Benjamin Pfeil, and Project Director Maciej Telszewski on the GOA-ON Executive Council.

IOCCP has expanded its expertise beyond carbon to biogeochemistry and now serves as the Biogeochemistry Panel of the Global Ocean Observing System (GOOS), including responsibility for the Essential Ocean Variables (EOVs) related to biogeochemistry. In this role, IOCCP

contributed to the Implementation of Multi-Disciplinary Sustained Ocean Observations (IMSOO) Workshop in February 2017. This workshop identified three demonstration themes:

- Plankton community changes
- Oxygen minimum zones
- Open ocean, shelf and coastal interactions

The outcomes of the IMSOO workshop will contribute toward the planning of the OceanObs'19 meeting.

IOCCP has assisted with the Surface Ocean CO<sub>2</sub> Atlas (SOCAT). SOCAT version 5 includes 21.5 million quality-controlled, surface ocean fCO<sub>2</sub> (fugacity of carbon dioxide) observations with an accuracy of better than 5  $\mu$ atm from 1957 to 2017 for the global ocean and coastal seas. More than 100 individuals worldwide have contributed to SOCAT, which is documented in articles published in the journal *Earth System Science Data* (see below). SOCAT data have contributed to the Global Carbon Project, OceanGHGFlux ESA project, Surface Ocean CO<sub>2</sub> Mapping project, and CMIP 6 model validations.

IOCCP has also contributed to the GLObal Ocean Data Analysis Project (GLODAP) project, which is a compilation of carbon data in the interior ocean. GLODAP v2 is the latest version, which was released in January 2016. It is a global collection of CO<sub>2</sub>-relevant data from 45,306 stations on 724 cruises. The data are corrected for biases and extensively documented.

IOCCP is planning a Second International Summer Course on Best Practices for Selected Biogeochemical Sensors, following the success of the first course in 2015 and the demand for more training.

Three community publications that resulted from IOCCP activities acknowledged NSF support through SCOR:

- Olsen, A. et al. 2016. The Global Ocean Data Analysis Project version 2 (GLODAPv2) – an internally consistent data product for the world ocean. *Earth System Science Data* 8:297-323, doi:10.5194/essd-8-297-2016.
- Lauvset, S.K. et al. 2016. A new global interior ocean mapped climatology: the 1°×1° GLODAP version 2. *Earth System Science Data* 8:325-340, doi:10.5194/essd-8-325-2016.
- Bakker, D.C.E. et al. 2016. A multi-decade record of high quality fCO<sub>2</sub> data in version 3 of the Surface Ocean CO<sub>2</sub> Atlas (SOCAT). *Earth System Science Data* 8:383-413. doi:10.5194/essd-8-383-2016.

David Halpern noted that presentation shows the organization of the project and Ed Urban added that the office is very active. Peter Burkill suggested that SCOR should send a letter to IOCCP to acknowledge the project's good work.

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

Sebastian Swart, one of the co-chairs of SOOS, provided an updated about the project. SOOS is developing 5 Regional Working Groups that will coordinate and implement the observing system in their regions, bringing together efforts in planning, logistics, resources, data management and access. These regional groups will encompass national observing efforts, and will work with circumpolar observing programs and projects to ensure required coverage of observations in the following regions: West Antarctic Peninsula (WAP), Southern Ocean Indian Sector, Ross Sea, Weddell Sea/Dronning Maud Land sector, and Amundsen/Bellingshausen. The WAP workshop took place in May 2017, the Indian Ocean workshop will take place in August 2017, and the Ross Sea workshop will take place in Sept. 2017. SOOS Capability Working Groups help develop important observational capabilities, such as developing and implementing technologies; improving observational design, efficiency and coverage; and enhancing information management and dissemination. The Capability Working Groups include the following: Censusing Animal Populations from Space, Southern Ocean Fluxes, Benchmarking (eEOV), and a SOOS-initiated POGO Working Group on Observing and Understanding the Ocean beneath Antarctic sea ice and ice shelves (OASIIS). The SOOS report details various SOOS mapping tools and databases that are coming on line.

Swart noted that DueSouth is an example of a key product. It is a database of upcoming expeditions in the Southern Ocean. The system is easy to use and SOOS is planning to automate it via datamap (from the Alfred Wegener Institute and other organizations). Another product is SOOSmap, which shows current platforms that are recording data (ranging from GO-SHIP to gliders). It is possible to click on an asset on the map and be directed to a metadata file. The Southern Ocean Mooring Network was the last example mentioned by Swart. In addition to these activities,

The 7<sup>th</sup> SOOS SSC meeting will be held in China in 2018. The SOOS International Project Officer (IPO) is funded until 2018 and the Australian Antarctic Division (AAD) may fund the position for a longer term. But the staff needs to grow since SOOS is expanding its activities quickly. They are hoping to have their working groups be quite independent but that will require time. There is currently too much reliance on Australia funding. There is a discussion with China at the moment concerning funding for IPO activities.

Funding was approved for SOOS for 2018.

#### **4.3 IAPWS/SCOR/IAPSO Joint Committee on Seawater (JCS)**

Denise Smythe-Wright reported on the activities and progress of the Joint Committee on Seawater (JCS). The full group did not meet in 2016-2017. However, 6 JCS members attended the 2016 International Association for the Properties of Water and Steam (IAPWS) Annual Meeting in Dresden, Germany (11-16 Sept 2016). Two JCS members attended the 2016 International Symposium on Stratified Flows (San Diego, 29 Aug-1 Sept. 2016). The four *Metrologia* review papers published in January 2016 continue to be heavily downloaded, especially part 4 on relative humidity. Parts 1 and 4 of the *Metrologia* papers have just been selected as one of the “2016 Highlights of *Metrologia*”. These papers have their own Web page

([http://iopscience.iop.org/journal/0026-1394/page/Highlights\\_of\\_2016](http://iopscience.iop.org/journal/0026-1394/page/Highlights_of_2016)). IAPSO has budgeted US\$12,500 for the 2018 meeting and SCOR agreed to match this amount.

#### 4.4 GlobalHAB

Ed Urban presented an update about the GlobalHAB project, prepared by the GlobalHAB Chair, Elisa Berdalet.

GlobalHAB SSC members have helped work on the GEOHAB legacy projects:

- Special issue of [Oceanography](#), including a paper about GlobalHAB.
- Book published by Springer International Publishing AG: *Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB)*
- GEOHAB/IOCCG Monograph on HABs and Remote Sensing

The GlobalHAB SSC met for the second time in March 2017 in Naples, Italy to discuss revisions to the GlobalHAB Science and Implementation Plan, implementation activities for the 2017-2019 period, the GlobalHAB Web site, and development of a conceptual structure of a Good Practices Manual to investigate HABs and Climate Change.

The GlobalHAB SSC identified the following priority tasks for 2017-2019:

1. Develop a review paper to identify the knowledge gained and existing gaps on the biogeography and biodiversity of selected taxa.
2. Coordinate with the IPHAB Task Team to implement the multi-agency IOC-IAEA-FAO-WHO "Global Ciguatera Strategy".
3. Convene a workshop on the mode of action of fish-killing microalgae (and other related issues), in coordination with the Task team on "Fish-killing HABs".
4. Endorse an inter-laboratory validation study on mass spectrometry methods of PSP-toxin analysis.
5. Contribute to a special issue on "Harmful Algae and Climate Change" in *Harmful Algae*, by 2019.
6. Development a good-practices manual for the study of climate change on HABs.
7. Co-organize and participate in the activities of the IOC GO<sub>2</sub>NE network.
8. Establish a Working Group on Macroalgal Blooms (*Sargassum*, *Ulva*).
9. Help to develop the GOOS Phytoplankton EOVS (Essential Ocean Variable), which includes HABs, <http://goosocean.org/>.
10. Foster development of Global HAB Status Report (GHSR).

GlobalHAB is developing links with various related projects (e.g., the IOC GO<sub>2</sub>NE project and the Global Ciguatera Strategy), and is working with the Intergovernmental Panel on Harmful Algal Blooms on a good practices manual for research on harmful algal blooms.

Urban noted that the project is underfunded and that he had recommended to the SSC that they focus on work that can be done quickly without extra funding (e.g., papers, special issues,

coordination and workshop about fish-killing microalga; a working group on macroalgal blooms; development of GOOS Phytoplankton EOVS).

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

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. Ed Urban reported that *Trends in Ecology and Evolution* invited submission of a manuscript from the workshop.<sup>7</sup>

### **5.0 CAPACITY-BUILDING ACTIVITIES**

#### **5.1 SCOR Committee on Capacity Building**

Venu Ittekkot, the former chair of the SCOR Committee on Capacity Building, reported on the work of the committee over the past year. The committee revised the application form for the SCOR Visiting Scholars program and created a request form for meeting organizers to submit to request funds for travel of developing country scientists to their meetings. The SCOR Executive Committee approved Claudia Benitez-Nelson (USA) to replace Venu Ittekkot as the chair of the committee in early 2017. Benitez-Nelson and Ed Urban represented SCOR at a side event at the UN Ocean Conference in June 2017, which SCOR led. SCOR approved funding for 2018 activities of the committee. Ittekkot mentioned an article that he and Ed Urban wrote on the SCOR capacity-development activities related to the IIOE-2, published in the *Indian Ocean Bubble-2* (see [http://www.iioe-2.incois.gov.in/IIOE-2/pdfviewer.jsp?docname=IndianOceanBubble2\\_7th.pdf](http://www.iioe-2.incois.gov.in/IIOE-2/pdfviewer.jsp?docname=IndianOceanBubble2_7th.pdf)).

Salvatore Arico asked for SCOR's participation in an International Training Workshop coming up. Arico and Ed Urban will follow up on this idea. Urban suggested to also include POGO.

#### **5.2 SCOR Visiting Scholars**

SCOR has sent 26 Visiting Scholars to 15 different countries in the first 9 years of the program, including 5 in 2017. 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 (see item 5.5).

SCOR receives 25-30 applications each year for the Visiting Scholars program, with more good applications than can be funded. SCOR support from NSF is used to fund three Visiting Scholars each year. SCOR added funding for two additional visiting Scholars in 2017 and again in 2018. About one-third of the applicants pre-match scholars with university/institute. Crowdfunding was attempted in 2017 to raise support for the program, to increase the number of Visiting Scholars but only \$250 was raised.

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<sup>7</sup>The publication has been accepted by *Trends in Ecology and Evolution* and published online in December 2017 (see DOI: <http://dx.doi.org/10.1016/j.tree.2017.11.004>)

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

Ed Urban reported that SCOR has co-funded this program with POGO since 2001. The program has funded more than 125 fellows so far. Four fellowships were awarded in 2017.

### **5.4 NSF Travel Support for Developing Country Scientists**

Ed Urban reported that SCOR was awarded a three-year renewal of its grant from the National Science Foundation for travel of developing country scientists to scientific meetings. The new grant will run until 31 July 2020. 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 2016 SCOR meeting and additional requests will be considered after the SCOR meeting in South Africa.

David Halpern asked whether SCOR should ask NSF for permission to devote more funding for specific capacity-development activities and less for travel grants.

### **5.5 Research Camps at the University of Namibia**

Ed Urban reported that the Research Camps at the University of Namibia have reached the end of their first 4-year grant from the Agouron Institute. An evaluation is being conducted to determine what changes should be made if the program were continued. This evaluation included a visit by Venu Ittekkot and Ed Urban to Namibia to meet with officials at the University of Namibia and the Namibian National Marine Information and Research Centre (NatMIRC), a partner in the program. Ittekkot and Urban were in Namibia to discuss their views of the results of the first four years of research camps in order to determine whether to renew the activity.

## **6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS**

Marie-Alexandrine presented an update about several intergovernmental and international activities in which she had been involved to represent SCOR.

Agenda 2030 includes 17 sustainable development goals, of which SDG 14 is “Life Below Water”, which is so far strictly marine. The UN Ocean Conference in June 2017 was designed to advance SDG 14. The conference produced a call for action, approved on 6 July 2017 (see <https://oceanconference.un.org/callforaction>). Within the SDGs are targets; for SDG 14, the targets range from marine pollution (microplastics) and ocean acidification to technology. Ten targets were grouped into 7 themes and concept dialogues (10-page papers) were produced for each theme. The Ocean Conference Web site (<https://oceanconference.un.org/>) provides information on how the conference was organized and what partners were involved. Partners produced volunteer commitment documents. Ed Urban produced a table showing how SCOR activities relate to the 7 themes, which will be included in the next *SCOR Newsletter* (see <http://www.scor-int.org/Publications/SCOR-NL-35.pdf>). For each voluntary commitment, there are targets, deliverables and resources (in-kind for SCOR; funds, activities and time SCOR is already providing).

Future Earth has set up Knowledge Action Networks (KANs) on several topics, and SCOR is participating in the Ocean KAN, in partnership with Future Earth, WCRP, and IOC.

The G7 Science Ministers have an ongoing initiative to better organize sustainable use of ocean resources. They held a workshop of technical and policy experts to discuss and refine action proposals. Which places need better/more observation, how to do this and what is the time line for new observations? SCOR has joined as an observer in the G7 initiative.

Sicre summarized that SCOR is trying to be more involved in supporting fulfilment of SDGs, and the maintenance of healthy oceans, and to help build on the work done through the first World Ocean Assessment (WOA). We will nominate individuals for the Pool of Experts for WOA-2. SCOR can suggest and stimulate nominations through national governments, which will be done through the *SCOR Newsletter* and email list. By helping with the nominations, SCOR can help make the assessment that is relevant and authoritative.

The various intergovernmental activities that are going on should not affect the way SCOR does its business and the focus of SCOR working groups should continue to be on science. Ed Urban added that SCOR is focused on fundamental science, but a lot of this science is relevant to policymakers. SCOR should help with intergovernmental initiatives as much as possible, and feed the results of SCOR activities into them. Peter Burkill also noted that SCOR can also ask these initiatives to let us know of their progress.

## **6.1 Intergovernmental Oceanographic Commission (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 3.5).

Salvatore Aricò of IOC provided an update of IOC activities relevant to SCOR. He noted that ocean research is related to all the other IOC focus areas. He reported that IOC is the “custodian agency” within the UN system for SDG 14.3’s indicator: “Average marine acidity (pH) measured at agreed suite of representative sampling stations.”

One of IOC’s focus areas is harmful algal blooms and nutrient loading to coastal ecosystems. IOC addresses HAB science jointly with SCOR through the research program GlobalHAB. IOC has also supported a long-term capacity-development effort related to HABs and is developing a Global HAB Status Report. In addition to SCOR, IOC works with ICES, PICES and IAEA in relation to HABs. IOC has responded to the nutrient issue through several actions: (1) Linking Nutrient Sources to Coastal Ecosystem Effects; Implemented a GEF-funded Global Nutrient Cycle Project with UNEP, (2) IOC engagement in the Global Partnership on Nutrient Management, (3) contributions to SDG Indicator 14.1. (ICEP) via UNEP, and (4) training of trainers and technology validation of the Global Nutrient Management Toolbox.

IOC supports its own Blue Carbon Initiative, which co-organizes a scientific working group to support Member States in increasing technical capacity related to this topic. The IOC working group contributes to the International Partnership for Blue Carbon, whose goal is to increase



understanding of, and accelerate action on, the use of coastal blue carbon ecosystems to remediate climate change.

IOC supports several other groups related to different aspects of ocean science:

- International Group for Marine Ecological Time Series (IGMETS)—has issued a report that describes what marine ecological time series tell us about the ocean. The IGMETS status report is IOC Technical Series Report 129 (see <https://igmets.net/2017/report>). IGMETS has also created a Times Series Explorer (see <https://igmets.net/2017/explorer>).
- Climate Change and Global Trends of Phytoplankton in the Oceans (TrendsPO)—The group's first meeting was hosted in China in December 2016. A work plan has been drafted and a data management plan is being drafted.
- IOC also contributes to two GESAMP working groups, on Microplastics and on Marine Geoengineering.

Arico noted that the conference on The Effects of Climate Change on the World's Oceans, co-sponsored by IOC, ICES, PICES, and FAO, will be held on 4-8 June 2018 in Washington, D.C.

IOC issued its Global Ocean Science Report in 2017. The report provides a snapshot of the global status in relation to research capacity and infrastructure, funding for ocean science, research productivity and scientific impact, oceanographic data and information exchange, international supporting organizations on ocean science, and contributions of marine science to the development of ocean and coastal policies and sustainable development. See <http://www.unesco.org/new/en/natural-sciences/IOC-oceans/sections-and-programmes/ocean-sciences/global-ocean-science-report/>.

IOC has proposed a UN Decade of Ocean Exploration for Sustainable Development (2021-2030). This activity will focus on how ocean science could contribute to economic and non-economic benefits from the ocean. It will also describe where we should be by 2030, in terms of research, observations, modelling, and capacity development.

The SCOR Executive Committee will discuss how SCOR could be involved in the Ocean Decade. SCOR has already expressed an interest in some kind of involvement.

Arico summarised that IOC activities are very complementary to those of SCOR. IOC and SCOR work together, and IOC also picks up after SCOR working groups have been disbanded to take the activities to the next step (e.g., WG 137 transformed to TrendsPO, with many of the same people involved). Another example is in ocean acidification, where IOC and SCOR co-sponsored the symposia on The Ocean in a High-CO<sub>2</sub> World and IOC is taking the topic further. Peter Burkill asked if the current working relationships between SCOR and IOC are effective. Arico looked into this question when he was appointed recently. It is a question because SCOR is non-governmental and IOC is inter-governmental. Arico's goal is to create partnerships that benefit both organizations. Perhaps a bit more mapping of SCOR and IOC activities could be helpful.

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

Ed Urban provided an update about GESAMP Working Group 38 on Atmospheric Input of Chemicals to the Ocean. SCOR has provided partial support for this group's activities through grants from the U.S. National Science Foundation. From 27 February to 2 March 2017, two workshops took place at the University of East Anglia (UEA), Norwich, United Kingdom under the auspices of Working Group 38 and sponsored by WMO, NSF, SCOR, SOLAS, and UEA. These workshops focussed on the changes in the acid/base balance of the atmosphere and ocean, and their impacts on air-sea exchange. Workshop 1 focussed on Changing Atmospheric Acidity and its Impacts on the Oceanic Solubility of Nutrients and Workshop 2 focussed on The Impact of Ocean Acidification on Fluxes of Non-CO<sub>2</sub> Climate-Active Species. As many as 12 peer-reviewed publications may result from these workshops.

## **6.3 North Pacific Marine Science Organization (PICES)**

Sun Song delivered a presentation prepared by Hal Batchelder of PICES. PICES plays an important role in bringing a North Pacific perspective to the global activities of SCOR. By participating in and implementing these activities in the region, PICES can advance its own scientific agenda. Ed Urban represented SCOR at the 25<sup>th</sup> PICES anniversary meeting in November 2016. SCOR provided travel support for developing country scientists to attend PICES-related meetings in the past year and PICES has provided support for people from PICES nations to attend the activities of SCOR projects. PICES supports the participation of one Associate Member of WG 149 and one Associate Member of WG 154 (FLOTSOM). Of particular note is the participation of PICES in implementing the SCOR-IOC GlobalHAB project, and cooperation with IOCCP and with the IMBeR ESSAS activity and with IMBeR more broadly.

Sun Song noted that PICES core elements include the following:

1. Scientific Excellence—PICES sponsors numerous scientific symposia alone or in cooperation with other organizations, such as ICES and IOC. Many of these symposia serve as excellent locations for special sessions of SCOR working groups and research projects.
2. Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems (FUTURE) Program, which has four core areas: (a) Climate System, (b) Process Studies, (c) Marine Ecosystems including food web dynamics, and (d) the Human Socio-ecological System. All other PICES activities contribute to achieving the goals of FUTURE. The FUTURE program will program wrap up in 2023 or 2024.
3. Capacity Building—The presentation noted past support by SCOR for travel of early-career scientists to PICES-related meetings, and a request for future support.
4. Building Relations with other Organizations/Programs—Some of the relations with other organizations, such as with SCOR, relate to capacity-building activities.

## **7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS**

### **7.1 International Council for Science**

Marie-Alexandrine Sicre noted that ICSU reviewed SCOR and SCAR in 2015 and 2016. The SCOR Executive Committee drafted a response to the review, including implementing actions related to the recommendations, and gave an opportunity for national SCOR committees to respond to the draft response. The final response was sent to ICSU on 4 May 2017. The SCOR Executive Committee met in closed session on 3 September 2017, immediately before the SCOR annual meeting, to discuss progress on the actions that are underway to respond to recommendations from the ICSU Review Panel. The SCOR Executive Committee is effectively addressing all the points of the review. Sicre mentioned that the Executive Committee is particularly interested in getting national committees to promote the involvement of early-career scientists in SCOR working groups. There was an action item for Ed Urban to contact national SCOR committees about this issue.

#### **7.1.1 World Climate Research Programme (WCRP)**

Nico Caltabiano, the Deputy Director of the International CLIVAR Project Office, provided a presentation for the meeting. WCRP co-sponsors the SOLAS project. Other WCRP projects particularly related to SCOR interests include the CLIVAR project and the WCRP Grand Challenge on Regional Sea-Level Change and Coastal Impacts. SCOR is co-sponsoring and providing funding for the WCRP Polar Challenge (see <http://www.wcrp-climate.org/index.php/polarchallenge>) and provided travel support for a scientist from India to attend the WCRP/IOC Regional Sea Level Changes and Coastal Impacts in New York City in July 2017.

WCRP activities range from those focused on seasons to activities focused on century-scale variations. WCRP's work is conducted through four working groups and five research projects. The working groups are on the following topics:

- Subseasonal to Interdecadal Prediction (WGSIP)
- Numerical Experimentation (WGNE)
- Coupled Modeling (WGCM)
- Regional Climate (WGRC)

WCRP's research projects are the following:

- CLIC: Cryosphere-Climate
- CLIVAR: Ocean-Atmosphere (see below)
- GEWEX: Land-Atmosphere
- SPARC: Troposphere-Stratosphere
- CORDEX: Regional Climate Downscaling

Regional sea-level change is a major issue being pursued by WCRP, mostly recently though the conference on Regional Sea Level Changes and Coastal Impacts, mentioned earlier.

WCRP is also leading the Polar Challenge, which is providing 500,000 euro for the first 2,000 km under-ice mission by an autonomous underwater vehicle. SCOR contributed to the prize fund.

WCRP is active in capacity development, to ensure the development of future leaders in climate science and to stimulate fulfilment of specific regional requirements. WCRP's capacity development activity includes training workshops, as well as special activities in conjunction with other WCRP-related meetings. One example is the Early Career Scientists' Symposium held in conjunction with the CLIVAR Open Science Conference in Qingdao, China in 2016. The First Institute of Oceanography (FIO), UNESCO/IOC Regional Training and Research Center on Ocean Dynamics and Climate (ODC), and the International CLIVAR Project Office are discussing the establishment of a biannual CLIVAR/IOC/ODC Joint Summer School, beginning in the summer of 2018 for early-career scientists from around the world.

CLIVAR is focused on understanding the dynamics, the interaction and the predictability of the coupled ocean-atmosphere system. It carries out its work through regional and topical panels. The regional panels cover the Atlantic, Pacific, Indian, and Southern oceans and, recently formed, a panel for the Arctic Ocean.

CLIVAR's overarching goal is "Building a society resilient to environmental changes." To achieve this goal, it will be necessary to further develop understanding of the uncertainty of climate predictions; to provide seamless predictions across regions and various time scales; to understand mechanisms and consequences of climate variability and change, both globally and regionally; to establish a multi-scale approach in space and time to climate science and mitigation/adaptation approaches; and to increase awareness of gaps in understanding and the continuing need for fundamental climate science. CLIVAR is developing a new Science Plan, to be released at the end of 2017.

CLIVAR Research Foci (RF) were launched in 2015. They are focused limited-lifetime initiatives (5 years or less) on topics of high priority in the climate research community that would benefit from enhanced international coordination. They are similar to SCOR working groups. Current RF topics include the following;

- Decadal Climate Variability & Predictability
- Planetary Heat Balance & Ocean Heat Storage (with GEWEX participation)
- ENSO in a Changing Climate
- Eastern Boundary Upwelling Systems
- Regional Sea Level Change & Coastal Impacts (with CliC)

CLIVAR is leading reviews of ocean observing systems for the Indian and Atlantic oceans.

### **7.1.2 Scientific Committee on Antarctic Research (SCAR)**

SCOR cooperation with SCAR is particularly in relation to the Southern Ocean Observing System, but SCAR conducts several other activities that may interest SCOR..

### **7.1.3 Future Earth**

PowerPoint slides were presented remotely by Erik Pihl, the liaison to SCOR from Future Earth. SCOR has been working with Future Earth in 2017 to help develop an Ocean Knowledge-Action Network (O-KAN), in cooperation with the IMBeR and SOLAS projects. The KANs are collaborative frameworks designed to facilitate highly integrative sustainability research to generate knowledge required to make possible solutions for complex societal issues. The work of KANs is co-designed and co-produced with the people who will use the results of the research, so that their results can be applied immediately. The O-KAN is co-organized by Future Earth, SCOR, WCRP, and IOC. SDG 14 of the UN's Agenda 2030 ("Life Below Water") is one source of ideas for the O-KAN. A workshop was held in December 2016 in Kiel, Germany to develop other ideas. The workshop included 100 participants from 27 countries (see report at <http://www.futureearth.org/future-earth-ocean>). Another purpose for this workshop was to help prepare for a Belmont Forum scoping workshop on "Transdisciplinary Research for Ocean Sustainability" in May 2017. Four major work streams were proposed to the Belmont Forum:

1. Resource & Service Use: Pathways toward the sustainable and equitable use of oceans
2. Global Change: Accounting for and minimizing the impacts of global change
3. Pollution: Exploring and minimizing the impact of pollution on ocean health
4. Risk: Predicting, mitigating, and responding to ocean disasters to reduce risk

Since the Belmont Forum scoping workshop, an O-KAN Development Team (researchers and stakeholders) was formed, the O-KAN was launched at the UN Ocean Conference in June 2017, and plans are developing for a Town Hall at the 2018 AGU Ocean Sciences meeting. Pihl finished by mentioning the Program for Early Stage Grants Advancing Sustainability Science (PEGASuS), a Future Earth grants program. There will be a call for proposals on Ocean Sustainability in 2018.

## **7.2 Affiliated Organizations**

### **7.2.1 International Association for Biological Oceanography (IABO)**

Patricia Miloslavich reported on IABO, which is a constituent section of the International Union of Biological Sciences (IUBS). IABO has continued its work to coordinate the field of marine biodiversity research internationally, particularly through the series of World Conferences on Marine Biodiversity.

The 4<sup>th</sup> World Conference on Marine Biodiversity (WCBM) will be held in Montreal, Canada on 13-16 May 2018 (see <http://www.wcmb2018.org>). The conference will feature more than 40 sessions within 10 different themes. The next IABO General Assembly will be held in conjunction with the WCMB.

IABO has established an international award, in recognition of Carlo Heip's leadership in marine biodiversity research and founding of the World Conference on Marine Biodiversity, the Carlo Heip International Award for outstanding accomplishments in marine biodiversity science. The award will recognize an individual who has demonstrated exemplary leadership in marine

biodiversity science. IABO invited SCOR members to encourage their scientists to nominate people for this new award.

MARINE-B: the MARine Research Information NETwork on Biodiversity is the official IABO email network, with about 1,000 subscribers. It is used for communication related to marine biology and biodiversity research. Miloslavich welcomed SCOR Working Groups and associated organizations to subscribe and send out news of new positions available, meetings, publications and questions to subscribers of MARINE-B. To join, send the message "SUBSCRIBE MARINE-B firstname surname" to [listserv@listserv.heanet.ie](mailto:listserv@listserv.heanet.ie).

Miloslavich staffs the Biology and Ecosystems Panel of the Global Ocean Observing System and presented an update of the Panel's work, which is related to IABO. The Panel has been working on defining Essential Ocean Variables (EOVs) related to biology and ecology. Each EOVS specification sheet is being validated by the scientific community and by policymakers (e.g., related to the Convention on Biological Diversity), and is being coordinated with Essential Climate Variables of the Global Climate Observing System. Following validation will be an integration step, across networks and across disciplines, and standardization of methods and data collection. Implementation will be globally coordinated, with global coverage. The data will be intercomparable and openly accessible to support international reporting needs. Capacity development and funding will be needed.

### **7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS)**

John Turner, President of the International Association for Meteorology and Atmospheric Sciences (IAMAS), provided an update about the work of IAMAS. IAMAS is one of 8 associations of the International Union of Geodesy and Geophysics (IUGG), which is part of the International Council for Science. IAMAS has national members in 70 countries.

The international Commission on Atmospheric Chemistry and Global Pollution (iCACGP) of IAMAS co-sponsors SOLAS. iCACGP is one of 10 IAMAS commissions that form the core of IAMAS activities. iCACGP will hold its 14<sup>th</sup> Quadrennial Symposium in Japan in 2018.

The IAMAS Bureau and Executive have been heavily involved in the planning of the joint IAPSO-IAMAS-IAGA assembly, which was held in Cape Town, South Africa on 27 August–1 September 2017, just before the SCOR annual meeting. Just under 1,000 individuals participated in this assembly. An early-career scientist event attracted 40 individuals, which provided opportunities for early-career scientists to network with senior scientists and commission presidents. The IAMAS Early Career Scientist Medal was awarded to Corinna Hoose of the Karlsruhe Institute of Technology. IAMAS will next meet at the IUGG General Assembly in Montreal in July 2019.

Turner reported that SCOR was mentioned in an editorial he co-authored in *Nature*: <http://www.nature.com/news/solve-antarctica-s-sea-ice-puzzle-1.22317>.

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

Denise Smythe-Wright, President of the International Association for the Physical Sciences of the Oceans (IAPSO), presented an update on the organization's work. Like IAMAS, IAPSO is

one of IUGG's eight associations. The goal of IAPSO is "To promote the study of the oceans and the interactions that take places at its boundaries with the sea floor, coastal environment and atmosphere, through the use of physics, chemistry, mathematics and biogeochemistry." IAPSO works mainly through biennial scientific assemblies, working groups, committees, commissions, services and information provided through its Web site. Special importance is given to involving scientists and students from developing countries in oceanographic activities. IAPSO assemblies are organized every two years, either as part of IUGG General Assemblies or in meetings convened jointly with other IUGG associations. The IAPSO-IAMAS-IAGA assembly in Cape Town featured 7 IAPSO-only symposia and 8 interdisciplinary symposia, and about 250 of the participants registered from the IAPSO community. The next IAPSO event will be at the IUGG General Assembly in Montreal in 2019.

The IAPSO Executive Committee reviews SCOR working group proposals each year and IAPSO occasionally contributes between \$5-10K to a SCOR working group that aligns with IAPSO goals. 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. IAPSO now has formal links with the IIOE-2 community and there was a large joint session at the IAPSO-IAMAS-IAGA Assembly.

The winner of the 2017 IAPSO Prince Albert I Medal was Lynne Talley (USA) "For her seminal contributions to our understanding of all ocean basins, including landmark discoveries in the Pacific, Atlantic and Southern Oceans". The winner of the 2017 Eugene LaFond Medal (for a developing country scientist) was Jonathan Durgadoo (Mauritius) for his oral presentation on "Indian Ocean sources of Agulhas leakage".

Smythe-Wright mentioned the work of SCOR and IAPSO on a document for the G7 Science Ministers.<sup>8</sup>

IAPSO Committees, Commissions, and Services include the following:

- Joint (SCOR/IAPSO/IAPWS) Committee on the Properties of Seawater
- Commission on Mean Sea Level and Tides (CMSLT)
- Tsunami Commission (Joint with IASPEI and IVACEI)
- Permanent Service for Mean Sea Level
- IAPSO Standard Seawater Service

Peter Burkill asked whether IAPSO has concerns about ICSU moving towards social sciences. Smythe-Wright responded that IAPSO realizes that they have to address this issue and will discuss it during next meeting. IAPSO actions will depend, in part, on how the ICSU-ISSC merger develops.

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<sup>8</sup>Future of the Ocean and its Seas: a non-governmental scientific perspective on seven marine research issues of G7 interest (see [http://www.iugg.org/policy/Report\\_FutureOcean\\_G7\\_2016.pdf](http://www.iugg.org/policy/Report_FutureOcean_G7_2016.pdf)).



## 7.3 Affiliated Programs

### 7.3.1 InterRidge - International, Interdisciplinary Ridge Studies

Jérôme Dymont, one of the InterRidge co-chairs, provided an update about the project. InterRidge has been a long-time affiliated program of SCOR, and the two organizations are co-sponsoring WG 135 on Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles.

InterRidge promotes interdisciplinary, international studies of oceanic spreading centers by creating a global research community, planning and coordinating new science programs that no single nation can achieve alone, exchanging scientific information, and sharing new technologies and facilities. InterRidge has two roles. The first focuses on science, such as identifying scientific priorities and the means to address these priorities, providing a forum for the exchange of information, and building capacity for InterRidge-related science. The second role is to serve as a voice for the international community of ridge scientists to communicate with the broader scientific community, the public, and policymakers. InterRidge is an observer to the International Seabed Authority (ISA).

InterRidge has three levels of membership (principal, regular, and corresponding), depending on the level of financial contributions made to support the project.

The InterRidge Office moved from China to France in 2016 and was not fully operational, with a new Coordinator, until April 2017. Scientific activities of InterRidge are guided by the InterRidge Third Decadal Plan 2014-23. InterRidge forms working groups to develop reports and plans for scientific work. They usually interact with the interested community by organizing InterRidge Workshops. SCOR-InterRidge WG 135 on Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles falls within this category. InterRidge issues a call for new working groups in April each year, with a deadline in June, open to the international community.

A variety of information of interest to the international ridge science community is available through InterRidge:

- The InterRidge Vent Database is a portal to other databases of interest for ridge scientists (see <https://vents-data.interridge.org/>). It is maintained with funding from the U.S. National Science Foundation and contains 689 records and a mapping function.
- The InterRidge Web site (<http://www.interridge.org/>), *InterRidge Info* (biweekly e-mail), annual *InterRidge News*, and workshop and Working Group reports are disseminated within the community.
- Cruise information is provided to promote the exchange of information, technologies and facilities among international research groups (<http://www.interridge.org/cruise>).
- InterRidge has created a Code of Conduct for responsible research at hydrothermal vents (see <http://www.interridge.org/node/16908>).



InterRidge conducts capacity building through several approaches:

- InterRidge Fellowships promote the involvement of young scientists in international, collaborative, and interdisciplinary studies of oceanic spreading centers. Two fellowships of up to US\$5,000 were awarded in 2017.
- InterRidge Cruise Bursaries are awards for travel and subsistence costs to encourage new collaborations across the InterRidge member nations and to enable early-career scientists to participate in mid-ocean ridge research cruises. The cruise bursaries are provide up to US\$2,000 each and two were awarded in 2017.
- Support is provided for early-career scientists to participate in ridge-related meetings, for example, the 6<sup>th</sup> International Symposium on Chemosynthesis-Based Ecosystems (CBE6 in Woods Hole, Massachusetts, USA). In this case the support took the form of Travel Awards offered to young scientists to attend the meeting (11 students and 3 post-docs from 8 countries).

Dyment expressed an interest for InterRidge and SCOR to continue to develop links through, for example, the IIOE-2.

### **7.3.2 International Ocean Colour Coordinating Group (IOCCG)**

Stuart Bernard, the former chair of IOCCG, presented a presentation prepared by Venetia Stuart, the IOCCG Project Coordinator. IOCCG became an Affiliated Program of SCOR in 1997. SCOR provides financial management of NASA funds for IOCCG and enables IOCCG to submit funding proposals to NASA via SCOR. The IOCCG Committee membership includes 12 space agency representatives and 14 research scientists.

IOCCG's mandate includes the following:

- To provide a common voice for the ocean color user community. One means of achieving this goal is through the International Ocean Colour Science (IOCS) meetings, of which three have been held so far. The next IOCS meeting is planned for May/June 2019 in Busan, South Korea.
- To advocate the importance of ocean-color data. This goal is primarily accomplished through IOCCG's working groups. IOCCG currently has working groups on the following topics: Harmful Algal Blooms (with GEOHAB); Earth Observations in Support of Global Water Quality Monitoring; Uncertainties in Ocean Colour Remote Sensing; Role of Ocean Colour in Biogeochemical, Ecosystem and Climate Modelling; Atmospheric Correction Algorithms over Optically-Complex Waters; and Long Term Vicarious Adjustment of Ocean Colour Sensors.
- To communicate to the ocean color community worldwide. The goal is accomplished through the IOCCG Report series (see <http://ioccg.org/what-we-do/ioccg-publications/ioccg-reports/>), news bulletins, and the IOCCG Web site ([www.ioccg.org](http://www.ioccg.org))
- To foster expertise in using ocean-color data. This goal is accomplished through introductory and advanced training courses, including three successful IOCCG Summer Lecture Series. SCOR has contributed financial support for developing country scientists to participate in these events.

- To ensure continuity and quality of the ocean-color data stream. This goal is accomplished through IOCCG's interactions with space agencies, and participation in the Committee on Earth-Observing Satellites Ocean Colour Radiometry Virtual Constellation effort.

### **7.3.3 Global Alliance of CPR Surveys (GACS)**

Peter Burkill, SCOR Executive Committee Reporter for the Global Alliance of Continuous Plankton Recorder Surveys (GACS), presented slides prepared by the GACS chair, Sonia Batten.

Continuous Plankton Recorder (CPR) surveys are taken from or by Angola, Australia, Brazil, Canada, China, Cyprus, Japan, India, Namibia, New Zealand, South Africa, and the United Kingdom. The surveys are designed to collect samples at 10 nautical mile-resolution along repeated transects at monthly intervals. The surveys are able to monitor biodiversity in terms of phyto- and zooplankton species, as well as the presence of plastics and pathogens (e.g., *Vibrio*).

GACS continues work toward fulfilling its goals of providing a global network of CPR surveys and has achieved some success in helping establish new CPR surveys and providing training for people responsible for these new surveys. The latest Global Status report was released in June 2016, available electronically at <https://www.sahfos.ac.uk/publications/scientific-reports/ecostatus-reports/>.

Training (e.g., on larval fish identification and phytoplankton taxonomy) is an important part of GACS work, because it is important for surveys in different locations to be carried out in comparable ways. Training is carried out at the CPR Headquarters, the Sir Alister Hardy Foundation for Ocean Science, as well as other regions, such as in Tasmania.

CPR samples from the Northwest Pacific are being analyzed by micro X-ray computed tomography (CT) to quantitatively measure acidification impact on planktonic organisms. The Japanese CPR team started a feasibility study to apply this technique to measure variation in shell density of foraminifera collected by the CPR. After the feasibility is established within the GACS framework, it could become a global standard method to monitor ocean acidification impacts on marine ecosystems.

Denise Smythe-Wright stated that it would be good to see the workings of the CPR during the 2018 SCOR meeting in Plymouth, UK. Burkill replied that he would discuss this with the meeting organizers.

## **7.4 Other Organizations**

### **7.4.1 Partnership for Observation of the Global Oceans (POGO)**

Sergey Shapovalov, the liaison between SCOR and POGO, reported that the two organizations have many areas of mutual interest and have a good history of cooperation over the 17 years of POGO's existence. The two organizations have co-sponsored a fellowship program for ocean observations since 2001 and worked together to develop the International Quiet Ocean Experiment (see item 3.4). SCOR and POGO also work together in relation to global capacity

building for ocean science, and their executive directors are currently working together on publications related to the organizations' capacity-building activities.

## **8.0 ORGANIZATION AND FINANCE**

### **8.1 Membership**

#### **8.1.1 National Committees**

The following changes in national SCOR committees were noted since the 2016 Annual SCOR Meeting:

- CANADA: David Greenberg replaced Bjorn Sundby as a Nominated Member
- POLAND: Czesław Druet, Piotr Szefer, and Jan M. Wesławski were replaced by Janusz Pempkowiak, Waldemar Surosz, and Waldemar Walczowski as Nominated Members
- UNITED KINGDOM: Alessandro Tagliabue was added as a Nominated Member

### **8.2 Publications Arising from SCOR Activities**

Ed Urban reported that the following publications resulted from SCOR-sponsored working groups since the 2016 General Meeting. Each project maintains lists of their publications on their Web sites, so their publications are not listed here.

- Bullister, J.L., D.P. Wisegarver, and S.T. Wilson. 2017. The Production of Methane and Nitrous Oxide Gas Standards for Scientific Committee on Ocean. [http://www.scor-int.org/Publications/SCOR\\_WG\\_143\\_Technical\\_Report.pdf](http://www.scor-int.org/Publications/SCOR_WG_143_Technical_Report.pdf) - WG 143
- Culverhouse P.F., R. Williams, C. Gallienne, J. Tilbury, and D. Wall-Palme. 2016. Ocean-Scale Monitoring of Mesozooplankton on Atlantic Meridional Transect 21. *Journal of Marine Biology and Aquaculture* 2(1):1-13. – WG 130
- Giering, S.L.C. 2017. Optical Sensors Can Shed Light on Particle Dynamics in the Ocean. *Eos* 98, <https://doi.org/10.1029/2017EO072123>. Published on 2 May 2017. – WG 150
- Turner, D.R., E.P. Achterberg, C.-T.A. Chen, S.L. Clegg, V. Hatje, M.T. Maldonado, S.G. Sander, C.M.G. van den Berg, and M. Wells. 2016. Toward a Quality-Controlled and Accessible Pitzer Model for Seawater and Related Systems. *Frontiers in Marine Science* 3, Article 139 – WG 145
- Wurl, O., W. Ekau, W.M. Landing, and C.J. Zappa. 2017. Sea surface microlayer in a changing ocean – A perspective. *Elementa: Science of the Anthropocene* 2017;5:31. DOI: <http://doi.org/10.1525/elementa.228>. – WG 141

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

### **8.3 Finances**

The SCOR Executive Committee approved a Finance Committee consisting of Annalisa Griffa (Italy), Jorma Kuparinen (Finland), Sinjae Yoo (Korea), and Jing Zhang (Japan). This committee conducted its work during the SCOR meeting and reported on (1) the 2016 Audit report, (2) recommendations related for revisions to the 2017 SCOR budget, (3) recommendations for the 2018 SCOR budget, and (4) recommendations for dues levels in 2019. The following issues were presented:

- Final financial report for 2016: Total discretionary income from dues and grants was about \$506,000. Total discretionary scientific expenses were about \$177,000, of which working group expenses accounted for about \$111,000. Administrative expenses (salaries, benefits, secretariat costs, annual meeting) were about \$323,000. The increase in the year-end cash balance was about \$6,000, and maintained the cash balance above the required level of \$100,000. The final 2016 report tied in with the annual audit. The Finance Committee recommended approval of the 2016 report and it was approved.
- The Finance Committee reviewed the auditor's report of 2016 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, with no special remarks in the Audit to consider, so the Finance Committee recommended acceptance of the 2016 Audit report. It was accepted by meeting participants.
- The revised 2017 budget was examined. The revised income decreased from the budgeted amount of about \$465,000 to suggested revised amount of \$408,000, due to less use of grant income than was budgeted and less recovery of indirect costs. Membership dues are on pace to reach the budget level by the end of the year. Working group expenses and other expenses from scientific activities were lower than budgeted, resulting in a decrease of about \$95,000 in budgeted expenses. Taking into account the greater decrease in expenses than the decrease in income, the revised budget would increase the cash balance at the end of the year by about \$40,000. The Finance Committee recommended that the revised 2017 budget be accepted and meeting participants accepted it.
- The proposed 2018 budget includes about \$459,000 in discretionary income and \$597,000 in discretionary expenses, leaving about \$109,000 in the cash balance at the end of 2018, which is above the \$100,000 minimum. This budget assumes that the 12 working groups that will meet will use their entire budgets, including three new working groups starting in 2018. The Finance Committee recommended that the proposed 2018 budget be approved and meeting participants approved it.
- The Finance Committee recommended that the dues be increased by the usual amount (3%) in 2019 and this recommendation was approved by meeting participants.

## **9.0 SCOR-RELATED MEETINGS**

### **9.1 SCOR Annual Meetings**

#### **9.1.1 2017 Meeting**

Marie-Alexandrine Sicre thanked the South African SCOR Committee for hosting the meeting, arranging a wonderful meeting dinner, and providing an afternoon session about the marine science being conducted in South Africa, particularly by early-career scientists. Ed Urban presented a gift to Isabelle Ansorge, chair of the South African SCOR Committee.

#### **9.1.2 2018 Meeting: Plymouth, UK**

Peter Burkill gave a preview of the 2018 SCOR Annual Meeting in Plymouth, UK. The meeting will be hosted by the University of Plymouth, but there will also be opportunities to visit other marine science institutions in the city and to hear about their work. Plymouth can be reached by train, ferry from France, and air (via Exeter). The SCOR meeting will be held at the University of Plymouth Marine Station, which is an easy walk from nearby hotels, the National Marine Aquarium, and many restaurants in the historic section of Plymouth.

#### **9.1.3 2019 Meeting: Toyama, Japan**

Jing Zhang gave a presentation about ideas for the 2019 SCOR Annual Meeting in Toyama, Japan. The Japanese SCOR Committee is proposing to hold the SCOR meeting in conjunction with the annual meeting of the Oceanographic Society of Japan (JOS), as was the arrangement for the 2002 SCOR Annual Meeting in Sapporo. It is proposed to hold the meeting in September 2019, at the Toyama International Conference Center, with a joint session of SCOR and JOS held at the University of Toyama. Toyama has good air connections and a high-speed train line from Tokyo. The Japanese SCOR Committee is raising local support for the meeting.

## Appendix 1

### 43<sup>rd</sup> SCOR EXECUTIVE COMMITTEE MEETING

Cape Town, South Africa

4-6 September 2017

#### LIST OF PARTICIPANTS

(as of 1 August 2017)

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**NM = Nominated Member**



## Appendix 2

### Agenda

#### **43<sup>rd</sup> SCOR EXECUTIVE COMMITTEE MEETING**

Cape Town, South Africa

4-6 September 2017

#### **AGENDA**

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##### **1.0 OPENING**

- |   |                              |
|---|------------------------------|
| 1.1 Opening Remarks and Administrative Arrangements   | <i>Ansorge, Sicre, Urban</i> |
| 1.2 Approval of the Agenda                            | <i>Sicre</i>                 |
| 1.3 Report of the President of SCOR                   | <i>Sicre</i>                 |
| 1.4 Report of SCOR Executive Director                 | <i>Urban</i>                 |
| 1.5 Appointment of an <i>ad hoc</i> Finance Committee | <i>Sicre</i>                 |
| 1.6 2018 Elections for SCOR Officers                  | <i>Burkill</i>               |

##### **2.0 WORKING GROUPS**

- |   |                               |
|---|-------------------------------|
| 2.1 Current Working Groups  |                               |
| 2.1.1 SCOR/InterRidge WG 135 on Hydrothermal energy transfer and its impact on the ocean carbon cycles  | <i>Smythe-Wright</i>          |
| 2.1.2 SCOR/IGBP WG 138: Modern Planktic Foraminifera and Ocean Changes  | <i>Brussaard</i>              |
| 2.1.3 WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean   | <i>Devey</i>                  |
| 2.1.4 WG 141 on Sea-Surface Microlayers   | <i>Burkill</i>                |
| 2.1.5 WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders  | <i>Burkill</i>                |
| 2.1.6 WG 143 on Dissolved N <sub>2</sub> O and CH <sub>4</sub> measurements: Working towards a global network of ocean time series measurements of N <sub>2</sub> O and CH <sub>4</sub> | <i>Turner</i>                 |
| 2.1.7 WG 144 on Microbial Community Responses to Ocean Deoxygenation  | <i>Miloslavich</i>            |
| 2.1.8 WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)  | <i>Sicre</i>                  |
| 2.1.9 WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5)  | <i>Smythe-Wright</i>          |
| 2.1.10 WG 147: Towards comparability of global oceanic nutrient data (COMPONUT)   | <i>Roman, Sicre</i>           |
| 2.1.11 WG 148 on International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)   | <i>Hutchinson, Shapovalov</i> |
| 2.1.12 WG 149 on Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?  | <i>Miloslavich</i>            |
| 2.1.13 WG 150 on Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT)   | <i>Burkill</i>                |
| 2.1.14 WG 151: Iron Model Intercomparison Project (FeMIP)   | <i>Devey</i>                  |
| 2.1.15 WG 152 on Measuring Essential Climate Variables in Sea Ice (ECV-Ice)   | <i>Turner</i>                 |

- 2.2 Working Group Proposals
  - 2.2.1 Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs (P-OBS) *Burkill*
  - 2.2.2 Eastern boundary upwelling systems (EBUS): diversity, coupled dynamics and sensitivity to climate change *Shapovalov*
  - 2.2.3 International Network for the Study of How Organisms Respond to Environmental change (INSHORE) *Miloslavich*
  - 2.2.4 Expanding Regional Application of Dynamic Ocean Management (ERADOM) *Devey*
  - 2.2.5 Floating Litter and its Oceanic Transport Analysis and Modelling (FLOTSAM) *Halpern*

### 3.0 LARGE-SCALE SCIENTIFIC PROGRAMS

- 3.1 SCOR/Future Earth Integrated Marine Biosphere Research *Burkill*
- 3.2 GEOTRACES *Devey*
- 3.3 Surface Ocean – Lower Atmosphere Study (SOLAS) *Garçon, 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 *Telszewski, Halpern*
- 4.2 SCAR/SCOR Southern Ocean Observing System (SOOS) *Swart, Miloslavich*
- 4.3 IAPWS/SCOR/IAPSO Joint Committee on Seawater (JCS) *Smythe-Wright*
- 4.4 GlobalHAB *Urban, 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*
- 5.5 Research Camps at the University of Namibia *Urban*

## 6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

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

## 7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

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

## 8.0 ORGANIZATION AND FINANCE

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

## 9.0 SCOR-RELATED MEETINGS

- |       |   |                |
|-------|---|----------------|
| 9.1   | SCOR Annual Meetings  |                |
| 9.1.1 | 2017 Executive Committee Meeting  | <i>Sicre</i>   |
| 9.1.2 | 2018 General Meeting: Plymouth, UK  | <i>Burkill</i> |
| 9.1.3 | 2019 Executive Committee Meeting: Toyama, Japan                                     | <i>Zhang</i>   |
| 9.2   | Locations of Past SCOR Annual Meetings  |                |
| 9.3   | SCOR-Related Meetings Since the 2016 SCOR Annual Meeting and Planned for the Future |                |

## Appendix 3

### Proposal for a Working Group on Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs (P-OBS)

#### 1. Summary/Abstract

Measurements to characterize life in the ocean—including its composition, abundance, and changes in distribution—are fundamental to our understanding of marine ecosystems. The abundance of many fish species, sea birds, and marine mammals is critically tied to fluctuations in the abundance of smaller planktonic organisms. Similarly, plankton mediate the cycles of many chemical elements in the ocean that are critical for life, including oxygen, nitrogen, phosphorus, carbon, and many others.

The primary goal of this proposed SCOR Working Group (WG) is to identify measurements that can expand the number of observations of biological stocks, diversity, and rates or fluxes of planktonic organisms. The objective is to identify methods and technologies that can be incorporated into large-scale sampling programs such as GO-SHIP and OceanSITES as well as other similar programs from around the world. Emphasis of the WG would be on methods and technologies that can be implemented in the *short term* without disruption to established observing programs, and identifying gaps and opportunities that can significantly increase the number of routine and sustained observations of life in the ocean in the longer term. A document produced by this WG will identify the rationale for each measurement, associated costs and human investment (e.g., technical expertise and time needed), and data collection, quality control (QC), and data archival protocols.

#### 2. Scientific Background and Rationale

##### 2.1 **Why do we need sustained biological observations?**

Oceanic plankton, the base of the marine food web, are extremely under-sampled. Their diversity, abundance, and variability are largely unknown at high spatial and temporal resolution. There is a need to establish a baseline of distribution and phenology (change in seasonal timing) in different regions of the ocean. As of today, there is still no clear consensus regarding the processes responsible for phytoplankton and zooplankton phenology. There are incompatible top-down and bottom-up arguments brought to describe the same phenomena (e.g., the North Atlantic spring bloom, or changes in the abundance and make-up of phytoplankton and zooplankton in any region).

Higher-resolution information on changes in phytoplankton and zooplankton is fundamental to constrain ecosystem and biogeochemical models. These models are used to forecast the success and recruitment of organisms such as fish, the efficiency of food webs in cycling elements and transferring energy from one trophic level to another, and understanding and forecasting of water quality and other changes that affect rates and composition of biological stocks. These models require proper parameterization of plankton and their functions at appropriate temporal and spatial resolution, and are important because they help develop fundamental understanding about life in the ocean and its biogeochemical consequences. Models are the only way to evaluate large-scale processes such as the potential expansion of hypoxic areas in the ocean, the modulation of air-ocean exchange of gases (e.g., oxygen, carbon dioxide), and the amount of organic matter that may be sinking to the bottom of the ocean, where food for deep ocean life is otherwise limited. Models are also a powerful tool to predict the response of plankton to climate change, with possible feedbacks to the ecological and biogeochemical functioning of the ocean.

##### 2.2 Emerging technologies to maximize investments in ocean observing

Large investments have been made in long-term ocean measurement infrastructure (e.g., Global Ocean Observing System, GOOS). These include the development of long-term ecological monitoring stations, coordination for repeated observations on ship lines, sustained moorings, deployment of autonomous vehicles, and various other remote data-collection technologies, such as cabled observatories. Many of these are deployed over large geographical domains and are intended for long-term observations. Important developments in technologies to

measure physical and chemical parameters (e.g., salinity, temperature, oxygen, pH, currents) have meant that these parameters tend to make up the majority of the observations collected from automated platforms today. Adding the capability to measure biological parameters (e.g., stock, diversity, rates and fluxes) to these existing platforms and programs would fill critical gaps in our knowledge of ecosystem function. Linking such multidisciplinary measurements to ocean color radiometry, other remote sensing technologies, and other global observing systems (e.g., BGC- Argo, CPR surveys) will assist in better characterizing and explaining synoptic changes of life in the ocean. Developments in biological and bio-optical sensors, including genetic analyses, automated microscopy and flow cytometry, provide a pathway for the development and implementation of biological observations as part of global and regional ocean observing systems.

### **2.3 Benefits:**

SCOR can foster progress in a number of areas by convening a Working Group focused on developing a strategy for automated, sustained, and widespread plankton observations.

Specifically:

Science: increased biological data are critical to quantify variability of known plankton in space and time, discover and quantify new life forms, constrain models, and better characterize processes leading to ecosystem changes.

Society: data on plankton are critical to quantify marine food webs, detect harmful algal/cyanobacterial blooms, and sustain ecosystem services such as fisheries and nutrient cycling.

Observing systems: increasing the value of these assets to science and society, including developing markets of technology and information transfer. The outcomes from our WG will benefit many other national and international programs (e.g. OOI, bioGEOTRACES) that have similar platforms and interest in sampling biological properties.

Conservation: Establishment of ecosystem-based approaches to marine resource management critically depends on sufficient data to quantify ecosystem members and functions.

Ultimately, developing the strategy to incorporate plankton observations into global observing systems, using well-described and robust protocols, facilitates the development of technology and incorporation of observations in a framework spanning from viruses to fish.

### **2.4 The challenge:**

We propose to develop sets of detailed recommendations to augment existing, large-scale sampling programs with feasible observations of phytoplankton and zooplankton. The recommendations will be prioritized based on science and information content. A strategy will be developed to prioritize the technology so that observations can be ramped up by the systematic incorporation into various Global Ocean Observing System elements. The assessment will include realistic costs and the requirement for capacity development.

The incorporation of biological measurements into regional ecosystem status and trend assessments is not trivial. Scientists, modelers, and resource managers are often not aware of the data available, methods of collection, or other limitations of biological measurements (Everett et al., 2017). Hence, it is critical that data disseminated follow standardized protocols for collection and quality control. Dissemination is incomplete without adequate metadata. Recommendations for the community also need to include suggestions for data repositories, descriptions of what the data represent, and examples of how such data have been used. These examples will help promote the collection of additional observations and will facilitate the application of ocean biology information in research, management, and sustainable development.

This SCOR WG would address the following goals:

1. Provide recommendations to GO-SHIP and OceanSITES regarding instrumentation and water-sample analysis that should be added to their protocols together with their scientific relevance and resource requirements (both in funds and people time). The recommendations would be broadly applicable to other national, regional, and global observing systems.
2. Deliver the appropriate protocol and provide appropriate points of contact for each recommended measurement.

3. Identify databases to curate the data and the associated requirements.
4. Identify synergies with other programs (e.g., BGC-Argo, spaced-based measurements, Continuous Plankton Recorder surveys) to provide complementary measurements and cross-validation.
5. Build capacity in the access to, and use of, biological oceanographic datasets

## 2.5 The Role of SCOR

SCOR is uniquely positioned to provide credibility, weight, and support to this international and diverse group of experts to trace a viable path to increased observations of life in the ocean.

## 3.1 Terms of reference

**General:** To identify best practices (technologies and sampling protocols) and technical feasibility to incorporate plankton measurements into global ocean observing platforms (initially GO-SHIP and for expansion into the mooring array of OceanSITES).

### *Specific:*

1. Identify current technologies (sensors as well as water sample analysis) that can be integrated into existing observing infrastructure to provide input and guide studies of plankton for marine ecosystem and biogeochemistry studies.
2. Provide the necessary details associated with every technology/measurement proposed (e.g., power, cost, and human effort).
3. Document potential applications, including science case studies and lists of publications, and document measurement protocols. Develop adequate protocols when these are not available.
4. Identify synergies with specific measurements done from other observing programs (e.g., BGC-Argo, space-based measurements, Continuous Plankton Recorder surveys) to provide cross-calibration and a better representation of the 4-D distribution of the parameter measured.
5. Identify technological limitations and/or gaps, and identify areas of priority investments to develop and implement the required observation technologies and tools for specific needs.
6. Increase awareness of the availability of biological oceanographic datasets internationally and identify barriers to their access and use, particularly in developing nations.

## 4.0 Work Plan

The group is planning to convene three times by meeting in conjunction with major ocean science conferences so that some Full Members will be able to self-fund their travel costs and to maximize the likelihood that Associate Members will attend.

**Month 1-6: Sep. 2017-Feb. 2018.** Focus on planning; Find champions to review existing measurements (Bio-optics, flow-cytometry, genetics, Bio-Acoustics, imaging, HPLC). Contact experts for input and references.

**Month 6:** Kick off meeting (in conjunction with the Ocean Sciences 2018). Draft an *Eos* article advertising the WG (Deliverable a). Work on chapters associated with above measurements.

**Month 6-14:** Setup of website with content. Submit *Eos* article. Prepare presentations for OceanObs'19 about adding plankton measurements to GO-SHIP. Work on chapters for manual, website content and identify gaps and people in the community able to contribute relevant expertise. Draft of manual to GO-SHIP.

**Month 14:** 2<sup>nd</sup> meeting (in conjunction with the OceanObs'19). Present draft of manual to GO-SHIP, ask community for feedback. Outline work on OceanSITES manual. Identify community members who could contribute their relevant expertise.

**Month 14-27:** Answer feedback by month 20 Final editing of manual for plankton measurements for GO-SHIP (Deliverable b). Identify gaps in OceanSITES manual.

**Month 27 or 32:** 3<sup>rd</sup> (final) meeting (in conjunction with Fall AGU or Ocean Sciences 2020 or spring EGU). Capacity-building workshop for early-career researchers (deliverable e). Final editing of OceanSITES manual (deliverable c) and website (deliverable d). Work on Report to SCOR office.

### **5.1 Deliverables**

- a. An *Eos*-type article after the first meeting reporting to the community about the activity and inviting input.
- b. A manual with the protocols for plankton measurements on board research vessels (initially GO-SHIP but expandable to Ships of Opportunities).
- c. A manual with the protocols for plankton measurements with research buoys (initially OceanSITES but expandable to other programs, including cabled observatories).
- d. A website where our findings will be disseminated. The website will include information on ALL the specifics outlined above.
- e. A workshop supporting capacity-building for early career researchers.
- f. Present progress at conferences associated with the meetings.

We will contact scientific societies and scientific agencies (e.g. IOC) to see if they will be willing to publish the reports we will produce (including assignment a doi), so that the reports' future use could be tracked.

### **6.0 Capacity Building**

The product of this working group will allow observing systems and programs throughout the world to identify measurements that can be added to their infrastructure. The deliverables will help the community understand the expanded scope of the science that the observations will support, the cost and effort associated with the measurements, databases where data could/should be submitted to, and experts available for consultation.

We plan a specific capacity-building workshop for early career researchers (ECRs) in conjunction with the Ocean Sciences meeting in 2020, particularly encouraging participation from developing nations. The workshop will support broader awareness of the availability of bio- oceanographic datasets, and identify specific communication and infrastructure gaps limiting their wider dissemination. We will approach SCOR requesting support for attendance by two ECRs from developing nations, from its grant for travel of developing country scientists. The WG will also ask SCOR to encourage its national committees (from developing and developed countries) to send their early-career scientists to the workshop. The workshop will be modeled on the ECR workshop held at the SCOR-sponsored Goa symposium in December 2015, which was assisted by one of the WG co-chairs (Anya Waite).

### **7.1 Working Group composition**

#### **7.2 Full members (responsible to produce the deliverables)**

<b>Name</b>	<b>Gender</b>	<b>Place of work</b>	<b>Expertise</b>
Emmanuel Boss (co- chair)	M	University of Maine, US	Optical oceanography and the use of optics to study ocean biogeochemistry and ecology, in-situ observing systems, BGC-Argo, Ocean Color, Sea-going.
Anya M. Waite (co- chair)	F	Alfred Wegener Institute, Germany	Ocean biogeochemistry; particle dynamics; marine food webs; biophysical coupling; mesoscale dynamics; Sea-going.

Silvia G. Acinas	F	Spanish National Research Council, Spain	Microbial ecology, flow cytometry, microbial genomics, Sea-going.
Ilana Berman-Frank	F	Bar-Ilan University, Israel	Phytoplankton photosynthesis and eco- physiology, aquatic microbial ecology, biological oceanography, marine N <sub>2</sub> fixation, in-situ flow cytometry, Anthropogenic impacts, Sea-going
Marcela Cornejo	F	Pontificia Universidad Católica de Valparaíso, Chile.	Biological rates and biogeochemistry, seagoing.
Katja Fennel	F	Dalhousie University, Canada	Coupled physical-biogeochemical and ecosystem modeling, Data assimilation.
Heidi M. Sosik	F	Woods Hole Oceanographic Institution	Phytoplankton ecology and photophysiology, automated flow cytometry, automated microscopic imaging, ocean color, biological oceanography, single cell to ecosystem. Sea-going.
Sandy Thomalla	F	Southern Ocean Carbon and Climate Observatory CSIR, South Africa	Biological carbon pump and primary productivity and their relation to physical and biogeochemical controls. Sea-going.
Julia Uitz	F	CNRS, Laboratoire d'Océanographie de Villefranche, France	Phytoplankton functional types, optics, HPLC, Ocean Color, BGC-Argo. Sea- going.
Hidekatsu Yamazaki	M	Tokyo University of Marine Science and Technology, Japan	Bio-Physical interaction, Optical measurements of plankton/aggregates, Microstructures. Sea-going.

### 7.3 Associate members

Name	Gender	Place of work	Expertise
Sonia Batten	F	SAHFOS, Canada	Plankton dynamics, Continuous Plankton Recorder, Ship of Opportunity plankton sampling, Global Alliance of CPR Surveys (GACS) Chair.
Jørgen Berge	M	UiT The Arctic University of Norway	Arctic marine biology, polar night, zooplankton, organisms associated with the Arctic sea ice, effects of climate change



Herve Claustre	M	CNRS, Laboratoire d'Océanographie de Villefranche, France	Phytoplankton ecology and pigments. Co-chair BGC- Argo. Sea going.
Gerald Gregory	M	CNRS, Institut Méditerranéen d'Océanographie (MIO), France	Plankton ecology, ion-microscopy, automated flow-cytometry.
Johannes Karstensen	M	GEOMAR   Helmholtz Centre for Ocean Research, Germany	Physical interaction with biogeochemical, biological and meteorological processes. Co-chair OceanSITES.
Frank Muller-Karger	M	University of South Florida, US	Phytoplankton dynamics, marine biodiversity, marine policy, public outreach, in- situ observing systems, ocean color, coastal and pelagic, Sea-going.
Anthony Richardson	M	CSIRO, Australia	Climate change ecology, plankton dynamics and ocean observations.
Bernadette Sloyan	F	CSIRO, Australia	Physical Oceanography, Climate, air-sea flux, GO-SHIP co-chair, in-situ observing systems, Sea-going.
Rik Wanninkhof	M	NOAA, Miami, USA	Chemical Oceanography, Climate, air-sea flux, GO-SHIP co-chair, in-situ observing systems, Sea-going.

## 7.4 Working Group contributions

Emmanuel Boss: 20 years of using commercial instrumentation on ships and fixed platforms. Physical-Biological interactions from micro-scale to basin scales.

Anya Waite is a biological oceanographer with extensive laboratory and field experience in integrating and interpreting large multidisciplinary datasets across arrays of biological and physical sensors, field sampling at a wide range of time and space scales as well as analytical experience in flow cytometry, image analysis, confocal and conventional microscopy.

Silvia Acinas is a microbial ecologist who is coordinator of the prokaryotic consortium of the Tara Oceans expedition and responsible also for microbial genomics analyses of the Malaspina 2010 global circumnavigation. Her team has been involved of deliver alternative approaches for exploring diversity and community structure of microbial communities and analyses of marine microbial metagenomics.

Ilana Berman-Frank has extensive experience on phytoplankton ecophysiology and specifically on marine N<sub>2</sub> fixation focusing for the past 15 years on the contribution of diazotrophs to production in the eastern Mediterranean Sea (EMS) and northern Red Sea. Has recently set up the first deep-moored station in the Levantine Basin (1500 m depth) to measure production and export and targeted as an ocean observatory platform to provide data for the ultraoligotrophic EMS.

Marcela Cornejo is a biogeochemical oceanographer with interest in carbon, nitrogen and phosphorus cycles in the surface and subsurface waters and the main physical and biological driving factors such as upwelling,

phytoplankton bloom, and the shallowing of the oxygen minimum zone. Her work is mainly focused in the upwelling regions and the mesoscale structures.

Katja Fennel has developed and applied numerical models of marine ecosystems and biogeochemistry for over two decades with particular focus on the cycling of nitrogen, carbon and oxygen. In addition, she has developed and applied methods for the assimilation of observations into models in order to improve their predictive capabilities.

Heidi Sosik is a plankton ecologist with extensive experience developing automated instrumentation, in particular submersible flow cytometry and imaging-in-flow cytometry; developing open-source analysis workflows and web-service based information systems to advance accessibility and use of the big data streams resulting from these technologies; serving as coastal ocean observatory science director; and promoting long-term ecological research in the oceans.

Sandy Thomalla is a biogeochemical oceanographer whose research focuses on using bio-optical approaches to parametrize the particle field (dominated by phytoplankton). The primary objective of her work is to develop and apply emerging techniques to derive optimized and regionally robust information from autonomous platforms and satellite ocean colour products in the Southern Ocean.

Julia Uitz is a biogeochemical oceanographer with strong interest in deriving information on phytoplankton diversity based on optical observations from a variety of research platforms such as vessels, profiling floats or ocean color satellites. Her research has mostly focused on the global open ocean and more recently on specific atypical regions (Mediterranean Sea, Southern Ocean).

Hidekatsu Yamazaki is a physical oceanographer. His research interests focus on examining the physical environment of phytoplankton and zooplankton. He is also investigating the relationship between turbulence and other phenomena (internal waves, ocean currents).

#### 8.0 Relationship to other international program and SCOR working groups

GO-SHIP & OceanSITES– We will provide recommendations to GO-SHIP and OceanSITES regarding instrumentation and water-sample analysis that should be added to their protocols together with their scientific relevance and resource requirements (both in funds and people time). Associate Members Sloyan and Wanninkhof are the co-chairs of GO-SHIP and Associate Member Karstensen is the co-chair of OceanSITES.

SOLAS – data to be collected would directly link atmospheric measurements done on research vessels and buoys to plankton-related parameters and rates, providing data to constrain processes at the interface of ocean and atmosphere (Boss is on SOLAS SSC).

IOCCG - data to be collected will provide validation for algorithms using space-based measurements. (Boss is on the IOCCG SSC).

BGC-Argo – Synergies with BGC-Argo are in providing a platform to deploy floats where relevant biogeochemical parameters are collected near to the deployment location to assess measurement accuracy (e.g., many SOCCOM floats have been deployed from GO-SHIP cruises and POC and HPLC pigments have been collected in conjunction as well as oxygen, nitrate, and carbonate chemistry). When float trajectory are in vicinity of cruise tracks or moorings, cross- calibration can be done to assess presence and magnitude of sensor drift. Proposed WG Associate Member Claustre is the co-chair of BGC-Argo.

Global Alliance of CPR Surveys (GACS) – Synergies with GACS are in relating our proposed plankton measurements to their past and present efforts in quantifying global plankton biomass and diversity and lesson learned in curation and dissemination of data. Associate member Batten is the chair of GACS.

SCOR WG 150, translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT) – Optical technologies that will be evaluated by this WG (optical sensors, automated microscopes, cameras) are the same TOMCAT is reviewing. Proposed WG Full Member Thomalla is also a member of WG 150.  
Appendix: 5 relevant publication by each Full Member

#### Boss:

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## Appendix 4

### Proposal for a Working Group on Eastern boundary upwelling systems (EBUS): diversity, coupled dynamics and sensitivity to climate change

#### Summary/Abstract

Eastern Boundary Upwelling Systems (EBUS) (California, Humboldt, Benguela and Canary Current System) are characterized by complex dynamical processes spanning a wide range of spatio-temporal variability due to the strong coupling between the ocean and atmosphere. They are among the most productive marine ecosystems in the world supporting some of the world's major fisheries, yet occupying only 0.1% of the global surface. Trade winds drive coastal upwelling, which brings cold and nutrient-rich waters to the surface, where favorable light conditions sustain high phytoplankton growth. Below the surface, Oxygen Minimum Zones develop due to high organic matter export. When these waters upwell, they release CO<sub>2</sub> and N<sub>2</sub>O, potent greenhouse gases, to the atmosphere. Locally, the mesoscale low-level atmospheric circulation is affected by air-sea-land interactions, which impact the upwelling and productivity, while remote forcing can modulate upwelling at timescales from intraseasonal (*e.g.* Kelvin waves) to interdecadal (*e.g.* gyre circulation) and longer. EBUS are natural laboratories for studying the breadth of interactive processes between land, ocean and atmosphere at the regional scale. This SCOR WG will focus on the integration of existing knowledge on EBUS to formulate a strategic recommendation white paper for setting up regional observational systems and climate modeling approaches to monitor and understand physical and biogeochemical ocean-atmosphere interactions. These observational systems will be instrumental in improving the performance and reliability of climate models in these socio-economically relevant regions of the world ocean. This WG will also review and critically evaluate the different "hard science" approaches that are pursued with respect to the socio-economic benefits they could bring.

#### Scientific Background and Rationale

The Eastern Boundary Upwelling Systems (EBUS) are the most productive areas of the world's oceans (Pauly and Christensen, 1995), supporting large populations of commercially important fish species (Bakun et al., 2015). In these regions the equatorward alongshore winds drive offshore Ekman transport of the surface layers of the ocean and, cold, nutrient-rich deeper waters outcrop to re-establish the geostrophic equilibrium in eastern boundaries, developing the so-called Coastal Upwelling Systems. These areas (California, Peru-Chile, Benguela and Canary Current, Sumatra-Java Systems) are characterized by equatorward alongshore boundary currents, poleward undercurrents, filaments, squirts, mesoscale eddies and internal waves, also driven, triggered and modulated by the local-to-regional wind field (*e.g.*, Chelton et al., 2007). These processes interact at different timescales influencing a wide variety of processes including marine fishery production (*e.g.*, Mbaye et al., 2015), phytoplankton cell size (*e.g.* Van der Lingen et al., 2009), plankton and fish community structure (*e.g.* Van der Lingen et al., 2006) and biogeochemical cycling (*e.g.* Woodson and Litvin, 2015). High biological productivity in the surface layer drives elevated rates of downward vertical flux of organic matter that in combination with sluggish circulation results in the development of the Oxygen Minimum Zones (OMZs). The four EBUS display varying levels of OMZ development from the shallow, anoxic Peru-Chile system to the deeper hypoxic California system (Chavez and Messié, 2009). Low-oxygen areas strongly influence the distribution of macroorganisms that are displaced by oxygen-poor conditions. Deoxygenation may also modify plankton regimes that can have profound consequences on ecosystem structure (*e.g.* Gomes et al., 2014). Extreme anoxic events can reduce habitat (for instance in Peru-Chile by creating a shallow habitat leading to increased catchability) or increase mortality (rock-lobster walkouts in the Benguela are well documented). Specific biogeochemical processes (denitrification, anammox, methanogenesis) which only occur at low oxygen concentrations influence global ocean nutrient cycles as well as production of greenhouse gases (*e.g.* Stramma et al., 2010). The impact of oceanic trace gases on atmospheric chemistry is also yet to be determined (*e.g.* Rees et al., 2011).

The basic forcing mechanisms are similar across the different EBUS and establish similarities in physical dynamics and ecosystem structure, and progress has been achieved in understanding the EBUS dynamics from an integrative and comparative perspective (*e.g.*, Pegliasco et al., 2015; Capet et al., 2014; Lachkar and Gruber, 2012; Gruber et al. 2011; Chavez and Messié, 2009; Capet et al., 2008; Carr and Kearns, 2003). However, owing to differences in the relative strength of the potential stressors (*e.g.* the strength of the equatorial oceanic teleconnection or subtropical pressure system), a unified view is yet to be established and challenges to understanding the sensitivity of individual

EBUS to climate variability and change remain (e.g. Wang et al., 2015; Bakun et al., 2015; Mackas et al., 2006). From a global climate perspective, some EBUS are also thought to influence large-scale climate modes. For instance, the EBUS in the Indian Ocean, the Sumatra-Java upwelling system, is relatively less studied, although it plays an important role in the development of the Indian Ocean Dipole (Saji et al., 1999). The difference in their latitudinal positions implies that some EBUS or EBUS sub-components are more wind-driven (those at high-latitudes) while others experience more tropical oceanic teleconnections, although the Benguela EBUS is also influenced by the Agulhas leakage. Therefore while commonalities in the nature of the forcing have suggested that a common theory of the circulation and its role on biogeochemical properties (e.g. OMZs) could be drawn, the characteristics of the forcing (amplitude, frequency, persistence, asymmetry) linked to inherent non-linearities of the systems call for a revision of this paradigm. In addition, progress in regional modeling has shed light on potentially important processes that were only inferred until recently (e.g. effect of the wind-drop off on upwelling dynamics (Capet et al., 2004; Renault et al., 2015, 2016); current-wind coupling (Chelton et al., 2007); eddy-induced transport (Bettencourt et al., 2015; Vergara et al., 2016; Gruber et al., 2011; Rossi et al., 2008) and that are, so far, difficult to tackle only with observations or from global models. The latter in particular still suffer persistent warm biases (Richter, 2015; Zuidema et al., 2016) that have limited our predictive capability of the EBUS evolution at various timescales (intraseasonal to climatic timescales) (Cabr   et al., 2015; Stramma et al., 2012). While most regional modeling studies have been process-oriented, some long-term regional hindcast simulations are becoming available (Dewitte et al., 2012; Franks et al., 2013; Combes et al., 2015) and regional model simulations with data assimilation are becoming available (Neveu et al., 2016). Although not yet including all relevant processes (e.g. air-sea coupling at the mesoscale) and mostly limited to the physical component of the system, they however allow the investigation of processes at low-frequency time scales and within a climate framework, overcoming some of the limitations of the observational studies and modeling studies based on low-resolution global models. So far the focus has been on the four major EBUS (California, Canary, Humboldt, Benguela). However it is also of interest to contrast the EBUS with the weak upwelling/less productive eastern boundary current systems such as the Iberian Current and Leeuwin Current systems, so as to better understand transient processes in the context of global warming.

The challenge for better understanding EBUS dynamics as a whole has spurred, in recent years, a number of joint efforts from an observational and modeling perspective, e.g., the international CLIVAR program VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land Study) was implemented to develop and promote scientific activities leading to an improved understanding of the South Eastern Pacific coupled ocean-atmosphere-land system on diurnal to interannual timescales (Mechoso et al., 2014). VOCALS also motivated research on the Benguela upwelling system (e.g. European projects MEECE and PREFACE). The transdisciplinary AMOP (*Activities of research dedicated to the Minimum of Oxygen in the eastern Pacific*) project was launched to investigate the mechanisms leading to the formation of the OMZ off Peru and its variability from hourly to centennial timescales. The German initiative SFB754 '*Climate-Biogeochemistry Interactions in the tropical Ocean*' addressed the relatively newly recognized threat of ocean deoxygenation, its possible impact on tropical OMZs and implications for the global climate biogeochemistry system. The recently initiated TPOS 2020 project (<http://tpos2020.org/>) aims at designing a future tropical Pacific observing system including monitoring the Eastern boundary and addressing coastal upwelling dynamics (Takahashi et al., 2014). A CLIVAR/SOLAS/IMBER Research Focus on upwelling systems has also been initiated recently that is aimed at making progress in our understanding of EBUS dynamics from physics to fisheries.

These observing programs along with recent progress in regional coupled modeling offer a new perspective for understanding EBUS and can revitalize the intercomparison approach. In particular, the perspective of long-term regional simulations (not just climatological) is an asset for addressing temporal and spatial scale interactions (upscaling, rectification processes) and their sensitivity to low-frequency changes in the environmental conditions, providing material for revisiting the interpretation of historical data. The on-going international effort for intensifying the ocean observing systems (e.g. Argo, IOCCP, SWOT mission, Sentinel missions) in order to address small spatial scales of variability also sets favorable conditions for documenting quantitatively the continuum of small scales (from mesoscale to submesoscale) and its impact on the ecosystem dynamics. In that sense the context is favorable for launching a working group on related issues. Its aims will be in particular to stimulate the interactions between the modelers and experts in observations interested in EBUS.

There are a number of regional processes in EBUS that modeling studies suggest to be key but that have been undocumented by observations (e.g. impacts of coastal mesoscale atmospheric jets, transports of water properties by eddies, deep zonal oceanic jets, air-sea interactions at mesoscales, etc). This calls first for more quantitative



evaluations of the role of such processes in EBUS dynamics from integrated modeling platforms, i.e., that take into account the complexity of feedbacks and scale interactions, and within a climate perspective, i.e., from long-term (multidecadal) simulations. Second, it motivates the design of dedicated observing programs in order to document these processes in nature and in return evaluate the realism of the coupled models. The socio-economic importance of EBUS (0.1% of global ocean area that sustains 20% of the world's fish catch) further urges the investigation of the role of these regional processes in the biogeochemistry of the OMZs. This is a prerequisite for improving our predictive capabilities of the evolution of marine ecosystems in these key economic regions and for anticipating changes in the nature of extreme events (e.g. hypoxia). This will require the design and implementation of efficient and cost effective observing systems, which are motivated by adequate scientific objectives. The activities that will be carried out within this proposed working group are thus also oriented towards providing guidance for the design of such observation systems based on modeling and process studies and synthesis of existing knowledge. It will build upon current initiatives both at national and international levels (e.g. TPOS2020, GOOS IMSOO (Implementation of Multi-Disciplinary Sustained Ocean Observations) panel on Oxygen Minimum Zones) while providing a synthetic view through looking at all upwelling systems.

The EBUS WG will address the knowledge gaps outlined above by making recommendations as to how better and more cost-effectively observe these regions in both the ocean and atmosphere simultaneously. It will first provide a comprehensive evaluation of current knowledge regarding control mechanisms, impacts on biogeochemical cycles and feedbacks derived from all published observational and modeling approaches, and will then develop a strategic recommendation white paper to fill these gaps. This WG will thus have material for conducting a socio-economic exercise to review and critically evaluate the different "hard science" approaches that are pursued with respect to the socio-economic benefits they could bring (at what scales, what level of complexity on the physics, what level of complexity on the ecosystem, what precise applications, what are the enduring challenges, inter alia). While the latter is not in the main scope of the WG, the objective is to take advantage of the rich networks of collaboration of the WG participants to identify relevant experts during the course of the project, and invite them to collaborate on a recommendation paper. As well this will be coordinated with relevant programs (CLIVAR RF on EBUS, GEF (Global Environment Facility), Future Earth Oceans KAN, etc).

To achieve these goals, a unique group of early career scientists and more senior scientists, all experts in different EBUS of the world ocean and involved in relevant national and international programs, has been invited to participate in this working group. This group is composed so as to cover issues of both observations and modeling, and gather scientists originating from a range of developed and developing countries and disciplines, which shall ensure communication of the outcomes to the wider research community, and alignment with national and global research platforms.

#### Terms of Reference

1. **Synthesize existing knowledge** on the different physical mechanisms occurring over different time scales (i.e., diurnal, intraseasonal, interannual, decadal, multidecadal) and their implications on water column properties, biogeochemical cycles, biodiversity/ecosystem structure and functioning and the regional climate, to identify the key feedback processes, establish similarities, differences and the knowledge gaps.
2. **Conduct a regional database initiative** to hold a web-based platform for graphically querying integrated information of observational systems (e.g. including data access, available timescale, papers published, associated databases) and numerical outputs (e.g. including configuration details as well as associated scientific production and responsible scientists together with their contact details) as well as protocols for measuring key properties and indicators in EBUS. Such a database will be used in particular to explore the processes that are difficult to tackle with just observational datasets (e.g. submesoscale processes and their role in structuring the biological environment)
3. **Produce a comparative analysis** from modeling validated/published results, presented as a **high impact factor review paper**. While such an analysis will have mostly a regional focus, it will also attempt to address subregional scales building upon past and on-going research programs on specific upwelling centers (e.g. Bay of Hann near Dakar (Senegal), Bay of Monterey (USA), Bay of Concepcion (Chile)), which will help linking to the socio-economic exercise (see Term of Reference 5).

4. **Provide a strategic recommendation brief** for setting up regional observational systems to monitor and understand physical and biogeochemical ocean-atmosphere interactions. These observational systems will be designed so as to be instrumental in improving the performance and reliability of climate models in these socio- economically relevant regions of the world ocean. Such a recommendation brief will also address needs for fostering interactions between the observational and modeling communities (e.g. coordinated experiments with common forcing; recommendations on resolution of specific processes or a specific scale, etc).
5. **Conduct a socio-economic exercise** to review and critically evaluate the different hard science approaches that are pursued with respect to the socio-economic benefits they could bring, that will provide useful information about scales, level of complexity on the physics and on the ecosystem, precise applications, among others. This document, prepared as a report (printed and online) for diverse target audiences including the scientific community, policy-makers and stakeholders, will present the basis on which to assess changes across EBUS and will be useful for governance activities.

#### Working plan

##### Year 1 (2018)

The first year will be focused on organizing the working group and assembling the information needed to achieve terms of references 1, 2 and 3. This will be discussed initially via email and coordinated at a **first meeting** where full and associate members will attend together with their PhD students, postdocs or early career scientists (at least one each). The meeting will be developed in two parts, the first where full and associate members will (1) agree on a clear plan of the strategies required to achieve the goals and (2) organize the structure of the **peer-reviewed publication** that will be submitted and published in an open-access journal at the end of the first year (Deliverable 1). The second part will be devoted to capacity building and activities in which early career scientists will be involved, and would look for to be linked with the IMBER early career Network of socio-ecologists and CLIVAR and SOLAS initiatives. The first meeting will be organized four months after the SCOR WG is implemented.

##### Year 2 (2019)

The second year will be dedicated to organizing the **regional database initiative** and **summer school**. This will be developed in a **second meeting/workshop** where full and associate members will attend together with some invited stakeholders from the scientific community and decision-makers. Following the second meeting, a **summer school** will be organized either in Senegal and/or Peru involving PhD students and early career scientists mostly from Africa and South America, having the objective to ‘Provide an overview of the main processes occurring in EBUS (including physical, biogeochemical, biological, fish and fisheries processes and trends), in order to understand ocean-atmosphere interactions, combining lectures and hands-on sessions, and practical lessons’ as well as ‘to identify potential students to integrate the capacity building strategy’ (i.e., create an early career network from alumni of the summer school). All experts and younger scientists will participate giving lectures and tutorials. The WG will request funding from SCOR and other sources to facilitate the participation of students and early-career scientists. Classes given during the summer school will be recorded and available from the SCOR WG EBUS webpage that will be provided and supported by the Computational Geophysical Fluid Dynamic Laboratory at IGP (Geophysical Institute of Peru).

The **regional database initiative** (Deliverable 2) will be developed in close collaboration with the early career scientists, with the aim to involve graduate students from different developing countries and disciplines (some of them identified in the summer school) to prepare a web based graphical platform where the compilation of regional observational systems and numerical simulations will be available for the scientific community and stakeholders. Also, it will serve as material for preparing and submitting a **high impact factor review paper** (Deliverable 3) compiling modeling results, addressing the comparison between EBUS, and establishing the strengths and weaknesses of regional coupled models, and directions for the future.

### Year 3 (2020)

The third year will be oriented towards organizing the **Open Science Conference** composed of three parts:

- *Day 1*: Objective ‘Organize the strategic recommendation brief to be presented as a short paper to the Executive Panel (i.e. defined as a representative group of decision makers, stakeholders and scientific experts from different areas)’, where only full and associated members will participate.
- *Days 2-3*: Objective ‘Bring together all interdisciplinary and multidisciplinary ocean and atmospheric science communities involving modelers and observationalists studying EBUS and related topics’.
- *Day 4*: Executive Panel. Objective ‘Bring together decision makers, stakeholders and the scientific community to present and highlight the main findings, suggest first priority topics, offer suitable and cost-effective alternatives to approach solutions to further understand EBUS dynamics’. It will be developed just after the Open Science Conference.

During this year a **strategic recommendation brief** (Deliverable 4) on how to best set up regional observational systems to monitor and understand physical and biogeochemical ocean-atmosphere interactions in the EBUS will be presented. Note that the Executive Panel discussion will feed the strategic recommendation brief.

### Year 4 (2021)

The fourth year will be focused on **preparing the report** of the socio-economic exercise (Deliverable 5) which will be developed in a meeting where full and associate members will attend, together with some invited stakeholders from the scientific community and decision-makers. In addition, the **final report** of the SCOR WG will be delivered.

### Deliverables

*Deliverable 1.* **A multidisciplinary synthesis peer-reviewed publication**, with the existing knowledge about the different physical and biogeochemical mechanisms developed over different time scales on EBUS as well establishing similarities and differences.

*Deliverable 2.* **A web-based platform**, where graphically the EBUS databases will be queried and useful information about measurements and protocols

*Deliverable 3.* **A high impact factor review paper** (e.g., Nature Geoscience), wherein a comparative analysis based on modeling results from both the ocean and atmosphere is presented

*Deliverable 4.* **A short recommendation paper for stakeholders and policy makers** where a strategic recommendation on how to more cost effectively design and improve regional observational systems with the overarching goal to improve the performance and reliability of global climate models.

*Deliverable 5.* **A report** where a socio-economic exercise for EBUS is conducted.

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

The WG is planning to hold an international summer school focused on PhD students and young post-docs mainly (but not exclusively) from Africa and South America and other developing countries. The objective will be to provide the young scientists with an integrative view of the land-atmosphere-ocean continuum in their modeling coupled physical/biogeochemical approach. The basics of atmospheric physics and chemistry and associated coupled and modeling platforms will be presented. An introduction to regional weather and climate systems off the EBUS will be given, as well as basic concepts in physical oceanography and biogeochemistry and hands-on practicals with the ROMS-BIOEBUS<sup>9</sup> modeling platform. Statistics applied to climatology and challenges of regional climate downscaling for performing regional climatic projections will be taught. We will try to explore a new, innovative capacity-building concept: the Network of Early Career Scientists (NECS). This will combine

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<sup>9</sup>This model is chosen for its relative versatility and simplicity, which is convenient for capacity building

traditional capacity- building of individual early career scientists with a new level of institutional networking. The ultimate goal is to build long lasting capacity through training and by interconnecting the next generation of scientists, and to develop enduring institutional interactions that will help address the scientific challenges facing the EBUS. We will also encourage and facilitate other training and professional development workshops and programs, such as those funded by the Marie Skłodowska Curie Innovative Training Network. Funding for sustaining our NECS will be sought from a range of sources and stakeholders supporting training and networking measures worldwide. We will collaborate with START, IAI, POGO and APN, so that their fellowship schemes and other mechanisms can be used for capacity development.

Several of the scientists involved in the consortium are dedicated to supervise students from southern countries, therefore this WG proposal will also serve as a platform for networking and increasing the critical mass of young researchers hence reinforcing capacity in oceanic sciences in these developing countries. The co-chair of the Working Group is a female early career scientist originating from a developing country, thus guaranteeing the attention given to capacity building and to gender equity.

Additionally, the web-based platform will be the key element to build a young multidisciplinary team from different disciplines and countries to work on EBUS to provide synthetic material for students and local researchers from the developing countries, as well as for decision-makers around the world. In this sense, since the database will provide comprehensive information including observational and numerical data as well as their respective owners and associated scientific production, students and local researchers would be in direct contact with the ocean science community reinforcing their capacity building in these topics and at the same time initiating and expanding their international collaborations.

#### [Working Group composition](#)

##### Full Members

Name	Gender	Place of work	Expertise relevant to proposal
1. Francisco Chavez (USA)	Male	Monterey Bay Aquarium Research Institute	Biological Oceanography/ California, Peru
2. Enrique Curchitser (USA)	Male	Rutgers University	Physical oceanography Modeling / CLIVAR
3. Boris Dewitte (France)	Male	IRD-LEGOS, CEAZA-Chile	Physical Oceanographer, EBUS Dynamics, Air-sea interactions, ENSO dynamics
4. Ruben Escribano (Chile) <b>Co-chair</b>	Male	Universidad de Concepción	Biological Oceanography, Chile/ IMBeR/CLIVAR
5. Sara Fawcett (South Africa)	Female	University of Cape Town	Biogeochemical Oceanographer
6. Salvador Lluch-Cota (Mexico)	Male	CIBNOR- CONACYT, México	Fishery/Socio-economist ecology
7. Baye Cheikh Mbaye (Senegal)	Male	University Cheikh Anta Diop of Dakar (UCAD), Senegal	Physical/biological Oceanography - Senegalese-Mauritanian coastal upwelling within the Canary upwelling system off North-West Africa
8. Ivonne Montes (Peru) <b>Co-chair</b>	Female	Instituto Geofísico del Perú (IGP)	Physical Oceanographer, biogeochemical coupled modeling and dynamics of the Peru/Chile System
9. Andreas Oschlies (Germany)	Male	Helmholtz-Zentrum für Ozeanforschung Kiel (GEOMAR) -78-	Physical Oceanography, Marine Biogeochemical Modeling
10. Parv Suntharalingam (UK)	Female	University of East Anglia (UEA)	Oceanographer, biogeochemical modeling/SOLAS

#### Associate Members

<b>Name</b>	<b>Gender</b>	<b>Place of work</b>	<b>Expertise relevant to proposal</b>
1. Edward Allison (USA)	Male	University of Washington	Interdisciplinary marine scientist focus on climate, social science and resource management
2. Javier Aristegui (Spain)	Male	University of Las Palmas de Gran Canaria (ULPGC)	Biological Oceanography/ Canary Current EBUE
3. Xavier Capet (France)	Male	CNRS-LOCEAN, Paris	Physical Oceanographer - modeler
4. Iris Kriest (Germany)	Female	Helmholtz-Zentrum für Ozeanforschung Kiel (GEOMAR)	Biogeochemical modeller
5. Eric Machu (France)	Male	IRD – LPAO-SF, ESP, Université Cheikh Anta Diop, Dakar Sénégal	Oceanographer, structuration of plankton communities from coupled approaches (observation & modeling)
6. Beatriz Yanicelli (Chile)	Female	Centro de Estudios Avanzados de Zonas Aridas (CEAZA)	Oceanographer, Chile Coastal Upwelling System
7. Damodar Shenoy (India)	Male	National Institute of Oceanography, Goa, India	Biogeochemistry/Bay of Bengal/Arabian Sea
8. Ryan Rykaczewski (USA)	Male	University of South Carolina	Biological Oceanography of EBUS – California System/CLIVAR
9. Lynne Shannon (South Africa)	Female	University of Cape Town	Fishery/Socio-economist ecosystem EBUE
10. Ming Feng (Australia)	Male	CSIRO Marine and Atmospheric Research	Physical oceanographer specialized in the Leeuwin Current dynamics

#### **Working Group contributions**

The full and associated members involved in this SCOR WG have been invited due to their field of expertise and past works, coming from various countries and disciplines; these are:

**Dr. Francisco Chavez** has published extensively on climate variability and EBUS, worked for many decades on the California and Humboldt EBUE, and has broad interests in oceanography, biogeochemistry, ecology, modeling, and new technology. He has led several synthesis efforts, edited multiple special issues and is active in national and international programs.

**Dr. Enrique Curchitser** is a physical oceanographer with interests in the dynamics of eastern boundary currents and shelf circulation and coupled bio-physical and numeric modeling. He is leading the CLIVAR Eastern Boundary Upwelling Research Focus that is trying to better understand the very large biases that climate models have in EBUS.

**Dr. Boris Dewitte** is a physical oceanographer involved in numerous projects dedicated to the study of Humboldt Current System; with wide experience on ENSO events and their impacts. He is currently a member of the CLIVAR



Scientific Steering Group and of the Task Team “Eastern Boundary” of the international program TPOS2020. He was an associate member of the SCOR group 128 on Natural and Human-Induced Hypoxia and Consequences for Coastal Areas (2006-2008).

**Dr. Ruben Escribano** is a biological oceanographer who specializes in zooplankton, was active in the GLOBEC program and is presently on the IMBeR Scientific Steering Committee, working extensively on the Humboldt.

**Dr. Sara Fawcett** is dedicated to understanding the complex relationships between biogeochemical fluxes (particularly nitrogen) and primary productivity in the ocean, with implications for past and future climate, ecosystem structure and function, ocean fertility, and global biogeochemical cycles.

**Dr. Salvador Lluch-Cota** has interests in climate variability and change and its effects on living marine resources; he was one of the six lead authors of the IPCC chapter on Ocean Systems. He has worked extensively in the California Current System particularly off Baja California, Mexico and has led synthesis efforts to uncover and better understand the variability of small pelagic fish in Atlantic and Pacific EBUS.

**Dr. Baye Cheikh Mbaye** is specializing in the Senegalese-Mauritanian coastal upwelling within the Canary upwelling system off North-West Africa. His main focus is to analyze how both physical and biological factors affect the survival of fish early life stage (eggs and larvae), and how this ecological understanding could help improve policies for marine conservation and fisheries management of eastern boundary upwelling systems; his approach integrates both modeling and observation (remote sensing).

**Dr. Ivonne Montes** is specialized on coupled physical-biogeochemical modeling applied to Eastern boundary current system (Guinea Gulf, Mexico and Peru/Chile) to study the role of the ocean in climate, the investigation of processes maintaining the Oxygen Minimum Zone off Peru, and the impact of remote and local air-sea interactions over the upwelling systems.

**Dr. Andreas Oschlies** is an expert on marine biogeochemical Modeling dedicated to study the physical, biogeochemical, and ecological constraints on the oceanic carbon uptake and its climate sensitivity as well as interested on mixing processes and their representation in numerical models.

**Dr. Parv Suntharalingam** is focused on biogeochemical cycles of climatically important species in the atmosphere and ocean.

#### Relationship to other international programs and SCOR Working groups

This EBUS theme is an integral part of the integrated topics in the new SOLAS Science Plan 2015-2025.<sup>10</sup> Moreover, CLIVAR (Climate and Ocean: Variability, Predictability and Change), IMBeR (Integrated Marine Biosphere Research) and SOLAS have a joint Research Focus on Upwelling systems. In addition, there is a strong link between this SCOR WG proposal and the new initiative from IOC-UNESCO called GO2NE (Global Ocean Oxygen NETwork), an interdisciplinary network concerned about the low oxygen concentrations in both the open ocean and coastal areas, which will be involved in the regional database initiative. This working group is also timely since it fits with the concerns of the program TPOS2020 that is aimed at designing the future of the observing system in the Pacific (<http://tpos2020.org/>). Interactions with the Task Team “Eastern Pacific” of the TPOS2020 program will be encouraged during the course of the SCOR group. It will also link with the GOOS IMSOO (Implementation of Multi-Disciplinary Sustained Ocean Observations) panel on Oxygen Minimum Zones. This SCOR WG will also have the opportunity to start with standards, datasets and comparative analysis of the oxygen deficient systems being generated by the SCOR Working Group 144 on Microbial Community Responses to Ocean Deoxygenation, developed for the world ocean to the wider oceanographic and Earth system science communities and the public.

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<sup>10</sup> [http://www.solas-int.org/files/solas-int/content/downloads/About/Future%20SOLAS/Revised\\_SOLAS%20Science%20Plan.pdf](http://www.solas-int.org/files/solas-int/content/downloads/About/Future%20SOLAS/Revised_SOLAS%20Science%20Plan.pdf).

\*By inversions we mean inversions to obtain information on the properties of materials in the ocean and the atmosphere (gas, particles, dissolved materials, drops etc') as well as at the interface (waves, bubbles). By properties we mean concentration, composition, size and shape, lifetime, optical properties.

This SCOR WG will also strive to integrate in its synthesis outcomes of relevant regional modeling and observational projects (e.g. CORDEX) through collaborations of its members.

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Appendix (For each Full Member, indicate 5 publications related to proposal)

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## Appendix 5

### Proposal for a Working Group on Floating Litter and its Oceanic Transport Analysis and Modelling (FLOTSAM)

#### 1. Summary

In October 2015, the G7<sup>11</sup> Science Ministers highlighted marine debris as a major ocean health issue. A number of international working groups have focused on ocean plastics, although the amount of plastic floating at the sea surface remains an open question, including knowledge about its origins, where it is accumulating, and its transport pathways. It is a complex oceanographic problem for a variety of reasons, including challenges in sampling in situ and remotely, as well as in modelling at a variety of space and time scales.

In this working group (WG) we plan to address the problem of floating litter in the open ocean at global scale by disentangling coastal processes (with their short timescales) from the open ocean low-frequency processes. The major objectives of this WG are to:

- identify gaps in our knowledge of the near-surface ocean dynamics that may affect litter distribution and transport;
- improve future marine litter modelling capabilities;
- evaluate existing and emerging remote sensing technologies that can be applied to detect marine litter in the open ocean;
- improve awareness of the scientific understanding of marine debris, based on better observations and modelling results.

Bringing together scientists with expertise in plastic marine debris with those focused on ocean observations, remote sensing, and numerical modelling will create a powerful collaboration for the understanding of marine debris.

We propose one chairperson and 3 vice chairs, each responsible for a specific objective. There are 10 Full members and 9 Associated members from a total of 13 different countries.

#### 2. Background and motivation for the working group

##### **2.1 The importance of environmental plastic pollution and current knowledge gaps**

Contamination by man-made debris is increasingly reported in marine habitats around the world. An estimated 70-80% of marine litter is made of plastic polymers, and that percentage is probably much higher at the sea surface of the open ocean. Because they do not readily biodegrade, plastics may persist in the marine environment for years to decades or longer, longer than the time-scales of many of the ocean processes typically considered in physical oceanography. An estimated ~8 million metric tons of mismanaged plastic waste entered the oceans from land in 2010 (Jambeck et al. 2015), with additional sources including natural disasters (Maximenko et al., 2015) and accidents (Trinanes et al., 2016), and inputs are expected to rise with the continued acceleration in global plastics production (Plastics Europe 2016).

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Marine litter poses a variety of environmental and socioeconomic risks, which will be mitigated only with a substantial, sustained and integrated effort from individuals, industry, governments, and intergovernmental organizations at local to regional and global scales. In October 2015 the G7 Science Ministers highlighted marine litter, especially plastics, as a major ocean health issue, and the International Association for the Physical Sciences of the Ocean (IAPSO) and the Scientific Committee on Oceanic Research (SCOR) published conclusions

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<sup>11</sup>[https://www.bmbf.de/files/English\\_version.pdf](https://www.bmbf.de/files/English_version.pdf)  
<http://www.icsu.org/news-centre/news/pdf/Report%20to%20G7%20SMin%20on%20FOSs.pdf>

regarding those issues and recommendations for future action by G7 countries (Thompson and Maximenko, 2016). There is no single solution; rather, a variety of local and regional solutions will be required to effect change (Hardesty et al. 2017).

Marine litter occurs all over the world from densely inhabited to remote areas, from the seafloor to surface waters. However, our knowledge of the abundance and distribution of plastic in the open ocean is limited, with most prior work having focussed on floating microplastics (millimeter-sized particles and smaller) measured with plankton nets.

Floating microplastic debris is found in seas around the world, from oceanic subtropical gyres (e.g. the so-called ‘garbage patches’) where concentrations exceed 600,000 pieces per km<sup>2</sup> (Law et al. 2010), to inner seas (e.g. Suaria et al. 2016, Chubarenko et al. 2016, Chubarenko and Stepanova, 2017) to more remote regions such as the waters of the Arctic (Cozar et al., 2017, Bergmann et al., 2016) and the Antarctic (Barnes et al., 2010; Ryan et al., 2014), where far fewer plastic particles are observed. It has become clear that humanity's discarded litter is spreading throughout our seas and oceans (e.g., Pham et al., 2014; Jambeck et al., 2015; GESAMP, 2016) and ocean models of surface transport predict that marine debris should ultimately be expected everywhere (Van Sebille et al., 2015).

A number of international working groups have focused on ocean plastics, but the focus is often on impacts of plastics to marine organisms and ecosystems. With the goal to assess the risks of plastic debris, they frequently highlight the need for increased knowledge about its abundance, distribution and transport. A necessary step is to get an estimate of the amount of plastic in the ocean, including knowledge about its origins, where it is accumulating, and its transport pathways. This is a complex problem for a variety of reasons, including challenges in sampling, both in situ and remotely, as well as in modelling.

If 8M tons of plastic are added to the ocean annually and plastic is expected to be around for decades or even centuries, why don't we find these large amounts in the ocean (e.g. Ryan, 2015)? Estimates of floating litter to date only tally up to order of 100,000 tons of floating microplastics (Cozar et al. 2014, Eriksen et al. 2014, van Sebille et al., 2015), with only an order of 10,000 tons removed by coastal clean-ups.<sup>12</sup> What missing knowledge can explain this multiple order of magnitude mismatch? Emerging research in physical oceanography may help elucidate marine debris distribution patterns and transport processes. Bringing together scientists with expertise in plastic marine debris with those focused on ocean observations, remote sensing, and numerical modelling in a single SCOR working group will create a powerful collaboration that will advance our understanding of marine debris in the open ocean.

## 2.2 The Challenge

The major challenge of this WG is to explain the distribution patterns, trends, and pathways of plastics in the open ocean.

Limitations of our understanding of the transport of floating plastics result from technical gaps as well as gaps in our knowledge of the near-surface ocean dynamics. These gaps include:

- coarse vertical and time resolution of debris modelling
- high-frequency processes and their non-linear interactions (Stokes drift, inertial oscillations, diurnal cycle in the upper-ocean stratification),
- lack of data on critical parameters (e.g. fluxes) that could support next-generation models of plastics at sea, and limited observations of surface currents (remote or in situ) that could help calibrate/validate such models.

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<sup>12</sup><http://www.oceanconservancy.org/our-work/marine-debris/2016-data-release/2016-data-release-1.pdf>

In addition, there is a dearth of knowledge on the typical features of marine debris, including floating lifetime, settling, fragmentation, degradation, and ingestion by organisms, which may alter the debris properties affecting its transport. Questions to be addressed include:

- How variable is marine litter composition in time?
- How big are the differences in the composition between different regions?
- What characteristics of plastic debris should be used in models (different degradation and fragmentation rates for different polymers, average particle size, etc.)?
- How does the composition of microplastics correspond to the composition of macroplastics?
- How do the dispersion and physics that apply to floating debris differ between macroplastic, microplastic and nanoplastic?
- What are the roles and impacts of the biological pump on transfer of pollutants to deep waters at different scales?
- What are the temporal trends in composition of microplastics associated with changes in macroplastic production?

Drift models have been used to describe marine litter distribution and transport, but improvements are required to adequately simulate pathways of marine debris ranging in size from microplastics to large objects. This includes improved models of ocean motion and definition of the dynamics of buoyant objects in a turbulent sheared flow, together with characterization of properties of plastic debris.

Distribution of floating marine litter has been studied since the 1970s using plankton net tows and visual selection of plastic particles in collected samples. Preliminary efforts have been made to standardize collection procedures and sample analysis protocols. Yet global, or even regional, in situ sampling at high resolution is not feasible, which calls for development of remote sensing instruments. At present, only optical data are readily available and they are only capable of detecting very large debris items.

Prospective satellites and airborne sensors may be able to measure various indices related to plastics and other types of floating debris and quantify their abundance on the ocean surface. The scientific recognition on this topic is still in its infancy and the key issues to be addressed and the full potential of remote sensing are still to be fully discussed in the scientific community. In 2016, the European Space Agency (ESA) released a call for proposals on remote sensing of Marine Litter (RESMALI). In the same year, the U.S. National Aeronautics and Space Administration (NASA) sponsored a workshop on Mission Concepts for Marine Debris Sensing<sup>13</sup> and included marine debris research in the scope of NASA's Interdisciplinary Research in Earth Science (IDS) program.<sup>14</sup> Satellite remote sensing can best contribute to the marine debris field through new missions to measure surface velocities, as well as implementation of existing and development of new sensors (optical, hyper-spectral, SAR, etc.) to track larger objects or detect the presence and quantify the concentration of smaller particles.

In the proposed WG we plan to:

- address the problem of floating litter at the global scale by disentangling coastal processes (with their short timescales) from the open ocean low-frequency processes.
- improve the application of ocean circulation models to the drift of debris at sea.
- assess and promote the use of remote sensing tools to study floating debris at sea.

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<sup>13</sup>[http://iprc.soest.hawaii.edu/NASA\\_WS\\_MD2016/](http://iprc.soest.hawaii.edu/NASA_WS_MD2016/)

<sup>14</sup><https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=498140/solicitationId=%7BE4A477E6-5A41-B75E-5DA8-61724BC35768%7D/viewSolicitationDocument=1/A.28%20IDS%20Amend%2034.pdf>



## 2.3 Why a SCOR Working Group?

This is the first effort to address the problem of marine litter in a SCOR WG. The proposed focus on debris in the open ocean from the physical oceanography perspective is new and makes this WG unique. The presence of a scientifically sound and competent voice on the topic is needed to fill knowledge gaps. By focusing expertise and resources into an international community effort, we will be able to deliver much-needed knowledge of marine debris in offshore waters that are mostly out of our sight, but in the heart of the global ocean.

We have already seen capability and willingness in the scientific community working on marine debris to work together in international WGs – some of the proposed members of this SCOR WG are also members of other, non-physics, international WGs – and we see SCOR as the proper environment to transform these recommendations into a more detailed, effective and cutting-edge improvement in knowledge.

This SCOR working group will assemble a diverse set of ocean scientists to work jointly towards delivering a set of clear objectives that will have wide impact and resonance across the larger ocean scientific communities.

These communities are diverse and include physical oceanographers specializing in relevant dynamics and using in situ observations and remote sensing, experts in marine plastic debris and modellers who attempt to synthesize the theory and the data and summarize the overall knowledge of the marine system.

Because of the broad involvement from several different disciplines and because of the specific focus on the marine litter problem, the multi-disciplinary and international work we propose would be difficult to support through national agencies, private foundations or other international organizations.

## 3. Terms of reference

**(Objective 1) Identify gaps in our knowledge of the near-surface ocean dynamics that may affect litter distribution and transport.**

**Vice Chair: Kara Lavender Law**

Gaps that will be explored will include, but not be limited to, improved mixed layer parameterizations and refined vertical and time resolution of ocean circulation models, inclusion of high-frequency processes and their non-linear interactions (Stokes drift, inertial oscillations, and diurnal cycle in the upper-ocean stratification). The WG will address the absence of data on critical parameters (e.g., fluxes) that are needed to support next-generation models, as well as the shortage in observations of surface currents (remote or in situ) that could help calibrate/validate models. We will also discuss marine litter parameters that can characterize non-homogenous distribution and behaviour, floating lifetime, settling, fragmentation, degradation, and ingestion by marine life that can increase the power of debris drift modelling. The results of WG discussions will be presented in a synthetic paper in an open-access, peer-reviewed journal publication.

**(Objective 2) Improve future marine litter modelling capabilities.**

**Vice Chair: Erik Van Sebille**

The group will select a set of software and computing platforms (e.g., Python, R, Matlab, Ferret etc.) and models (MITgcm, MOM, POM, NEMO, ROMS, etc.) in order to identify a platform to lead the development of new tracking tools, taking into account the very rapid development of ultra-fine-resolution global ocean hydrodynamics simulations (which will reach 1/60° global resolution within the foreseeable future). The group will then agree on a common set of model metrics and diagnostics required to evaluate model performance, as well as a reference database from the observations. Platform leaders will be responsible for writing the code, which will be tested against a common model. Open-source scripts and codes will be made available to the ocean science community.

**(Objective 3) Evaluate existing and emerging remote sensing technologies that can be applied to marine litter in the open ocean.**

**Vice Chair: Nikolai Maximenko**

The working group will identify parameters important for understanding and modeling of the dynamics of marine litter that can be derived from variables measured by present satellite missions and from emerging remote sensing technologies. Inter-calibration of remote and in situ observations will be discussed in the context of a consolidated marine debris observing system.

**(Objective 4) Improve awareness of the scientific understanding of marine debris, based on better observations and modelling results.**

**Chair: Stefano Aliani**

The working group will aim to advance awareness on the topic through open sessions at scientific meetings and through the WG webpage. Open access scientific papers will be delivered as well as outreach actions through the media.

#### **4. Work Plan**

**To deliver Objective 1,**

we will identify gaps in knowledge of the near-surface ocean dynamics that may affect litter distribution and transport. We will utilize expertise within the working group to discuss key aspects of the state of plastic debris in the open ocean, especially focusing on those critical gaps in knowledge to understand the global distribution and transport of marine plastics. This will be expedited by close dialogue between modellers and observationalists within the working group. A peer-reviewed paper will be published in an open-access journal to report WG recommendations for studying plastics in the ocean from a multidisciplinary perspective.

**To deliver Objective 2,**

we will discuss governing equations in a unified mathematical notation and default parameter values or ranges necessary for parameterization, and test these across a subset of models. As part of this effort, we will produce consensus initialization fields that can be used by the global ocean modelling community, as well as open-source scripts and codes dedicated to marine litter modelling.

**To deliver Objective 3,**

we will review existing and emerging remote sensing technologies that can be used to measure marine debris floating on the ocean surface or distributed in the upper ocean. We will also review relevant activity of national space agencies, as well as published research reports utilizing remotely sensed data to study marine debris, and we will formulate requirements for future satellite missions.

**To deliver Objective 4,**

we will synthesize and publish our findings to improve awareness of scientists, the public, and policymakers. We will create a website and start social media dissemination. An open session at relevant international conferences dedicated to students, young scientists, journalists and NGO will be organized. This information will be helpful input to achieving the pollution sub-goal of Oceans 2030 Sustainable Development Goal #14.

*Timeline*

We expect that our Working Group will start working in September 2017, right after receiving the decision from SCOR.

As a part of our activity, we plan to hold annual WG meetings. To maximize impact of this SCOR WG and optimize costs for Associated Members, we will combine funding available from SCOR with other sources and will hold group discussions during other ocean science-related meetings.



#### Month 1-6: Sep 2017 - Feb 2018

Web meetings with Chair and Vice Chairs to define details and plans of year 1 activity. Discussions on web page design and subgroups (SG) structure.

#### Month 7-12: Mar - Aug 2018

The first SCOR working group meeting will focus on drafting an optimal roadmap to progression of all tasks. This meeting will involve all members in planning activities; selected experts will be tasked and sub-groups will be assembled.

Our first meeting could be linked to the Sixth International Marine Debris Conference (6IMDC) that will be held in San Diego, California, USA from March 12-16, 2018. Locations for future meetings will be set at that time.

A first Writing Team (WT1) will be set up to write the short presentation article of this WG. (Deliverable 1 in Section 5). A second WT (WT2) will prepare the text for a web site and web discussion platform available for accredited worldwide students (Deliverable 2) and launch the site.

#### Month 13-18: Sep 2018 - Feb 2019

The second working group meeting will be timed to coincide with the 2018 AGU Fall Meeting or other similar major conference. During the meeting, a special discussion session open to students will be organized. Preliminary results from sub-group activities will be presented and reviewed by the entire WG. The website will be update (Deliverable 3).

#### Months 19-24: Mar - Aug 2019

The WG will continue remote work on all objectives.

#### Month 25-35: Sep 2019 - Jul 2020

The WG will finalize results and disseminate them to the broader scientific community. Remote discussion will continue on about the key processes controlling marine debris dynamics and phenomena identified in observations and models. Sub-groups write up the analysis of key processes. The website will be updated and meeting report written and submitted (Deliverable 4).

#### Month 36: Aug 2020

Final symposium. Co-sponsorship will be sought from other organizations identified in due course. The aim of the symposium will be to highlight progress made in the linking of observational work (satellite and in-situ) with modelling, and also including extending the theory of marine litter distribution and transport.

We will complete final website updates and submit the meeting report publication (Deliverable 5 and 6). We will present results at scientific meetings and submit papers to peer-reviewed scientific journals (Deliverable 7).

### **5. List of Deliverables**

- (D1) Introduction of this SCOR WG in a short article in Eos or elsewhere. Contribution from WT1.
- (D2) Construction of a website to manage contributions from all sub groups, including a web discussion platform for accredited worldwide students and experts. Contribution from WT2.
- (D3) Annual meeting report (including session open to students) and update of the website.
- (D4) Peer reviewed paper(s) to disseminate results of WG sub-groups.
- (D5) Annual meeting report and update of website.
- (D6) Final symposium report and update of website.
- (D7) Peer-reviewed papers and presentations at scientific meetings.

## **6. Capacity building**

Skills and knowledge that will be shared in this WG pertain to a number of subjects: field sampling and marine instrumentation, data homogenization, oceanography, remote sensing and modelling. A large community of experts from different regions of the world will gather and share skills to enhance knowledge.

The partnerships include experts on plastics in the ocean as well as experts on specific ocean processes that affect ocean plastics. This results in a two-way capacity building between experts in oceanography and in plastic marine debris, and may encourage those who have not previously applied their ocean physics expertise to debris to continue this work beyond the WG itself. Our vision is also to broaden the dialogue between modellers and observationalists/experimentalists by bringing together these groups in a focused forum of this working group.

A major tool for knowledge transfer will be through international workshops, a website and journal articles, but we expect to achieve longevity through fostering a new community of skilled ocean scientists from both developed and developing nations.

A global community of young scientist working on marine debris will be developed also via an open discussion session at one of the Ocean Sciences Meetings. We also believe that the open web discussion platform will enhance the development of a competent new generation of scientists working on open ocean marine debris.

A meeting will possibly be held in an emerging country, also including some basic training for local scientists. The POGO SCOR Visiting Fellowship program will be considered to support people from low-income countries to learn techniques related to marine debris in one of the institutions of WG members. We will also endorse the possibility for partners to include the POGO Fellowships for Shipboard Training in their activity at sea.

## **7. Composition of Working Group**

This SCOR WG has 10 Full and 9 Associate members that combine together state-of-the-art skills in marine debris modelling and remote sensing as well as in situ experimental observations. Two associated members are experts in theoretical physical oceanography.

The Full Members are responsible for the delivery of the four objectives (each led by an assigned vice-chair) and the Associate Members provide important input from the complementary fields.

Our Full members represent 9 different nations, including emerging nations, with a total of 13 nations involved including Associated members. Moreover, we include one early career researcher as vice chair, and another as Associate member which will aid their career development.

We propose one chairman and 3 vice chairs from different disciplines, each of them being responsible for a specific WG objective.

## 7.1 Partnership:

Name	Gender	Place of work	Expertize	Status
Stefano Aliani	M	CNR ISMAR ITA	Chair – In situ observation	FULL
Nikolai Maximenko	M	Univ. Hawaii USA	Vice chair Remote sensing	FULL
Bertrand Chapron	M	IFREMER FRA	Remote sensing	FULL
Victor Martinez-Vicente *	M	Plymouth Marine Lab UK	Remote sensing	FULL
Yi Chao	M	Remote Sensing Solutions, Inc. USA	Remote sensing	Associate
Erik van Sebille *	M	Univ. Utrecht NED	Vice chair modelling	FULL
Atsuhiko Isobe	M	Kyushu Univ JPN	modelling	FULL
Irina Chubarenko	F	Univ Moscow RUS	modelling	Associate
Laurent Lebreton *	M	modellinghouse NZL	modelling	Associate
Miguel Morales Maqueda	M	Univ Newcastle UK	modelling	Associate
Christophe Maes	M	LPO-IRD, Brest FRA	modelling	Associate
Kara Lavender Law	F	Sea Education Association USA	Vice chair In situ observation	FULL
Peter Ryan	F	Univ Cape Town RSU	In situ observation	FULL
Won Joon Shim	M	KIOST KOR	In situ observation	FULL
Martin Thiel	M	UCN CHL	In situ observation	FULL
Melanie Bergmann	M	AWI GER	In situ observation	Associate
Denise Hardesty	M	CSIRO AUS	In situ observation	Associate
Tobias Kukulka,	M	Univ Delaware USA	Theoretical physical oceanography	Associate
Baylor Fox-Kemper	M	Brown Univ USA	Theoretical physical oceanography	Associate

\* is for young scientists.

Observers/stakeholders			
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#### Working group contributions

**Stefano Aliani** is in charge of the coordination as chair of this WG and of Objective 4. He has experience on observational data on marine litter distribution and in situ measurements of oceanographic processes. He is section head at Institute Marine Science of CNR in Lerici, Italy. He led/participated to many cruises worldwide and has considerable experience in data collection. He is involved in developing new quality control methods and protocols for in situ marine litter assessment.

**Kara Lavender Law** is in charge of the objective on in situ observations of marine debris as vice chair (O1). She is Research Professor of Oceanography at Sea Education Association (SEA), where she has published analyses of SEA's two long-term data sets on floating open ocean microplastics. She carries out research on SEA's 30-year archive of microplastics to understand what the physical and chemical characteristics of the debris might reveal about the transformation and fate of ocean plastics. She is also the co-PI of the National Center for Ecological Analysis and Synthesis (NCEAS) Marine Debris working group, which has published on the input of plastics to the ocean from land-based waste; on the global abundance of floating plastics; and a critical review of the biological and ecological impacts of debris.

**Erik Van Sebille** is in charge of the objective (O2) on modelling of plastic litter pathways as vice chair. He is an Early Career Scientist who has won the 2016 Outstanding Young Scientist Award from the European Geosciences Union's Ocean Division, and has recently been awarded a European Research Council Starting Grant on a five-year project 'Tracking Of Plastic In Our Seas'. He has worked extensively with marine ecologists to map the risk of plastic to marine life, and has been part of the GESAMP Working Group on microplastics. He has testified for UK Parliament on the impact of microbeads on the marine environment, and the effects of a potential ban of these materials.

**Nikolai Maximenko** is in charge of objective on remote sensing of marine debris as vice chair (O3). He is an established Oceanographer with expertise in ocean circulation and air-sea interaction physical dynamics and develops applications, such as drift models of marine debris. In his research, he combines in situ observations with satellite products to study multi-scale ocean debris. Maximenko is a member of NASA Ocean Surface Topography, Ocean Salinity and Salinity Processes in the Upper Ocean Regional Study Science Teams.

**Bertrand Chapron** will provide his multi-year experience on the combined use of space-borne ocean remote sensing measurements. He is senior scientist at Ifremer, co-responsible for the ESA Sentinel 1 (a and b) algorithms and scientific validation of ocean (wind, wave and current) products, co- and/or principal investigator in several other ESA (SMOS salinity mission, OceanGasFlux, GlobCurrent), member of NASA and CNES science and definition teams (SWOT and CFOSAT, Altika missions), and working on potential future space-borne instrument to provide ocean surface currents (Doppler off-nadir altimeter SKIM, multi-azimuth optical glitter GLISTERO).

**Atsuhiko Isobe** will provide a numerical model of microplastics using observed data for validation. He has been the principal investigator of three plastic-debris research projects sponsored by the Environmental Research and Technology Development Fund of Ministry of the Environment, Japan, and conducted field surveys of macroplastics and microplastics, around East Asian seas, North/South Pacific, and the Southern Ocean. Also, he and his group have conducted numerical modeling for pelagic marine debris including microplastics in these research projects.

**Peter Ryan** has studied marine plastics since the 1980s. He will provide his multi-year experience on field and laboratory assessments of the abundance, distribution and composition of macrolitter at sea, as well as experiments on the rates of sinking through biofouling.

**Victor Martínez-Vicente** will contribute the working group with a review on current techniques for plastic litter detection from satellites. He is principal scientist in the RESMALI proposal submitted by Plymouth Marine Laboratory to the European Space Agency. He is an Early Career scientist that focuses on validation of satellite observations and on developing new products from remote sensing. To do so, he has developed in-situ and laboratory techniques for characterising the optical properties of particles in the ocean, leading to novel phytoplankton Carbon algorithms.

**Won Joon Shim** will provide his expertise on distribution of microplastics in water and sediment and their fate including weathering and fragmentation in the environments. He is a principal research scientist at Korea Institute of Ocean Science and Technology and currently co-leads a national research project for environmental risk assessment of microplastics in coastal zone including microplastic monitoring in multi-media.

**Martin Thiel** will provide his 15 years' experience on field and laboratory studies on marine litter, especially about its distribution and composition at sea. He will also contribute to capacity building through citizen science program Científicos de la Basura ("litter scientists", [www.cientificosdelabasura.cl](http://www.cientificosdelabasura.cl)) in which schools from the entire Chilean coast are participating in scientific research on marine litter. He is Professor of Marine Biology at Facultad de Ciencias del Mar, Universidad Católica del Norte (UCN).

## **8. Relationship to other programmes and SCOR working groups**

### **8.1 Other SCOR Working Groups**

This SCOR WG will interface well with current SCOR Working Group 149 (Changing Ocean Biological Systems - COBS) when they address the presence of multiple drivers altering marine living resources and ecosystem services. We will also interface on producing a glossary of terms and guide for policy-makers to better understand the role of plastics as one of the multiple drivers of change in biological systems.

We will also interface with SCOR Working Group 150 (Translation of Optical Measurements into particle Content, Aggregation & Transfer - TOMCAT) for the part about remote sensing of debris and polymer characterisation usually performed by FTIR or Raman spectroscopy.

### **8.2 Other Programmes**

#### **GESAMP WG40**

GESAMP is the Group of Experts of the Scientific Aspects of Marine Environmental Protections and is sustained by UN, UNEP, FAO, UNESCO, IOC, UNIDO, WMO IMO IAEA and UNDP. Working Group 40 is about "sources, fate and effects of micro-plastics in the marine environment – a global assessment". This SCOR WG is the obvious consequence of GESAMP recommendations when they address the importance to assess distribution and transport of microdebris. Some members of this WG are also members of GESAMP, and plan to bring those general recommendations into a more detailed and active stage.

#### **SCAR**

The Scientific Committee on Antarctic Research (SCAR) is a committee of [International Council for Science](http://www.internationalcouncilforscience.org) dedicated to Antarctic science. Recently marine debris has been found in Antarctica. The source is necessarily from industrialized countries and this SCOR WG will interact with SCAR providing information about ocean transport and accumulation of debris, the ultimate challenge for Antarctic marine research. The possibility to create a SCAR WG dedicated to marine debris will be assessed as a product of this SCOR WG.

## MARPOL - IMO

MARPOL 73/78 is one of the most important international marine [environmental conventions](#). It was developed by the [International Maritime Organization](#) in an effort to minimize pollution of the oceans and seas, including [dumping](#), oil and air pollution. The objective of this convention is to preserve the marine environment in an attempt to completely eliminate pollution by oil and other harmful substances and to minimize accidental spillage of such substances. This WG will interact with IMO exchanging information on ship-based plastic pollution.

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## Appendix 6 Integrated Marine Biosphere Research (IMBeR) Project

### Annual Report to SCOR 2016 – 2017

#### A. Introduction

The Integrated Marine Biosphere Research project (IMBeR, formerly the Integrated Marine Biogeochemistry and Ecosystem Research project, IMBER) is a global environmental change research initiative co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and until December 2015, by the International Geosphere- Biosphere Programme (IGBP). In 2016 IMBeR signed a Memorandum of Understanding to become a co-sponsored global research project with Future Earth.

Since its start in 2005, IMBeR has aimed to develop a comprehensive understanding and accurate predictive capacity of the ocean's response to accelerating global change and the consequent effects on the Earth system and human society. In 2016 IMBeR produced a science and implementation strategy for the next decade, underpinned by the vision, "*Ocean sustainability under global change for the benefit of society*".

This vision recognises that the evolution of marine ecosystems (including biogeochemical cycles and human systems) is linked to natural and anthropogenic drivers and stressors, as articulated in the new IMBeR research goal to "*Understand, quantify and compare historic and present structure and functioning of linked ocean and human systems to predict and project changes including developing scenarios and options for securing or transitioning towards ocean sustainability*".

To implement its new vision and goal, IMBeR's mission is to "*Promote integrated marine research and enable capabilities for developing and implementing ocean sustainability options within and across the natural and social sciences, and communicate relevant information and knowledge needed by society to secure sustainable, productive and healthy oceans*".

IMBeR science aims to foster collaborative, interdisciplinary and integrated research that addresses important ocean and social science issues and provides the understanding needed to propose innovative societal responses to changing marine systems. The implementation of the new IMBeR Science Plan is underpinned by the International Project Office (IPO) in Bergen, Norway sponsored by the Institute of Marine Research (IMR) and the Norwegian Research Council, and the Regional Project Office (RPO) in Shanghai, China supported by the State Key Laboratory of Estuarine and Coastal Research (SKLEC) at the East China Normal University (ECNU). The IMBeR research goal is progressed through the activities of four regional programmes, five working groups and numerous endorsed projects, and is facilitated through focussed IMBIZO workshops, conferences and symposia and the training of early career researchers at biennial ClimEco summer schools (Figure 1).

## IMBeR Implementation

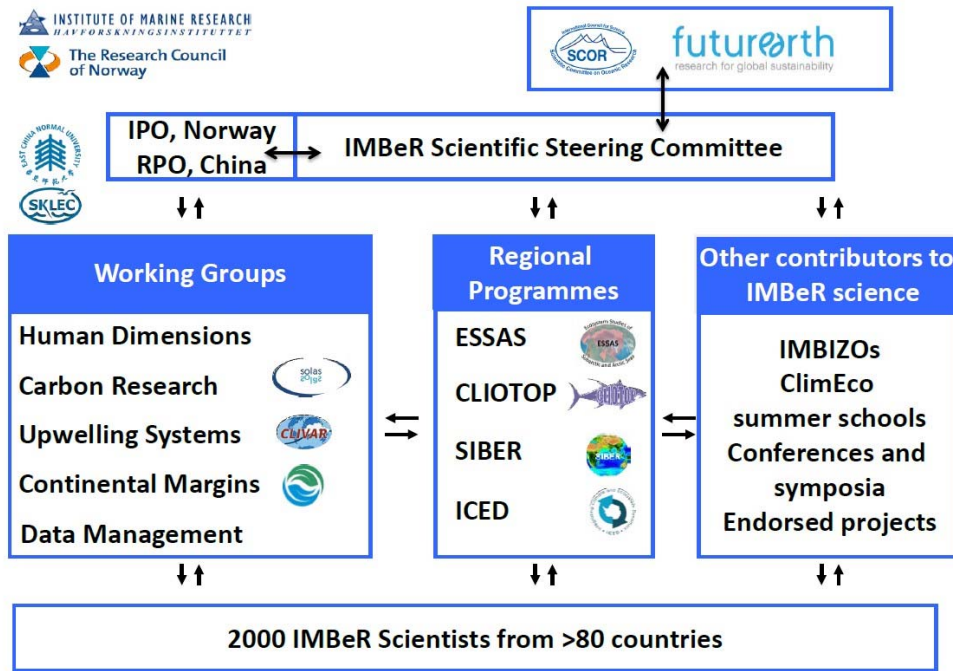


Figure 1. Implementation of IMBeR's research goal.

### B. Science Plan (2016-2025)

The Science Plan and Implementation Strategy (SPIS; 2016-2025) is developed around three Grand Challenges (GC) focussing on climate variability, global change and drivers and stressors. The qualitative and quantitative understanding of historic and present ocean variability and change (Grand Challenge I) are the basis for scenarios, projections and predictions of the future (Grand Challenge II). These are linked in Grand Challenge III to understand how humans are causing the variability and changes, and how they in turn are impacted by these changes, including feedbacks between the human and ocean systems. Priority research areas with overarching and specific research questions are identified for each Grand Challenge. The Grand Challenges are supplemented with four Innovation Challenges (IC) that focus on new topics for IMBeR where research is needed and where it is believed that major achievements can be made within three to five years. The Innovation Challenges also provide a means for IMBeR to adjust its focus as major science discoveries are made and new priorities arise (Figure 2).

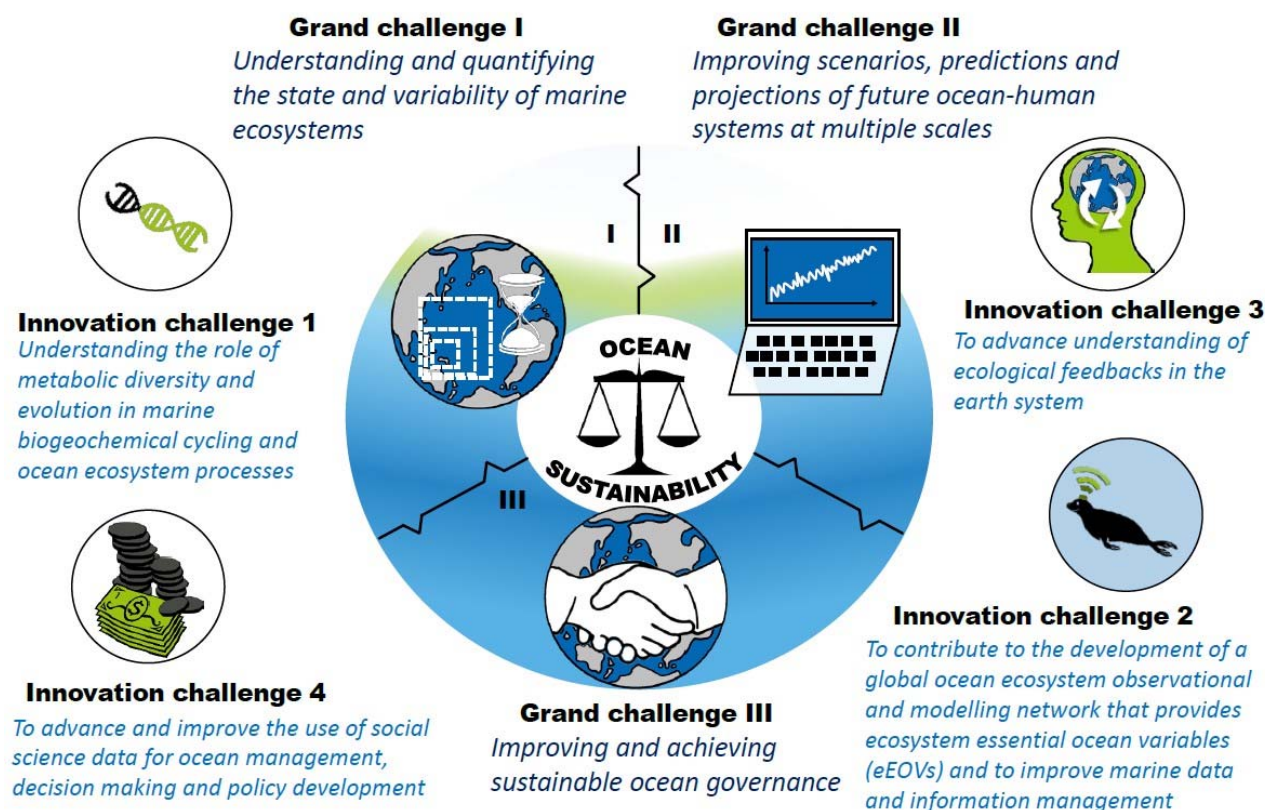


Figure 2. The Grand and Innovation Challenges

### C. Selected science highlights in 2016

A list of publications is given in section K, and activities which have specifically progressed the objectives of the Science Plan are given in section G. Here we identify a selection of studies where IMBeR has contributed to the progression of fundamental knowledge in marine ecology and biogeochemistry.

Members of the IMBeR regional programmes ESSAS (Ecosystem Studies of the Subarctic and Arctic Seas) and ICED (Integrating Climate and Ecosystem Dynamics) led a comparative study of the ecological impacts of atmospheric and oceanic circulation on polar and sub-polar marine ecosystems. The study highlights the effect of the strikingly different polar circulation patterns on the amount, thickness and duration of sea ice and the ecology of zooplankton, fish, seabirds and marine mammals (Hunt et al. 2016; <http://dx.doi.org/10.1016/j.pocan.2016.10.004>).

1. A session on the ecology of the polar cod *Boreogadus saida*, held at the ESSAS 2014 Annual Science meeting, led to the publication of a special issue of *Polar Biology* (Mueter et al. 2016; doi:10.1007/s00300-016-1965-3). The combined publications represent the largest single step towards understanding the ecology, life history and distribution of Arctic gadids in a changing Arctic.
2. A combined ESSAS and ICED study (Murphy et al., 2016; <http://dx.doi.org/10.1098/rspb.2016.1646>) proposes a conceptual framework that links the life histories of pelagic species and the structure of polar foodwebs, and highlights the low functional redundancy at key trophic levels which makes these ecosystems particularly sensitive to change.
3. Members of ICED used the Framework on Ocean Observing (FOO) to begin developing ecosystem Essential Ocean Variables (eEOVs) for the Southern Ocean Observing System (SOOS). The authors



outline the rationale, including establishing a set of criteria, for selecting eEOVs for the SOOS, develop a list of candidate eEOVs for further evaluation and discuss the importance of simulation modelling in helping with the design of the observing system in the long term (Constable et al. 2016; <http://dx.doi.org/10.1016/j.jmarsys.2016.05.003>).

4. An ICED study explored the views of representatives from the scientific, conservation and fishing industry sectors on the sustainability of the Antarctic krill fishery. The analysis identified key differences in viewpoints such as the priority given to different management approaches, and to continuing commercial fishing. However, the results also revealed considerable overlap between viewpoints. The study suggests that identifying shared management objectives based on stakeholder aspirations provides a strong basis for developing practical management solutions (Cavanagh et al. 2016; <http://dx.doi.org/10.1016/j.marpol.2016.03.006>).
5. As part of the IMBeR regional programme SIBER (Sustained Indian Ocean Biogeochemistry and Ecosystem Research), CO<sub>2</sub> and pH sensors were deployed on a mooring in the Bay of Bengal in November 2013 to provide the first continuous set of surface water and air CO<sub>2</sub> and pH measurements in the northern Indian Ocean. Data from the time series reveal strong seasonal variations in pCO<sub>2</sub> in the surface water relative to the air, which are associated with the monsoon seasonal cycle, with a slight predominance of ingassing over the annual cycle. Pronounced increases in pCO<sub>2</sub> during the early intermonsoon are driven by increasing temperatures and reduced CO<sub>2</sub> solubility, and decreases in pCO<sub>2</sub> during late intermonsoon and monsoon time periods are driven by decreasing temperatures and elevated CO<sub>2</sub> solubility.
6. SIBER has also motivated bio-Argo deployments in the Indian Ocean through a joint Indian-Australian project in the northern and southeastern Indian Ocean. The targets of these deployments have been biogeochemical hotspots in oxygen minimum zones, island wakes, enhanced-productivity eddies and subtropical convergence zones. About 40 biogeochemical Argo floats have been deployed in the Indian Ocean to date, providing insights into productivity and carbon cycling, oxygen distributions, phytoplankton community composition and eddy nutrient dynamics. The radiometric and chlorophyll data from these floats have been further applied to satellite ocean colour validation.
7. A special issue of *Deep-Sea Research II* outlines research arising from the CLIOTOP (Climate Impacts on Oceanic Top Predators) regional programme 2015 symposium, spanning topics such as conservation biology, trophic ecology, fisheries science, climate change and adaptive management (Hobday et al., 2017; doi:10.1016/j.dsr2.2017.03.008).
8. The CLIOTOP Task Team 2016-02 aims to build policy relevant scenarios for the sustainability of global oceanic ecosystems and fisheries. Maury et al., (2017; <http://dx.doi.org/10.1016/j.gloenvcha.2017.06.007>) developed five contrasting Oceanic System Pathways (OSPs) based on the shared socioeconomic pathways used in climate change research. These OSPs have been chosen to form the official scenario basis of the FishMIP (Fisheries Model Inter-Comparison initiative), the marine component of the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP), used to inform model studies in the context of IPCC and IPBES.
9. The SOLAS-IMBeR Ocean Acidification Working Group working through the IAEA Ocean Acidification International Coordination Centre (OA-ICC) co-sponsored the 4th International symposium on the Ocean in a High-CO<sub>2</sub> World, hosted by the University of Tasmania's Institute for Marine and Antarctic Studies, New Zealand and the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Hobart, Australia. The event, held every four years, discussed the latest developments in ocean acidification science, identified future research needs and trends, and offered prime networking opportunities to hundreds of international scientists working on ocean acidification.
10. The OA-ICC contributed to the 3rd GOA-On Science Workshop that followed the Symposium on the Ocean in a High-CO<sub>2</sub> World. The workshop brought together more than 100 scientists from 40 countries, and discussions tackled issues including GOA-On national and regional status, linkages to other global programmes, data management, developing regional hubs to facilitate national programmes and capacity building.
11. The IMBeR Human Dimensions Working Group has submitted a collation of 20 marine case studies which use the I-ADApT (Assessment based on Description and responses, and Appraisal for a Typology) framework to identify the natural, social and governance aspects of approaches used to deal with global change to the *Routledge Studies in Environment, Culture and Societies* book series.

12. Guillotreau et al. (2017), analysed six commercial bivalve industries affected by mass mortalities using I-ADaPT, to assess the impacts and consequences of these perturbations on the natural, social, and governing systems, and the consequent responses of stakeholders to these events.  
<https://doi.org/10.5751/ES-09084-220146>

#### **D. Regional Programmes**

##### **Ecosystem Studies of Subarctic and Arctic Seas (ESSAS)**

ESSAS objectives are to understand how climate variability and climate change affect the marine ecosystems of Subarctic and Arctic seas and their sustainability, and in turn, how changes in the marine ecosystems affect humans.

The Resilience and Adaptive Capacity of Marine Ecosystems in the Arctic (RACArctic) is an ESSAS initiative between Japan, the USA and Norway and is funded by the Belmont Forum. It is a 3-year project, now in its second year. Its objective is to synthesize information from completed and ongoing regional studies in order to examine how variability and changes in advection, temperature, pH and ice dynamics in the Subarctic to Arctic transition zone may affect future marine ecosystems of the Pacific and Atlantic Arctic. Of particular interest is how fish populations and their prey respond to, and may adapt to, natural and anthropogenic changes in the Arctic and how these responses are expected to affect existing and future fisheries, subsistence harvests, and the socio-economic systems that depend upon them. The first meeting was held in February 2016, in Hakodate, Japan. The first day was dedicated to a stakeholder forum with representations from the fishing industry, food processing, grocers, fisheries management, transportation industry, and a weather services company. It was conducted mostly in Japanese with translation into English. The stakeholders provided information on the kinds of information they need in order to meet the challenges of climate change. They stressed the desire to see more such meetings. Days 2 and 3 of the meeting were devoted to scientific presentations and discussions from representatives of each of the countries on topics of climate and meteorology, biogeochemistry, phytoplankton productivity, zooplankton, fish and higher trophic levels.

ESSAS co-chaired a session at the **Ocean Sciences** meeting in New Orleans in February 2016 on ‘Biophysical processes at the Arctic-Sub-Arctic Interface’ which explored patterns and processes at the interface between Subarctic and Arctic waters of the Pacific Arctic, the gradients in physical characteristics and biological communities that shape this region, and the role of climate change in modifying biophysical processes in the region.

ESSAS co-chaired several sessions at the **Annual PICES meeting** in San Diego in November 2016. The session on ‘Resilience, transitions and adaptation in marine ecosystems under a changing climate’ explored the concept of resilience in both physical ocean systems and in the associated ecological systems from plankton to fish. Presentations on theoretical studies and applied case studies examined resilience in a marine ecosystem context, provided practical approaches to measuring resilience, defined the “essential structure and function” of marine ecosystems, identified thresholds beyond which essential structure and function may be lost, examined ways in which resilience of marine ecological systems can be enhanced, and explored the phenotypic and evolutionary adaptive capacity of marine organisms to deal with gradual changes and transitions.

The 2016 ESSAS Annual Science Meeting was held in Yokohama, Japan. Fifty attendees participated in sessions on Challenges to the climate, ecological, biogeochemical and socio-economic sciences in a changing Arctic and Subarctic. The 2017 ESSAS Open Science Meeting will be held in Tromsø, Norway.

##### **Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED)**

The ICED regional 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](http://www.iced.ac.uk/index.htm).

ICED scientists contributed various oral presentations and posters at the **Scientific Committee on Antarctic Research (SCAR) Open Science Conference**, in August 2016, in Kuala Lumpur, Malaysia. ICED co-coordinated a mini-symposium on Linking Antarctic science with environmental protection, which aimed to highlight the relevance of the research carried out by the international community of Antarctic scientists, under SCAR, to the Antarctic Treaty System.

ICED scientists attended the **4th International Symposium on the Ocean in a High-CO<sub>2</sub> World**, in May 2016, in Hobart, Australia to present work on the effects of ocean acidification on Antarctic pteropod and phytoplankton species, as well as the development and delivery of scientific knowledge and policy guidance on high latitude ocean acidification.

ICED has continued to provide input to the Antarctic Treaty System (via SCAR; CCAMLR; Commission for the Conservation of Antarctic Marine Living Resources and CEP; the Antarctic Treaty's Committee for Environmental Protection), the Convention on Biological Diversity (CBD) and Marine Protected Areas. There is now an established recognition by these bodies of ICED's role as the provider of valuable, external input on climate change impacts on Southern Ocean ecosystems to their work.

ICED was represented at the second Joint Workshop of the CCAMLR Scientific Committee (SC-CCAMLR) and CEP, in May 2016 in Punta Arenas, Chile. The workshop aimed to identify the drivers and effects of climate change that are considered most likely to impact the conservation and management of Antarctica and its resources, and to identify existing and potential sources of research and monitoring data relevant to the work of the CEP and SC-CCAMLR on this topic. This led to ICED representation at the CCAMLR Working Group on Ecosystem Monitoring and Management meeting in Trieste, Italy, July 2016.

ICED scientists have been involved in key International Whaling Commission (IWC) work following on from a Southern Hemisphere humpback whale assessment (Jackson et al. 2016). Funding has been secured to support two inter-disciplinary voyages to study the sub-Antarctic right whale feeding population off South Georgia. Investigations will include identifying habitat use with satellite tracking, connecting these grounds to low-latitude calving grounds using photo identification and genetic matching, investigating the main prey sources through skin isotope analysis, and determining the health of the whales from photographs of body condition and analyses of whale hormones and microbiomes. Two years of surveys will allow whale abundance estimations at this site and contribute towards an assessment of right whale recovery in the southwest Atlantic.

ICED scientists have been involved in the agreement to establish the world's largest Marine Protected Area (MPA), in Antarctica's Ross Sea, via CCAMLR. This new MPA will come into force in December 2017 and will limit, or entirely prohibit, certain activities in order to meet specific conservation, habitat protection, ecosystem monitoring and fisheries management objectives. Seventy-two percent of the MPA will be a 'no-take' zone, which forbids all fishing, while other sections will permit some harvesting of fish and krill for scientific research. This is a significant achievement and has been several years in the making. A number of publications have been submitted by ICED scientists to CCAMLR in support of the development of future MPA's.

ICED scientists participated in delivering a chapter updating knowledge on the effects of climate change on Antarctic marine ecosystems to an International Union for the Conservation of Nature (IUCN) publication on the effects of climate change on the oceans.

The EUROMARINE science network represents the merger of three former Networks of Excellence (EUR-OCEANS, MarBEF and Marine Genomics Europe) that involved ICED Scientists. ICED scientists attended this year's EUROMARINE General Assembly, to maintain links between ICED and the network.

#### CLimate Impacts on Oceanic TOP Predators (CLIOTOP)

The CLIOTOP regional programme organises large-scale comparative studies 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 scientists contributed to a number of workshops and working groups in 2016 including the **Commission for the South Pacific Regional Fisheries Management Organisation**, Adelaide Australia in January 2017, the IOC-UNESCO (GOOS)/OceanObs Research Coordination Network co-ordinated workshop on the **Implementation of Multi- Disciplinary Sustained Ocean Observations (IMSOO)**, Miami, USA 8-10 February 2017, and the United Nations Group of Experts for the second cycle of the Regular Process for **Global Reporting and Assessment of the State of the Marine Environment**, including Socioeconomic Aspects, New York, USA March 2017.

The major activity of CLIOTOP in 2017 will be the development and organization of the Fourth CLIOTOP Symposium in late 2018. Members of CLIOTOP submitted a proposal for a SCOR working group 'Expanding Regional Application of Dynamic Ocean Management (ERADOM)'.

#### Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER)

The SIBER regional programme is co-sponsored by 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.

The 2<sup>nd</sup> International Indian Ocean Expedition (IIOE-2) was motivated by SCOR, SIBER, IOGOOS and IOP and has become the main scientific focus of SIBER. The first cruise was launched in December 2015. SIBER contributed to an IIOE-2 Town Hall meeting at the Ocean Sciences meeting, February 2016, New Orleans, USA, to the organisation and plenary presentations of the IIOE-2 symposium in February 2017 in Perth, Australia, and to the Bio-Argo workshop also held in February 2017 in Perth Australia.

A new SIBER website was launched in 2016, serviced from the Indian National Centre for Ocean Information Services (INCOIS) and linked to the IMBeR website, and a SIBER International Project Office has been set up at INCOIS, Hyderabad, India.

Together with IOP, SIBER is organising a winter school in 2018 at the National Institute of Oceanography, Goa, India.

### **E.      Working Groups**

#### **IMBeR-Future Earth Coasts Continental Margins Working Group (CMWG)**

The CMWG aims to compare a sparsely-populated northern Arctic shelf region with a shelf in a heavily-populated Southeast Asian region. IMBeR received funds from IGBP and the European Space Agency (ESA) to support a workshop to identify the relevant issues and knowledge needs for the Arctic margins case study. A special session was organized at the XMAS-III conference in Xiamen, China in early 2017 to discuss similar issues relating to the East China Sea case study. The IMBeR and Future Earth Coasts CMWG co-chairs are establishing a core group to take these case studies forward.

#### Human Dimensions Working Group (HDWG)

The HDWG continued development of the I-ADApT management tool. In March 2017, the manuscript of a book titled *Societal and Governing Responses to Global Change in Marine Systems* was submitted to Routledge. Objectives of the book are to explore and illustrate how the responses of the governance system have addressed the issue under consideration in 20 marine case studies from around the world.

HDWG members convened a session 'How to integrate natural and social science into advice for policy makers' with PICES, ICES and CLIOTOP at the World Fisheries Congress in Korea in May 2016, and contributed to the MSEAS Understanding Marine Socio- ecological Systems: Including the Human Dimension in Integrated Ecosystem Assessments conference in Brest, France in June 2016.

The 6<sup>th</sup> HDWG meeting was held at the Tokyo University of Marine Science and Technology, Japan in May 2016 and the 7<sup>th</sup> meeting will be held in France in 2017.

#### IMBeR-CLIVAR Eastern Boundary Upwelling Systems Working Group (EBUS)

EBUS contributed to the CLIVAR Open Science Conference “Charting the course for climate and ocean research” in Qingdao, China in September 2016, and held a workshop to refine the tasks of the working group in the context of the CLIVAR Science Plan. EBUS submitted a proposal for a SCOR working group in 2016 which unfortunately was not successful. They will revise the application and submit it again in April 2017.

#### SOLAS IMBeR IOCCP Carbon working group (SIC)

During 2016, it was decided to close the surface water and mid water SOLAS IMBeR carbon working groups as many of the original tasks were completed, and to create a new carbon working group with new objectives and incorporating the SCOR and IOC-UNESCO International Ocean Carbon Coordination project (IOCCP). The production (and review by IMBeR) of a new CLIVAR Science Plan also afforded an opportunity to align this group with CLIVAR. A small group of scientists representing IMBeR, SOLAS, CLIVAR and IOCCP will meet at the International Carbon Dioxide Conference (ICDC10) in Switzerland in August 2017 under the chairmanship of Nikki Gruber to propose new objectives for a new carbon working group.

#### SOLAS-IMBeR Ocean Acidification (SIOA)

The SOLAS-IMBeR Ocean Acidification Working Group continues to make advances, through the Ocean Acidification International Coordination Centre (OA-ICC), to its core activities of setting up a Global Observing Network, organising joint experiments and intercomparison exercises, maintaining advice on best practises and contributing to capacity building and outreach.

Selected highlights can be found in the quarterly releases from the OA-ICC available on their web page at <https://www.iaea.org/ocean-acidification>.

### **F. Endorsed projects**

#### *Atlantic Meridional Transect (AMT)*

AMT is a multidisciplinary programme which undertakes biological, chemical and physical oceanographic research during an annual voyage between the UK and destinations in the South Atlantic. The AMT provides a platform for scientists to capture and analyse data related to a range of oceanographic science areas. Over 256 scientists have participated in AMT cruises and many more have worked with the data which is accessible through the British Oceanographic Data Centre (BODC). The data has produced over 300 scientific papers, and the long-term nature of the data collected is useful in analysing trends and forecasting future outcomes.

#### *Gulf of Trieste Time series (GoTTs)*

The Department of Biological Oceanography of the Italian National Institute of Oceanography and Experimental Geophysics is responsible for the Gulf of Trieste site as part of the Long Term Ecological Research network in the North Adriatic. The research activities, which have continued since 1970, range from marine biogeochemistry to ecology and are aimed at understanding the dynamics governing marine ecosystems and to evaluate the role of the oceans in the global energy balance.

*Living-resource & Ecosystem Dynamics on the Slope of the South China Sea (LEDS)* The northern slope region of the South China Sea is the breeding and nursing ground for commercially-valuable fish species such as octopus and tuna. Their vertical migration behaviour potentially forms a key link between lower and higher trophic levels as they act as predators on zooplankton and as prey for bottom and pelagic fishes, and feed in the surface layer during the night while resting and excreting in the deep layer (400-1000 m) during the day. This project aims to progress understanding of the role of mesopelagic fish in marine ecosystems, resource protection and utilization, and carbon sequestration in the ocean.

#### *Mechanisms of Marine Carbon Storage and Coupled Carbon, Nitrogen and Sulphur cycles in response to global change (MCS-CNS)*

The sensitivity of marine biogeochemical cycles to climate change remains unclear, especially for key processes which influence the long-term health of marine ecosystems. By understanding the interactions between the

microbial carbon pump and the biological carbon pump, this project aims to decipher the mechanisms of marine carbon storage, and the response of biogeochemical processes to climate change and anthropogenic activities.

*Processes and Approaches of Coastal Ecosystem Carbon Sequestration (PACECS)*

This project aims to investigate the key processes and mechanisms of carbon sequestration in coastal ecosystems in order to propose ways in which to increase the ocean carbon sink. Most of this 'Blue Carbon Sink' resides in the biomass of phytoplankton, bacteria, archaea, and protozoa, and so maximising the efficiency of this sink requires fundamental knowledge of the dynamics of marine microbes.

*The Study of Kuroshio Ecosystem Dynamics for Sustainable Fisheries (SKED)*

This interdisciplinary study aims to investigate the paradox of high fisheries production in the low nutrient Kuroshio western boundary current of the North Pacific Ocean, in order to ensure sustainable use of this ecosystem.

*Variability of Ocean Ecosystems around South America (VOCES)*

The goal of this project is to assess the impact of climate variability - both natural and anthropogenic - on the Humboldt, Patagonia and South Brazil Large Marine Ecosystems (LMEs) which are amongst the most productive in the southern hemisphere.

*Integrated Arctic Observation System (INTAROS)*

INTAROS will develop an integrated Arctic Observation System (iAOS) by extending, improving and unifying existing systems in the different regions of the Arctic. An integrated Arctic Observation System will enable better-informed decisions and better-documented processes within key sectors (e.g. local communities, shipping, tourism, fishing), in order to strengthen the societal and economic role of the Arctic region.

*Ocean Foodweb Patrol – Climate Effects: Reducing Targeted Uncertainties with an Interactive Network (OCEAN CERTAIN)*

The goals of OCEAN CERTAIN are to 1. Determine qualitative and quantitative changes in the functionalities of the foodweb and the efficiency of the biological pump to export carbon as a response to multi-stressors, 2. Identify the interactions (impacts and feedbacks) between climate-related oceanic processes and global climate dynamics, 3. Integrate marine ecosystem scenarios with probable socio-economic scenarios to help estimate/quantify human feedbacks to the coupled socio-ecological system, relevant to mitigation and adaptation pathways, 4. Develop scenario-based impact prediction capacity, and 5. Produce and test decision support tools and systems and assess their ability to support the sustainable exploitation of marine resources.

**G. Implementation of the Science Plan in 2016**

The IMBeR regional programmes and working groups are working towards the research goal outlined in the SPIS (2016-2025). In order to ensure efficient progress towards this goal, a number of task teams led by members of the Scientific Steering Committee (SSC) were initiated at the 2016 SSC meeting in New Orleans. At the 2017 SSC meeting in Shanghai a more comprehensive gap analysis was undertaken, and specific SSC members were tasked to scope out relevant activities already being undertaken in the international community and to propose a plan of action for IMBeR to achieve the SPIS Grand and Innovation Challenges. Progress towards achieving the IMBeR research goal during 2016 is outlined below:

Grand Challenge I: Understanding and quantifying the state and variability of marine ecosystems

*The Challenge: To develop whole system level understanding of ecosystems, including complex biogeochemical cycles and human interactions, together with understanding of the scales of spatial and temporal variability of their structure and functioning.*

ESSAS contributes to this challenge through The Resilience and Adaptive Capacity of Marine Ecosystems in the Arctic (RACArctic) initiative, which examines how variability and changes in advection, temperature, ocean acidity and ice dynamics in the Subarctic to Arctic transition zone may affect future marine ecosystems of the Pacific and Atlantic Arctic.

ICED has continued to develop whole ecosystem level understanding of the structure and functioning of Southern Ocean ecosystems, and their variability and response to change across a range of spatial and temporal scales. They have focussed on key species from Antarctic krill to whales (e.g. Silk et al. 2016; Jackson et al. 2016), and the structure of food webs (e.g. Horswill et al. 2016), as well as furthering work on comparative studies with the Arctic, focussing on the role of biodiversity in ecosystem structure and function (Murphy et al. 2016b). ICED have also examined physical, chemical and biological interactions (e.g. Hunt et al. 2016) and the effects of past and recent variability and change, such as ocean acidification (e.g. Manno et al. 2016).

The long-term overarching goal of SIBER is to improve understanding of the role of the Indian Ocean in global biogeochemical cycles and the interaction between these cycles and marine ecosystem dynamics. In order to quantify the state and variability of Indian Ocean ecosystems, and importantly, the physical forcing that drives this variability, SIBER was instrumental in fostering the development of the 2nd International Indian Ocean Expedition (IIOE-2) and the Eastern Indian Ocean Upwelling research Initiative (EIOURI).

CLIOTOP Task Team 2016-01 has been working to improve understanding of the trophic pathways that underlie the production of tunas and other pelagic predators in the open ocean, the movements of these predators, and the natural variability forced by the environment. Improved understanding resulting from the outputs of this task team will directly assist IMBeR-CLIOTOP in progressing understanding of marine ecology, food web dynamics, movements of top predators in a changing climate, and ocean biogeochemistry.

CLIOTOP Task Team 2016-05 is focussed on developing a standard set of metrics for describing the movements of marine animals that could be used across multiple platforms and multiple species, thereby allowing for multi-species, multi-platform comparisons in investigating the environmental and physiological drivers of movement in marine animals.

The Human Dimension Working Group (HDWG) continues to develop I-ADApT - an integrated assessment framework and learning platform for global change response. I-ADApT is developed from case-studies that cover a wide range of natural and social systems around the world that have been challenged by critical global change issues, allowing cross-case comparisons within specific social and ecological contexts.

Grand Challenge II: Improving scenarios, predictions and projections of future ocean-human systems at multiple scales.

*The Challenge: To incorporate understanding of the drivers and consequences of global change on marine ecosystems and human societies at multiple scales into models to project and predict future states.*

Progress towards this challenge is led by IMBeR SSC member Laurent Bopp and will be the focus of one of the workshops at the IMBIZO5 conference in October 2017.

An initiative to produce policy-relevant future scenarios of ecosystem services in the oceanic realm was recently published (Maury et al., 2017), and the five contrasted Ocean System Pathways (OSPs) developed have been chosen to form the official scenario basis of FishMIP (the Fisheries Model Inter-comparison initiative).

A dataviz tool is under development to provide easy access to the recent CMIP5 climate model projections for ocean ecosystem stressors (warming, pH, oxygen, primary productivity). This tool will enable selection of any ocean region, and show visualization of projections for surface temperature, surface pH, sub-surface oxygen, integrated primary production.

ICED have continued their model development in support of creating a suite of models of physical dynamics (ocean circulation and climate), biogeochemical cycles, and biological dynamics (life histories, population dynamics, food web structure) within a hierarchical framework of models of different spatial, temporal and trophic resolution. The ultimate aim of these activities will be to advance end-to-end ecosystem modelling approaches that integrate physical, chemical and biological processes.

CLIOTOP Task Team 2016-03 is developing dynamic seasonal forecasting models relevant to fisheries and conservation management. This has included submission of a book chapter on 'Predicting the distribution of

bluefin tunas in a changing ocean’, presenting at the US CLIVAR workshop on ‘Dynamical and statistical modeling for ecosystem forecasts’, and attending the ICES conference on ‘Seasonal to decadal prediction of marine ecosystems: opportunities, approaches and applications’.

CLIOTOP Task Team 2016-06 is developing process-based animal movement models that are biologically reasonable and capable of i) modelling behavioural response in relation to environmental covariates, and therefore ii) predicting animal movements in response to climatic changes.

### Grand Challenge III: Improving and achieving sustainable ocean governance

*The Challenge: To improve communication and understanding between IMBeR science, policy and society to achieve better governance, adaptation to and mitigation of global change, and transition towards ocean sustainability.*

A scoping exercise for this Challenge is being led by SSC member Mark Dickey-Collas.

One of the objectives of ICED is to determine how Southern Ocean ecosystem structure, functioning and projections should be incorporated into adaptation, mitigation and sustainable management procedures by improving communication and understanding between science, policy and society. ICED is continuing its work with the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Antarctic Treaty’s Committee for Environmental Protection (CEP) and the International Whaling Commission (IWC) to ensure that ICED science is relevant and that scientific results are translated appropriately into messages that resonate with policy makers.

The SIBER activities that are most relevant to this IMBeR Challenge are related to IIOE-2 and the governance structure that has been created to guide it. The IIOE-2 is overseen by an international steering committee that aims to leave a lasting legacy of the expedition throughout the Indian Ocean region. This will be accomplished by establishing the basis for improved scientific knowledge transfer to wider segments of society and regional governments, and through the creation of educational and capacity development opportunities that target regional and early career scientists.

I-ADApT is an integrated assessment framework that builds on knowledge and lessons learned from past experience of responses to global change and is designed to enable decision makers, researchers, managers and local stakeholders to: (1) make decisions efficiently; (2) triage and improve their responses; and (3) evaluate where to most effectively allocate resources to reduce vulnerability and enhance resilience of affected people.

**Innovation Challenge 1** To enhance understanding of the role of metabolic diversity and evolution in marine biogeochemical cycling and ocean ecosystem processes.

Progress towards completion of this challenge will be led by SSC members Gerhard Herndl and Tatiana Rynearson. The first activity will be a workshop at the IMBIZO5 meeting in October 2017 leading to publication of a synthesis of current understanding of metabolic diversity in the light of environmental change and identification of approaches needed to include metabolism and evolution in marine ecosystem models at multiple scales, from individual organisms to systems.

**Innovation Challenge 2** To contribute to the development of a global ecosystem observational and modelling network that provides essential ocean variables (EOVs) and to improve marine data and information management.

A scoping exercise for this challenge is being undertaken by SSC member Dan Costa. Dan contributed to the organisation of the **Autonomous and Lagrangian Platforms and Sensors Scientific and Technical Review (ALPS-II)** held at the Scripps Institution of Oceanography in February 2017. The aim of the workshop was (1) to survey progress in autonomous platforms and sensors for ocean research since the original ALPS meeting 13 years ago, and (2) to assess future prospects and challenges.

Dan and CLIOTOP Co-Chair Kevin Weng participated in the The Global Ocean Observing System of the IOC-UNESCO (GOOS) and the OceanObs Research Coordination Network workshop on **Implementation of Multi-**

**Disciplinary Sustained Ocean Observations** in Miami, Florida, USA in February 2017. This workshop was tasked with identifying priorities for improving the coordinated planning and implementation of multi-disciplinary observing activities and demonstrations, by bringing together experts in physical, biogeochemical and biological/ecosystems ocean observations and modelling, users of established observing networks, and communities of practice.

The ICED community has made strong links with the SCAR-SCOR Southern Ocean Observing System and the CCAMLR Ecosystem Monitoring Program to progress integrated ecosystem observing to (i) support assessments of current status and trends of Southern Ocean ecosystems and (ii) provide foundation data for assessing the likelihood of future states of the system. Substantial progress has been made in identifying ecosystem Essential Ocean Variables as well as co-ordinating a year of field activities, proposed for 2022, to benchmark Southern Ocean ecosystems as a natural extension of the Census of Antarctic Marine Life undertaken a decade ago.

Several CLIOTOP members provided feedback on a draft paper on essential ocean variables for fish abundance and distribution circulated by the GOOS Panel on Biology and Ecosystems.

**Innovation Challenge 3** To advance understanding of ecological feedbacks in the Earth System.

Implementation of this challenge will be discussed at the 2017 SSC meeting in Shanghai. ICED scientists have undertaken a review of marine biogeochemical feedbacks resulting from plankton community stoichiometry changes to ocean acidification and climate change as part of the SCAR Ocean Acidification review.

**Innovation Challenge 4** To advance and improve the use of social science data for ocean management, decision making and policy development

Implementation of this challenge will be discussed at the 2017 SSC meeting in Shanghai.

ICED scientists have been actively developing studies to expand analyses of ecosystems to consider human social and economic system interactions. Following IMBIZO IV, Stuart Corney and Eugene Murphy have been working on an opinion piece “Integrating human dimensions into marine ecosystem models will improve management” that is under review with *Fish and Fisheries*.

## **H. Other IMBeR activities**

### **IMBeR ClimEco 5 Summer School**

The ClimEco 5 Summer School, was held in Natal, Brazil in August 2016 with the theme ‘*Towards more resilient oceans: Predicting and projecting future changes in the ocean and their impacts on human societies*’. Sixty four participants were chosen from more than 200 applicants based in 26 different countries. Topics that were covered include: Delineating the issues of climate change and impacts on marine ecosystems, Modelling approaches for natural and social science data, and Using science in management.

### **Early Career Researcher Network**

An IMBeR Early Career Researcher (ECR) network is being established to create a forum for interdisciplinary ECRs focussed on building capacity in developing nations, providing leadership roles for ECRs, and to promote gender equality throughout the marine sciences. An organizing committee has been established, and proposals are underway to attract funding for the first ECR meeting.

### **Gordon Research Conference on Ocean Biogeochemistry**

The conference was held at the Chinese University of Hong Kong in June 2016 and co- convened by past IMBeR SSC Chair Eileen Hofmann. One of the keynote presentations was given by the current IMBeR SSC Chair Carol Robinson, and several of the ICED community participated. The meeting emphasis was on the biologically-driven ocean carbon pumps, and included sessions on variations through geological time, microbial oxidation of organic matter within the water column, and the linkage of the carbon pump with silicon, nitrogen, phosphorous and iron cycles.

#### IMBeR-Future Earth Norway workshop

In September 2016, IMBeR and Future Earth Norway collaborated to convene a workshop to explore priorities for Norwegian research on ocean sustainability, oral presentations are available at [www.futureearth.org/norway/results-IMBeR-fen-wshop-2016](http://www.futureearth.org/norway/results-IMBeR-fen-wshop-2016), and the meeting report at [http://www.imber.info/resources/images/prosjekter/imber/IMBER\\_Future- Earth\\_Norway\\_Worshop\\_Report-Final-1-Dec.pdf](http://www.imber.info/resources/images/prosjekter/imber/IMBER_Future-Earth_Norway_Worshop_Report-Final-1-Dec.pdf).

#### Future Earth – Ocean Knowledge-Action Network (KAN)

IMBeR continues to contribute to the development of the Future Earth Ocean KAN.

As part of a Future Earth core research project meeting in Bern, Switzerland in June 2016 Peter Liss chaired a brainstorming session to produce a draft proposal to be presented to the Belmont Forum for consideration for funding as a Collaborative Research Action (CRA). At its annual Plenary Meeting in Doha in October 2016, the Belmont Forum agreed to progress with the full scoping process of a Future Earth — Belmont Forum co-branded CRA on "Transdisciplinary Research for Ocean Sustainability". This process will be coordinated by the Swedish Research Council FORMAS, and the first scoping workshop will be held in May 2017.

In conjunction with this, Future Earth, the International Council of Science (ICSU), WCRP- CLIVAR, IOC- UNESCO and ICSU-SCOR organized a scoping workshop on the development of an integrative Ocean Knowledge-Action Network (Ocean KAN) hosted by the Kiel Cluster of Excellence “The Future Ocean“ on 4-5 December 2016. The workshop was overseen by a scientific committee (including the IMBeR SSC Chair) and assembled nearly 100 representatives from 27 countries. As part of this meeting, the scientific committee and executive committees met to discuss the formation of an Ocean KAN development team. The Terms of Reference and call for applications for the Development Team were discussed extensively and the call will be released in 2017. Once established the Ocean KAN Development Team will develop a Research and Engagement Plan and a Funding Strategy based on the scoping activities held during the workshop. The aim is to formally launch the Ocean KAN at the UN Ocean Conference in June 2017.

#### IMBIZO 5

The fifth IMBIZO conference ‘Marine biosphere research for a sustainable ocean: Linking ecosystems, future states and resource management’ will be held from 2-5 October 2017 at the Woods Hole Oceanographic Institution, USA. Three concurrent but interacting workshops aim to progress specific aspects of the IMBeR Science Plan. These are: 1) Critical Constraints on Projections of Marine Systems (Laurent Bopp and Eric Galbraith), 2) Metabolic Diversity and Evolution in Marine Biogeochemical Cycling and Ocean Ecosystem Processes (Gerhard Herndl/ Tatiana Rynearson) and 3) Managing Strategy Evaluation: Achieving Transparency in Natural Resource Management by Quantitatively Bridging Social and Natural Science Uncertainties (Ingrid van Putten/Cisco Werner).

A capacity building workshop will be held the day before the start of the IMBIZO on how to create infographics to communicate science.

#### IMBeR China / Japan / Korea Symposium 2018

Planning is underway for the next CJK symposium, to be held in Shanghai in October 2018.

#### IMBeR Open Science Conference 2019

IMBeR received seven international applications to its open call to host the next open science conference. Brest, France was chosen to be the host, and planning is underway.

#### International Project Office (IPO, Norway)

Einar Svendsen, Lisa Maddison and Svein Sundby successfully applied for and were awarded funding for the IPO from March 2017 to March 2020 from the Norwegian Research Council and the Institute for Marine Research.

Einar Svendsen retired from the Executive Officer post at the end of June 2016. Gro I. van der Meeren was Executive Officer between 1 August 2016 and the end of June 2017. The post is currently being advertised, with applications due in September 2017.

IMR have confirmed that a renewal of funding after 2020 is unlikely, and so IMBeR has begun to investigate other possible hosts for the IPO from 2020.

During 2016, the IPO revised the IMBeR communication strategy. An e-newsletter is distributed weekly, the front page of the upgraded [www.IMBeR.info](http://www.IMBeR.info) website gives regular news highlights and @imber\_ipo twitter account is frequently used to relay information to its 500 followers.

#### Regional Project Office (RPO, China)

Yi Xu and Fang Zuo successfully applied for a further three years of funding (2017-2020) for the RPO from the East China Normal University (ECNU). Carol Robinson and Gro I. van der Meeren visited Shanghai in October 2016 to sign the Memorandum of Understanding with the Director of the State Key Laboratory for Estuarine and Coastal research (SKLEC) and the Vice-president of ECNU.

SKLEC hosted the 2017 SSC meeting and will host the 2018 China/Japan/Korea IMBeR conference.

Yi Xu represented IMBeR at the 3<sup>rd</sup> Xiamen Symposium on Marine Environmental Sciences (XMAS III), the SCOR China meeting in Qingdao and the annual Future Earth Asia Workshop in Tokyo, Japan.

#### **I.** Scientific steering committee

The 2016 scientific steering committee consisted of a chair, Carol Robinson, *ex officio* Past Chair Eileen Hofmann and 14 members (8 male and 6 female). Edward Allison (M, USA), Alida Bundy (F, Canada) and Katrin Rehndanz (F, Germany) rotate off the SSC at the end of 2016. Eugene Murphy (M, UK) agreed to continue as an *ex officio* member of the SSC and Vice Chair of the Executive Committee.

An open call for nominations for three new SSC members was advertised in April 2016, requesting expertise in marine sustainability science, marine policy and governance science, integrated modelling of social and marine ecological systems, biodiversity and climate adaptation science and ocean literacy. From more than 30 applications, three new members were proposed and accepted by SCOR and Future Earth - Mark Dickey-Collas M, Denmark), Marion Glaser (F, Germany) and Alistair Hobday (M, Australia).

#### **J.** Collaborative partners

IMBeR science is strengthened and its impacts extended through on-going and new partnerships and collaborations with international and national organisations, including the International Council for Science (ICSU), the Scientific Committee on Oceanic Research (SCOR), Future Earth, the World Climate Research Programme (WCRP), and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) which sponsors the Global Ocean Observing System (GOOS) and the International Ocean Carbon Coordination Project (IOCCP).

IMBeR continues to have long standing collaborations with the SCOR and Future Earth global research projects SOLAS, Future Earth Coasts and PAGES. Further collaboration with the Earth System Governance, bioDiscovery and bioGENESIS projects are envisaged through implementation of the IMBeR Scien Plan and development of a Future Earth Ocean Knowledge-Action Network.

#### **a.** *Too Big To Ignore (TBTI)*

IMBeR is a partner of the TBTI project which includes 15 partners, 62 scientists from 27 countries. TBTI is conducting a global analysis, based on information systems, to better understand small-scale fisheries and to develop research and governance capacity to address global fisheries challenges.

#### **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 are hosting and co-sponsoring IMBIZO 5 at Woods Hole in October 2017.

#### **c.** *World Climate Research Project (WCRP)*

CLIVAR, a core project of WCRP, and its Indian Ocean panel works closely with SIBER. The IMBeR Eastern Boundary Upwelling working group is co-sponsored by CLIVAR. A representative from the China CLIVAR office



attended the IMBeR SSC meeting in Shanghai in April 2017, and discussions are ongoing for a CLIVAR contribution to a newly formulated SOLAS IMBeR IOCCP carbon working group.

**d. GOOS**

SIBER has strong connections with the Global Ocean Observing System in the Indian Ocean – IOGOOS. Eric Lindstrom, GOOS co-Chair attended the 2016 IMBeR SSC meeting in New Orleans.

**e. ICES**

Collaboration with ICES will be developed through the appointment of Mark Dickey-Collas (ICES) to the IMBeR scientific steering committee.

**f. PICES**

IMBeR and PICES continue to collaborate, with representatives from both communities attending and funding each other's summer schools and science meetings. Gro van der Meeren, Cisco Werner, Ken Drinkwater and Masao Ishii attended the PICES 25<sup>th</sup> Annual Meeting in the USA in November 2016.

**K. Selected IMBeR Publications**

IMBeR has produced more than 1000 refereed research papers since 2005, with around 150 papers published in 2016-2017.

**ICED**

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## **L. 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. IMBeR is especially grateful for the advice and assistance received from the SCOR Executive Director, Ed Urban, and Financial Officer, Liz Gross.

We are requesting funding to support students and researchers from developing countries to attend the ClimEco 6 Summer School that will be held in Accra, Ghana in August 2018.

Amount requested: 7 500 USD

## Appendix 7 Surface Ocean – Lower Atmosphere Study (SOLAS)

### *SOLAS Annual Report to SCOR*

**Reporting period: June 2016- May 2017**  
**Version of 31 May 2016 by Emilie Brévière**

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

##### **I.a. SOLAS 2015-2025: Science Plan and Organisation**

In October 2016, SOLAS received some more comments on the 2<sup>nd</sup> draft from the four SOLAS sponsors (SCOR, iCACGP, WCRP and Future Earth), which we addressed and returned in January 2017. The sponsors' official approval of the science plan was received in February 2017.

The SOLAS 2015-2025: Science Plan and Organisation (SPO) is available to download from the SOLAS website (<http://www.solas-int.org/about/solas.html>) and hardcopies are available upon request to the IPO.

The SOLAS science mission is organised around five core themes:

- Core Theme 1: Greenhouse gases and the oceans
- Core Theme 2: Air-sea interface and fluxes of mass and energy
- Core Theme 3: Atmospheric deposition and ocean biogeochemistry
- Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems
- Core Theme 5: Ocean biogeochemical control on atmospheric chemistry

In addition, the study of these themes will be integrated in efforts to understand key environments, e.g. upwelling systems, polar oceans, and coastal waters, as well as to evaluate the environmental efficacy and impacts of geoengineering proposals, policy decisions, and societal developments.

##### **I.b. SOLAS 2015-2025. Implementation Strategy 2016-2018**

With regard to the Implementation Strategy, SOLAS chose to use a pragmatic approach and proposes a strategy over a period of 2 years at a time. The document is structured around three major sections: 1) events; 2) established working groups and their activities; and 3) working groups under development. The nature of the exercise obviously makes the document a moving target that needs constant update that is what SOLAS intends to do by having a live web-based document only. The Implementation Strategy will be updated and revised annually. The document is available to download on the SOLAS website at <http://www.solas-int.org/activities/implementation.html>. Version 2 is already being discussed and a major revision will take place in summer 2017.

##### **I.c. SOLAS- IMBER Carbon Group**

Much of the science of SOLAS Focus 3 of the original science plan (2004-2014) overlapped with IMBER and thus a joint SOLAS/IMBER Carbon Group (SIC) was formed during a meeting held in Colorado in Oct 2005. This group worked in close collaboration with the International Oceanic Carbon Coordination Project (IOCCP). The SIC group was currently subdivided into three working groups:

- \*WG1-Surface Ocean Systems.** Chair: Andrew Lenton (Australia)
- \*WG2-Interior Ocean.** Chair: Nicolas Gruber (Switzerland)
- \*WG3-Ocean Acidification.** Chair: Jim Orr (France)

Since SOLAS and IMBeR have a new science plan, as well as CLIVAR that include work on carbon, the SIC has been revisited. The WGs 1 and 2 have been dismantled in April 2017 and a side event is been organised at the 10th International Carbon Dioxide Conference, Interlaken, Switzerland, 21-25 August 2017 with key scientists to discuss

about a future structure (SOLAS is co-sponsor of the ICDC10).

However SOLAS and IMBeR will keep supporting SOCAT and other products from the SIC WG 1 and 2, as well as the Ocean Acidification group.

#### 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 exists, the data originator and where it is 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](mailto:solas@geomar.de). Access the SOLAS metadata portal at <http://www.solas-int.org/solas-metadata-portal.html>

#### I.e. Task teams

##### **Halogens in the Troposphere (HitT)**

This SOLAS/IGAC sponsored task team was established in 2003 with the primary objective to determine and quantify the importance of reactive halogen compounds in tropospheric chemistry and climate forcing. The goal of HitT was 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.

In late 2015, IGAC decided to end its sponsorship of HitT. SOLAS continued to support HitT with the hope that the task team will be revisited by SOLAS SSC member Alfonso Saiz-Lopez and Lucy Carpenter. Both worked on a proposal for a new activity built upon HitT since, however in the meantime an activity named CATCH on cryosphere and atmospheric chemistry, see below, emerged and Alfonso and Lucy are currently looking into the development of CATCH in parallel of reshaping HitT in order to avoid overlaps and/or cover gaps.

There was a PICO session at the EGU 2017 on Halogens in the Troposphere, well attended, with approximately 100 people and it is planned to have another one in 2018 too.

##### **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).

As one of the ADOES activities, aerosol sampling was conducted during the Training Ship "Kagoshima Maru" (belong to Kagoshima University) cruise in the south of Kyushu Island crossing the Kuroshio with China and Japan collaboration from 12 to 20 November 2016.

##### **SOLAS Task Team: Air-Ice Chemical Interactions (AICI)**

The Air-Ice Chemical Interactions Task Team (AICI) was created in 2003 and endorsed by SOLAS and IGAC. 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 (USA) and Thorsten Bartels-Rausch (Switzerland). Since late 2015, IGAC is no longer sponsoring AICI.

In parallel, 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.

SOLAS did not follow IGAC and still endorses AICI/OASIS. However the group was asked to revisit their goals and to re-structure themselves. From this regrouping emerged CATCH, Cryosphere Atmospheric Chemistry activity, supported by IGAC. A first shaping community workshop took place on 19-21 April 2017 in Paris, France. SOLAS supported this workshop and will discuss at its SSC meeting in June a possible endorsement of the activity.

The CATCH mission is to facilitate atmospheric chemistry research within the international community, with a focus on natural processes specific to cold regions of the Earth. Cold regions include areas which are seasonally or permanently covered by snow and ice, from the high mountains to the polar ice sheets and sea ice zones as well as regions where ice clouds are found.

CATCH scientists will aim to understand and predict:

- How aerosols are formed and processed in cold regions;
- How cold region aerosols act as and impact cloud properties;
- Feedbacks between climate change and atmospheric chemistry that are determined by changes in the cryosphere;
- How the ice core record can be used to understand global environmental change;
- How physical, chemical, biological, and ecological changes in sea ice and snow impact atmospheric chemistry;
- How microbiology adapts and impacts biogeochemical cycling of elements in ecosystems of cold environments; and
- Establish background composition (trace gases and aerosols) in cold regions that are undergoing industrialization as well as impacted by climate change.

More information available at <http://igacproject.org/CATCH>

#### **I.f. SOLAS Open Science Conference 2019**

A call to bid for hosting the next SOLAS Open Science Conference in 2019 was issued in March 2017. As today, no proposal has been received. The call mentioned that SOLAS would welcome proposal from a country of the southern hemisphere.

#### **I.g. Ocean Knowledge-Action Network (KAN)**

SOLAS took part in the scoping workshop on the development of an integrated ocean research network, in Kiel, Germany, 4-5 December 2016 (report available on line) and is involved in the establishment of teams to lead the O-KAN. The O-KAN is coordinated by Anke Schneider based in Kiel, Germany. The O-KAN will be officially pre-launched at the UN Ocean conference in early June 2017 in New York, USA.

SOLAS is also taking part in a scoping Belmont Forum CRA meeting on 30-31 May in Brussels, Belgium.  
<http://www.futureearth.org/future-earth-ocean>

## **II. Activities (including capacity building) and publications that resulted from the project's work since the previous year's report**

#### **II.a. SOLAS Summer School 2018**

The SOLAS Summer School 2018 (SSS) is scheduled to take place from 23 July to 3 August 2018 in Cargese, Corsica, France.

The programme of the school has been worked on. The request for the French Vessel has been made. A funding of 10kUSD from OCB has been secured. No other proposals are in the pipe yet. Crowd sourcing has been investigated but not yet set up. A webpage is open at the University of Galway, along with a mailing list for potentially interested participants. <http://solassummerschool.nuigalway.ie/>.

## II.b. Collaboration with ESA

After the completion of the OceanFlux projects, ESA mentioned its very high interest in continuing the collaboration with SOLAS, though additional funding.

The final workshop of the OceanFlux Greenhouse Gases Evolution project took place on 6-9 September 2016 in Brest, France, entitled 'Air-Sea Gas Flux: Progress and Future Prospects'. Posters and presentations are available at <http://www.oceanflux-ghg.org/Workshop>. The report is available at <https://tinyurl.com/ybcwfyow>.

A SOLAS/ESA workshop on "Harnessing Remote Sensing to Address Critical Science Questions in the Ocean-Atmosphere Interface" took place on June 13-15, 2016 in Frascati, Italy. Workshop conveners were SOLAS SSC members Ilan Koren and Emmanuel Boss.

The challenges in surface ocean-lower atmosphere exchange research are highly interdisciplinary, blending ocean and atmosphere chemistry and physics, with the cryosphere and clouds thrown into the mix. Moreover, the spatial and temporal scales of SOLAS challenges cover many orders of magnitude, and remote sensing is the only practical mean to monitor large-scale properties and trends. On the other hand, classical radiation transfer sciences focus on the interactions of electromagnetic radiation with matter, how to measure it and how to invert the measured electromagnetic signals into information on the underlying matter. Climate problems are challenging, and future progress is now dependent on extending radiation transfer and remote sensing science beyond the relatively well-defined domains of the oceanic ecosystem and atmospheric aerosols.

Toward dismantling boundaries between SOLAS science and remote sensing, we held a meeting dedicated to highlighting the key challenges in the SOLAS sciences, and how remote sensing measurements and approaches can help address them. We brought remote sensing, SOLAS, and related sciences experts together to brainstorm on the issue, and to produce few examples of key SOLAS problems that could be approached by new or improved remote sensing methodologies.

To set the stage, the first part of the workshop was dedicated to perspective talks on both, SOLAS subjects and remote sensing. We then moved to group discussions on key topics. Veronique Garcon opened with an overview of the SOLAS project, its importance, and key scientific challenges. Lisa Miller talked about SOLAS at high latitudes and how interactions with ice and land affect the dynamics of near interface processes, and Paulo Artaxo described how multidiscipline and multiscale climate questions are studied over the Amazon. The next cluster of talks was dedicated to the state of the art in ocean and atmosphere remote sensing. Chris Hostetler talked about current and future developments in active remote sensing of ocean and atmosphere. Jacek Chowdhary described recent developments in polarimeter data inversion to study the atmosphere and oceans, and Oleg Dubovik described the GRASP (Generalized Retrieval of Aerosol and Surface Properties) as a unified framework for characterizing atmospheric (and potentially oceanic) properties.

The subsequent discussions were organised around three groups tasked with identifying SOLAS themes with particular potential to benefit from new approaches to remote sensing measurements and data. Those discussions generated three questions for further development:

1. How can turbulence be quantified in the global ocean? (led by Griet Neukermans);
2. To what extent does the ocean ecosystem affect the composition and radiative properties of the lower atmosphere? (led by Brian Ward); and
3. How do the characteristics of surface ocean organic matter impact properties of primary aerosols? (led by Yoav Lehahn).

A commentary manuscript is now being prepared for the journal *Elementa: Science of the Anthropocene* and will present to the Earth system science community the new ideas generated at this workshop, including how existing and possibly future remote sensing tools could be used to answer these questions.

In October 2016, Ilan Koren and Brian Ward replied to an ESA/Future Earth call for funding for a follow up workshop. The proposal was successful and SOLAS will have 12k Euros to organise the event. This workshop is hoping to take place in late October 2017 in USA, in the vicinity of Washington DC in order to encourage participation from NASA scientists.



### II.c. 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, the People's Republic of China, the Republic of Korea, the Russian Federation, and the United States of America.

SOLAS did not attend PICES Annual Meeting of the last years, however SOLAS engaged with the scientific planning of the 4th International Symposium on 'The Effects of Climate Change on the World's Oceans', Washington DC, USA, 4-8 June 2018. SOLAS is a co-sponsor. This is a PICES, ICES, IOC, FAO event.

### II.d. SOLAS Science and Society workshop

At the SOLAS Open Science Conference in Sept 2015, a discussion session on SOLAS Science and Society took place and suited a lot of interest. One of the outcomes was to have a workshop dedicated to the topic. Christa Marandino and Erik van Doorn co-organised it in Brussels, Belgium on 26-27 October 2016. The workshop brought together researchers in the field of ocean-atmosphere interactions and social scientists. The two-day workshop focussed on three separate topics:

- Valuing carbon and the ocean's role,
- (In)Forming policy across the air-sea interface, and
- The shipping industry and air-sea interactions.

A paper for the review Ambio is being finalised and will be submitted shortly.

Following the success of this workshop, three more are underway.

- 1- A follow up on 'how to evaluate Blue Carbon?' took place on 30 March-1 April 2017 in Monaco at the occasion of the Monaco Ocean Week. It was co-organised by Nathalie Hilmi, Martin Johnson, Christa Marandino and Erik van Doorn. A special issue in Frontiers is under preparation.
- 2- A small workshop on air-sea interactions in policy and international stewardship of the open ocean will take place in Roma, Italy on 14-15 June 2017 co-organised by Emilio Cocco, Christa Marandino and Erik van Doorn.
- 3- A one-day workshop is organised on 26 October 2017, with the aim to develop plans for SOLAS research focusing on shipping, and to bring together groups of researchers keen to contribute to this research. This workshop is organised back-to-back with a conference co-sponsored by SOLAS on 'Shipping and the Environment- From Regional to Global Perspectives', 24-25 October 2017 in Gothenburg, Sweden. This conference is focussing on the environmental impact of shipping and its importance within policy, marine spatial planning and the maritime transport sectors.

### II.e. Biogeochemical Exchange Processes at Sea Ice Interfaces: BEPSII

BEPSII is now supported by SOLAS and CliC (Climate and Cryosphere).

Because of the strong linkage between BEPSII activities and SOLAS, and the conclusion of the SCOR support to this group in 2016, BEPSII is now co-sponsored by SOLAS and CliC. BEPSII will act as a link between both projects. <https://sites.google.com/site/bepsiiwg140/home>.

The BEPSII annual meeting took place early April in La Jolla, USA. A 'SOLAS event report' is underway. In the meantime, one may read an article on BEPSII published in January 2017 in the PICES Newsletter, available at <https://tinyurl.com/yacchxcx>.

#### **II.f. Workshop on 'Frontiers in ocean-atmosphere exchange: Air-sea interface and fluxes of mass and energy'**

This workshop took place on 15-19 May 2017 in Cargese, France. It is to target SOLAS Theme 2, which deals with the ocean atmosphere exchange of heat, greenhouse gases, momentum, freshwater, and aerosols. The uncertainty in the air-sea exchanges of these constituents constrains our ability to understand and model our changing climate. Accurate quantification of air-sea fluxes is required for forcing ocean models, understanding ocean dynamics, investigating the forcing of variability by the atmosphere and ocean, understanding the ocean's role in climate variability and change, and assessing the realism of models used for predictions from weather to climate time scales.

More information available at <http://airsea.nuigalway.ie/cargese/workshop>.

A 'SOLAS event report' is underway.

#### **II.g. Ocean Acidification Training and Community Networking in Africa: Pathways to Success, 13-16 Feb 2017, Dakar, Senegal**

Training and networking events on ocean acidification took place for the first time in West Africa at Dakar (Senegal). The events were organised by Future Earth Coasts with the support of KOSMOS Energy, SOLAS, MaREI, OA-ICC, IRD, to name a few, represented by participants of the events.

The training workshop assembled 15 participants from Senegal, Benin, Togo, Cameroon, Nigeria, Benin, and Cote d'Ivoire, and 6 trainers coming from France, Sweden, USA, Spain and South Africa. Lectures and discussions covered an introduction to oceanic conditions off West Africa, the goal and urgency to study ocean acidification, as well as the chemistry involved in the acidification of the ocean and its impacts on marine biodiversity. Theory was about ocean acidification, measurement techniques, design of relevant acidification experiments, and manipulations in the field and in the laboratory. One day field trip was organised for practical training where aquarium experiments of ocean acidification were built up in real time. The trainees received their certificates of completion.

Next to the training, a networking event took also place with interactions with the training participants on plenary sessions. About 17 networking participants were coming from Nigeria, Ghana, Morocco, Tunisia, Kenya, Cameroon, Cote d'Ivoire, Tanzania, Algeria, Togo, Benin, Egypt, Madagascar, Senegal, and South Africa. Presentations and discussions took place for developing the OA-Africa network and knowledge exchange on operational outcomes and identification of current needs (resources and capacity), identification of collaboration opportunity including funding, and of outputs and avenues for dissemination in Africa. Plans for white papers were presented to define current knowledge of OA-Africa and next steps forward. A steering committee involving researchers from Africa was then designed to provide guidance and direction of the network.

A dinner event was hosted where a range of NGOs, practitioners and government officials from Senegal were invited along with the scientists. This event recognised the importance of involving organisations and stakeholders based in Senegal who can provide important in-country context, expertise, and experience. This dinner event provided an opportunity to connect to researchers, NGOs, and government officials in Senegal who are working tirelessly to manage environmental and ocean resources with scientists and students working on ocean acidification across Africa.

A 'SOLAS event report' is underway.

#### **II.h. SOLAS in Asia: A Future SOLAS Symposium**

Asian countries have made considerable contributions to SOLAS in the broad context of international collaborations, especially in the fields of ocean carbon cycle, air-sea exchange and atmospheric deposition to the oceans. Considering Asian countries acting as the world economic engines, SOLAS studies therein should

strengthen internal collaborations and pioneer some international collaboration programs to encourage future social-economic activities.

An Asia Symposium was organised in Qingdao, China on 26-28 October 2016, following the 16th SOLAS Scientific Steering Committee meeting. This Future SOLAS Symposium aimed to foster the exchange of ideas and knowledge between 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.

**Organizer:** Ocean University of China

**Sponsors:**

National Nature Science Foundation of China (NSFC)

Qingdao National Laboratory for Marine Science and Technology, China

Key laboratory of Marine Environment and Ecology, Ministry of Education, Ocean University of China

State Key Laboratory of Marine Environmental Sciences, Xiamen University, China

**II.i. Contribution to 2017 Joint IAPSO-IAMAS-IGA Assembly**

The 2017 Joint IAPSO-IAMAS-IGA Assembly will take place in Cape Town, South Africa from 27 August to 1 September 2017.

There are two sessions of particular interest for the SOLAS community.

**M01: Atmospheric Chemistry and Physics for the 21st Century**

Convenors: James Drummond, Melita Keywood, John P. Burrows

With subsessions on Multi-scale transport processes or Tracer transport processes over complex terrain; Advances of science in delivering atmospheric services for science and society; Air quality, health and ecosystem impacts; Air-snow-ice interactions; Atmosphere ocean interactions and exchange of trace gases; Biomass burning; Global stratospheric ozone; Polar ozone; Climate chemistry interactions and feedback; and Laboratory studies  
In this session, SOLAS invited and supported Maria Kanakidou and Rainer Volkamer to present their work and pay a tribute to Roland von Glasow's contribution to SOLAS science.

**M06: Oceans as a source and sink for aerosols and related feedbacks**

Convenor: Zev Levin

Co-convenors: Ilan Koren, Paul DeMott

Production of CCN and IN from the ocean and the role of aerosols like dust and pollution in affecting the ocean acidity.

This session is a perfect opportunity to collaborate with the SOLAS community. It can link research related to marine ecosystems and aerosols in both ways (i.e. how ecosystems affect aerosol fluxes and properties and how aerosols affect the ecosystem) and on the complex interactions with clouds (i.e. marine aerosols affect clouds and clouds affect the ecosystem).

**II.j. SOLAS IPO welcomed a school pupil**

In February, the SOLAS IPO welcomed a school pupil for a week and showed her what an Ocean Research Institute has to offer and what a project like SOLAS is. Read more at <http://www.solas-int.org/events-archive.html>.

**II.k. SOLAS communication**

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

**SOLASNews newsletter** (NL); emailed to ~2400 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.

Due to lack of man power in the IPO, the last issue was published in summer 2015, there were no issue since and there are no plans underway to issue the next one yet.

**SOLAS Event Report;** since the IPO could not deliver the traditional newsletter and had a series of workshops that took place in 2016/17, the IPO started to produce a series of short reports in the month following an event. The issue 1 was about two GESAMP WG38 workshops in parallel on 'Changing Atmospheric Acidity and its Impacts on the Oceanic Solubility of Nutrients' and on 'The Impact of Ocean Acidification on Fluxes of Non-CO<sub>2</sub> Climate Active Species', 27 Feb-2 March 2017, Norwich, UK. Events endorsed by SOLAS. The report is available on the SOLAS website.

Issues 2 and 3 are about to be finalised and issues 4 and 5 are being planned.

**E-news (former E-bulletins);** are sent to over 2400 SOLAS scientists during the first week of every months since February 2017. Only 2 e-bulletins were sent out in 2016. All issues are archived on the website at <http://www.solas-int.org/archive.html>. The e-news 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. This flyer is printed and copies are available for free.

**Poster;** A poster presenting SOLAS and its new science plan is available to download on the SOLAS website. Anyone is welcome to freely use it for conferences/meetings/workshops or just to have a brief overview of SOLAS.  
**Twitter account;** The IPO created a SOLAS Twitter account in late 2016. Regular posts are sent out since Jan 2017 and the number of followers is steadily increasing since (currently 178).

### **III. SOLAS national networks**

**Thirty nations are part of the SOLAS network. Each has a representative. Find the list below.**

Australia: Sarah Lawson and Andrew Bowie  
Belgium: Nathalie Gypens  
Brazil: Leticia Cotrim Da Cunha  
Canada: Jon Abbatt (NEW)  
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  
India: VVSS Sarma  
Israel: Yoav Lehahn  
Ireland: Brian Ward  
Italy: Chiara Santinelli  
Finland: Lauri Laakso (NEW)  
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: Sarah Fawcett (NEW)  
Sweden: Katarina Abrahamsson  
Turkey: Baris Saglihoglu, Mustafa Koçak, Nazli Olgun  
UK: Tom Bell  
USA: Rachel Stanley

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 2017, 20 reports were received and posted on the SOLAS website. The information contained in the reports has been/are a great source of information for the IPO to report to sponsors but also to facilitate the coordination job and to redistribute the results and progress from some nations to the rest of the SOLAS community. Information provided through the reports is also used to update the implementation strategy of the new SOLAS science plan.

(All the reports received during the reporting period are available in an Addendum to this report.)

#### II.m. Endorsed projects

Over the reporting period, SOLAS endorsed the project Great Barrier Reef and the Tudor Hill Marine-Atmospheric Observatory.

Information about support letter and endorsement are accessible on the website, along with the endorsement submission form.

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

- EO salary, office space and in kind provided by GEOMAR until December 2020
- US-NSF via SCOR annual grant of 25kUSD until 2018, 1/3<sup>rd</sup> cover the annual SOLAS/IMBER working group on Ocean Acidification and the 2/3<sup>rd</sup> left cover the cost of the SSC meeting
- US-NSF via SCOR extra 40kUSD to hire a contractor
- Future Earth annual block grant of 15kEUR contributing to the cost of the SSC meeting
- French CNRS 8kEUR in 2016 and in 2017 for SOLAS activities

#### IV. Update on the Scientific Steering Committee and International Project Office status since the last report

##### IV.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. At the last SSC meeting in October 2016, a committee was set up to start the process to search for the next SOLAS SSC Chair. The committee was composed of Maurice Levasseur, Ilan Koren and Emilie Brévière. A consultation procedure was followed, in April 2017, Lisa Miller was nominated by SOLAS to the four SOLAS sponsors, which approved the nomination and appointed her. Lisa Miller will be the 5<sup>th</sup> SOLAS SSC Chair, acting from January 2018 for 3 years.

SOLAS has an Executive Committee composed of the chair, Ilan Koren, Maurice Levasseur and Cristina Facchini. Since the last report the following SSC members rotated off in December 2016:

- Lisa Miller
- Christoph Garbe
- Brian Ward

Ending his first term and being selected for a second term in the SSC was Alfonso Saiz Lopez. In January 2017 four new SSC members were appointed:

- Jun Nishioka (M, Japan)
- Erik Van Doorn (M, Germany)
- Guiling Zhang (F, China)
- Anna Rutgersson (F, Sweden)
- 

The SOLAS SSC met in Qingdao, China, 24-26 October 2016 for its 16<sup>th</sup> SSC meeting. The next SSC meeting is currently scheduled to take place on 19-21 June 2017 in Bologna, Italy. Unfortunately this year there will be no SOLAS symposium organised due to time constrain.

The current membership of the SOLAS SSC is listed below (17 members including the chair):

Last name	First name	Country of employment	Gender	Scientific expertise	SOLAS expertise	Term	End
Suntharalingam	Parvadha	UK	F	Numerical modelling / C, N, S bgc cycles	Theme 1, cross themes	1	18
Zhang	Guiling	China	F	Bgc of trace gases	Theme 1	1	19
Sarma	VVSS	India	M	Bgc cycling of C, N in the ocean and estuaries, stable isotopic geochem/ OA	Theme 1	1	17
Minnett	Peter	USA	M	Remote sensing, physical air-sea exchange	Theme 2	1	18
Rutgersson	Anna	Sweden	F	Air-sea physical interaction	Theme 2 WCRP rep	1	19
Boyd	Phil	Aus	M	Marine bgc	Theme 3, geoeng	1	18
Gao	Huiwang	China	M	Atm. deposition and ecological effect	Theme 3	2	17
Koren	Ilan	Israel	M	Cloud physics	Theme 4	2	18
Levasseur	Maurice	Canada	M	Ocean bgc, dimethylsulfide, Arctic, ice algae	Theme 4	1	17
Facchini	Cristina	Italy	F	Physical and chemical processes in multiphase atm. systems	Themes 4 and 5	1	17
Saiz-Lopez	Alfonso	Spain	M	Atm. halogens/ modelling	Theme 5, IGAC connection	2	19
Garçon	Veronique	France	F	Marine bgc and ecosystems dynamics	Integrated topics	2	17
Graco	Michelle	Peru	F	Bgc cycles in upwelling systems, OMZ	Integrated topics	2	17

Nishioka	Jun	Japan	M	Oc. trace metal bgc cycle, Polar oceanography and sea-ice bgc	Integrated topics	1	19
Van Doorn	Erik	Germany	M	Law of the Sea	SOLAS Science and society	1	19
Boss	Emmanuel	USA	M	Ocean optics and bgc	Remote sensing, cross themes	1	17
Engel	Anja	Germany	F	Microbial bgc, sea surface microlayer	Microlayer, cross themes	2	17

The current gender and country balance of the SSC is as follows; for a total of 17 members including the chair:

- 7 female members and 10 male members
- 4 members from developing countries and 13 from developed countries

#### IV.b. SOLAS International Project Office, Kiel

The SOLAS IPO is hosted at the GEOMAR Helmholtz-Centre for Ocean Research Kiel in Kiel, Germany. The office was staffed from June to September 2016 with Stefan Konradowitz, interim Executive Director. In October 2016, Emilie Brévière returned from maternity leave and Stefan Konradowitz left the IPO for a permanent position within GEOMAR. From Oct to Dec 2016, the IPO was staffed with one person, the Executive Director. From Jan to March 2017, Juergen Weichselgartner, ex LOICZ Senior Science Officer, seconded Emilie and in mid-April Jessica Gier started as project officer (75% time) for a year. Minhan Dai with the support from Huiwang Gao, secured some funding in China to hire a second project officer for the IPO to be sitting at Xiamen University. Deadline to apply for the position is 31 May 2017. This position is for 3 years full time. The SSC members should discuss at the next SSC meeting in June 2017 about the possibility to have an official SOLAS regional hub in Xiamen.

The salary of the ED is supported by GEOMAR until 2020, the salary of the PO supported by funding left over by IGBP when it shut down and extra funding from US-NSF via SCOR. Another request to NSF will be made to maintain the PO position after April 2018.

GEOMAR provides office space for the IPO since 1st February 2011 until December 2020.

## Appendix 8 GEOTRACES

### **GEOTRACES SCIENTIFIC STEERING COMMITTEE ANNUAL REPORT TO SCOR 2016/2017**

May 1, 2016 to April 30, 2017

#### SCOR Scientific Steering Committee (SSC) for GEOTRACES Co-Chairs

Ed Boyle, USA

Reiner Schlitzer, Germany

#### *Members*

Eric Achterberg, Germany

Adrian Burd, USA

Zanna Chase, Australia

Jay T. Cullen, Canada

Tina van de Flierdt, UK

Vanessa Hatje, Brazil

Tung-Yuan Ho, China-Taipei

Marina Kravishina, Russia

Phoebe Lam, USA

Rob Middag, Netherlands

Hajime Obata, Japan

Katharina Pahnke, Germany

Alakendra Roychoudhury, South Africa

Yeala Shaked, Israel

Géraldine Sarthou, France

Antonio Tovar-Sanchez, Spain

Liping Zhou, China-Beijing

The SSC membership (listed above) contains representatives of 16 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 oceans; hydrothermal fluxes of trace elements; tracers of ocean circulation; tracers of contaminant transport; controls on distribution and speciation of trace elements; and ocean modelling.

#### 1.0 Progress on implementation of the project

GEOTRACES continues to progress very successfully. GEOTRACES has now more than 1000 section stations completed (1024) from 95 GEOTRACES cruises (including 11 International Polar Year cruises). Next Intermediate Data Product will be released in summer 2017 including data from the first 5 years of the programme. So far, 818 peer-reviewed publications have been published including 20 publications in Nature journals and 12 in PNAS.

#### **1.1 Status of GEOTRACES field programme**

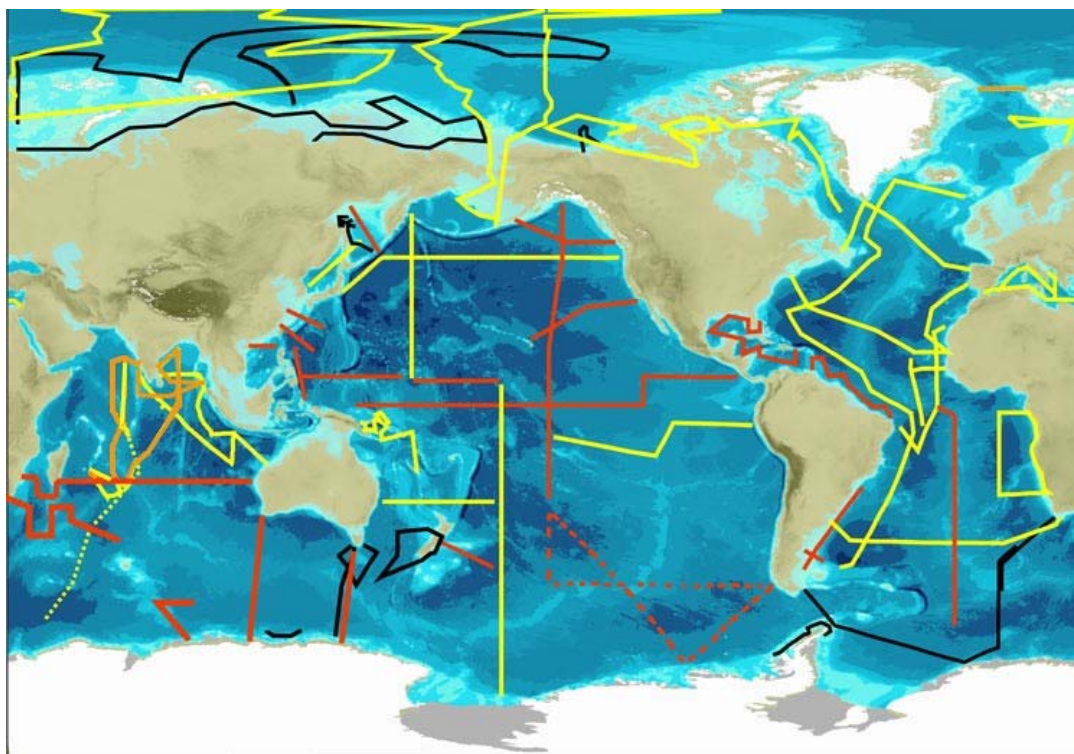
With the completion of the German expedition in the Fram Strait in summer 2016, GEOTRACES successfully completed the international Arctic GEOTRACES Programme (with 4 cruises from USA, Canada and Germany



already completed in 2015). In addition, during this reporting period, the Indian GEOTRACES programme completed 2 cruises in the Arabian Sea, Bay of Bengal and Indian Ocean.

In complement to the GEOTRACES Ocean sections cruises, one process study cruise from Netherlands was completed in the Atlantic Ocean.

The GEOTRACES cruise programme for 2017 includes 2 more section cruises, from UK and Japan, in the Atlantic and Pacific Oceans respectively, and 2 process studies: one from France in the Mediterranean Sea and another one from UK in the Atlantic Ocean.



**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>>.

## **1.2 GEOTRACES Intermediate Data Products**

### ***Release of the new Intermediate Data Product in summer 2017!***

Building on the success of the first Intermediate Data Product (IDP), released in 2014, the next intermediate data product will be delivered at the 2017 Goldschmidt Meeting in Paris, France. A town hall meeting is scheduled on **Wednesday 16 August 2017** at the main venue of the Goldschmidt conference.

The Intermediate Data Product 2017 (IDP2017) will present a remarkable synthesis of data from the Atlantic Ocean and a more complete coverage of data from the Arctic, Indian, Pacific and Southern Oceans and include a larger range of biogeochemical parameters that was included in the IDP2014.

Coming soon!



### *Intermediate Data Product 2014*

A new version of the Intermediate Data Product 2014 (IDP2014) was made available on June 2016. This version is available to download from the following web page: <http://www.bodc.ac.uk/geotraces/data/idp2014/>. A document describing the changes from previous version is available on the web page indicated above.

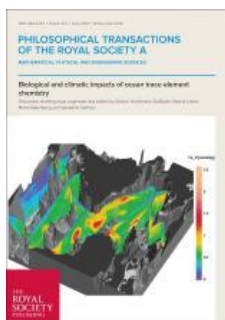
So far, the IDP2014 has been downloaded more than 900 times. In the past year, several events to publicise and promote use of the IDP data with the broader ocean research community were held. Please see section “3.4 GEOTRACES Workshops” below.

### 1.3 GEOTRACES Publications

During the reporting period, 140 new peer-reviewed papers have been published, including the most prestigious journals such as Nature (with 5 papers published) and PNAS (with 2 papers published). In total the GEOTRACES peer-reviewed papers database includes 818 papers.

It is important to highlight that the special issue from the GEOTRACES-Royal Society coupled meeting and workshop to discuss and synthesis findings from the GEOTRACES programme (7–10 December 2015, UK) was published in November 2016.

The volume includes four synthesis papers, which summarise current knowledge and identify areas for future work relating to chemical fluxes at the four ocean boundaries - with the [atmosphere](#), the [continents](#), [sediments](#), and [mid-ocean-ridges](#). These papers and some other papers are available open access.



[Philosophical Transactions of the Royal Society A \(28 November 2016; volume 374, issue 2081\)](#)

[Biological and climatic impacts of ocean trace element chemistry](#)

Edited by Gideon Henderson, Ed Boyle, Maeve Lohan, Micha Rijkenberg and Géraldine Sarthou

Publicity articles to promote GEOTRACES continue to be published nationally and internationally. The complete list of promotional articles is available here: <http://www.geotraces.org/outreach/publicity-documents>

For complete information about GEOTRACES publications please check the following web pages:

- GEOTRACES peer-reviewed papers database: <http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers>
- GEOTRACES special issues: <http://www.geotraces.org/library-88/scientific-publications/geotraces-special-issues>

#### **1.4 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 the following five:

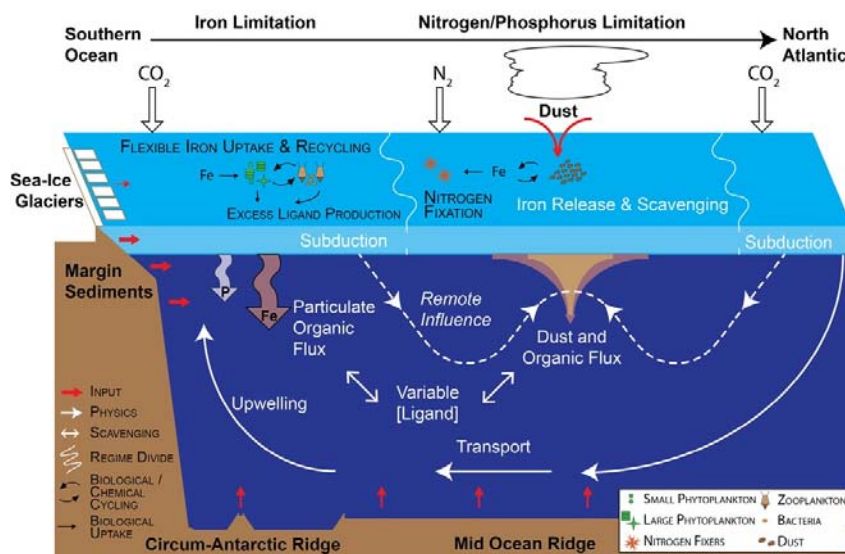
##### [Changing the paradigm on the oceanic iron cycle](#)

Tagliabue and co-workers (2017, see reference below) discuss an extensive review on the recent findings on iron (Fe) cycle in the ocean. They figure out clearly that:

- Fe is a nutrient as essential as nitrogen (N) or phosphorus (P) for the phytoplankton. In other words, the full understanding of any marine ecosystem cannot neglect the analysis of micronutrients anymore.
- Fe oceanic sources are multiple, and supply from continental margins extends far beyond the coastal zone while striking Fe inputs from hydrothermal activity along mid-ocean ridges were observed in all the oceans. This revolutionizes the preceding view of the dust inputs, although those are essential drivers of N<sub>2</sub> fixation at low latitude.
- The cycling of organic iron-complexing ligands has also emerged as a crucial component of the ocean iron cycle, ligand concentrations being not as uniform as considered earlier.
- It is also recognized that phytoplankton can exhibit substantial variations in their iron stoichiometry in different environments...

Synthesizing these new insights provides a more refined picture of the ocean iron cycle, challenging the global ocean modelling for testing hypotheses and projections of change. The authors also draw exciting new frontiers for the oceanic Fe cycle...

**Figure 2.** Revised model of the major processes in the ocean iron cycle, with focus on the Atlantic Ocean. Note that there is a broad meridional contrast between the iron-limited Southern Ocean and the major nutrient-limited low-latitude regimes. Dust remains a dominant source in the low latitudes, but continental margin and upwelled hydrothermal sources are more important in the Southern Ocean. Flexible iron uptake and biological cycling, together with the production of excess iron-binding ligands, dominate the Southern Ocean Nitrogen fixation occurs in the low latitudes (although this process can also be restricted by lack of iron outside the North Atlantic subtropical gyre). The particulate organic iron flux is decoupled from that of phosphorus at high latitudes and the flux of lithogenic material is important at low latitudes influenced by dust. Subduction of excess organic iron-binding ligands from Southern Ocean has a remote influence on the interior ocean at low latitudes.



#### Reference:

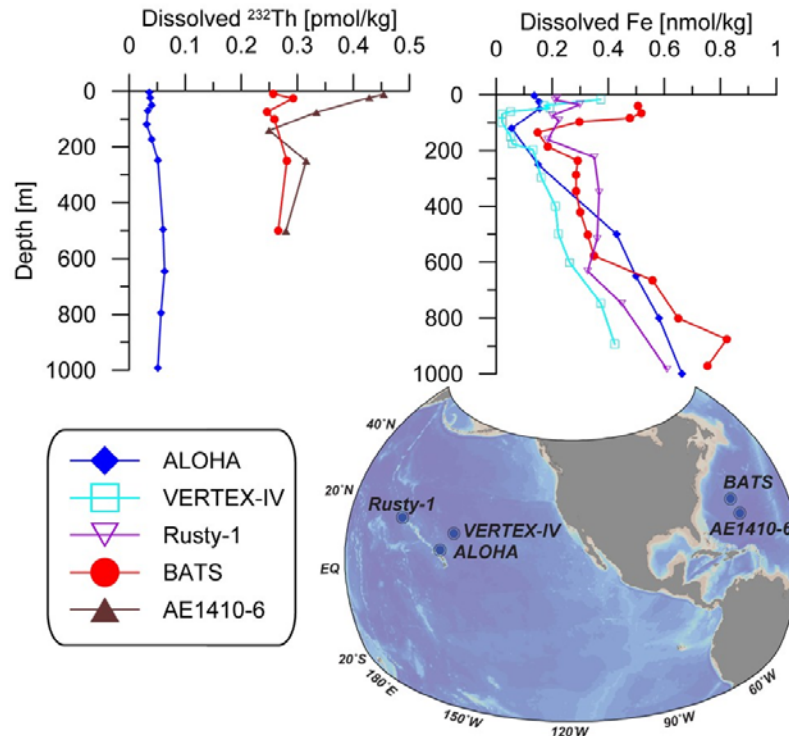
Tagliabue, A., Bowie, A. R., Boyd, P. W., Buck, K. N., Johnson, K. S., & Saito, M. A. (2017). The integral role of iron in ocean biogeochemistry. *Nature*, 543(7643), 51–59. DOI: <http://dx.doi.org/10.1038/nature21058>

#### Contrasting lithogenic inputs from North Atlantic to North Pacific Oceans traced by thorium isotopes

Dissolved thorium (Th) isotopes and iron (Fe) are used to document the transfer of lithogenic material to the ocean.

Two contrasting areas are compared: the Atlantic Ocean around Barbados Islands, under the influence of the Amazon plume and dust of Saharan origin, and the remote North East Pacific Ocean, far from dust inputs. The Amazon is a substantial source of dissolved <sup>232</sup>Th and iron (Fe) to the low-latitude Atlantic Ocean, even as far away a 1900 km from the river's mouth. This complicates the use of <sup>232</sup>Th as a dust proxy in river-influenced ocean regions.

A striking feature is the similarity in Fe concentrations from the North Pacific to the North Atlantic Oceans, while <sup>232</sup>Th reveals a dust flux six fold higher in the later. This supports the idea that dissolved Fe distribution is highly buffered in the ocean.



**Figure 3.** The North Atlantic Ocean receives a much larger input of mineral dust blown from the continents than does the remote North Pacific. This contrast is seen clearly in the seawater concentrations of dissolved Thorium-232, the isotope of thorium that is enriched in the continental crust (left panel). The distribution of Fe, however, is much more homogeneous between these two ocean basins (right panel), despite the fact that continental dust is the major source of Fe in these areas. We think this is because Fe is highly buffered in the ocean by a combination of biological uptake, adsorption onto particles, and complexation by organic molecules, or ligands.

Reference:

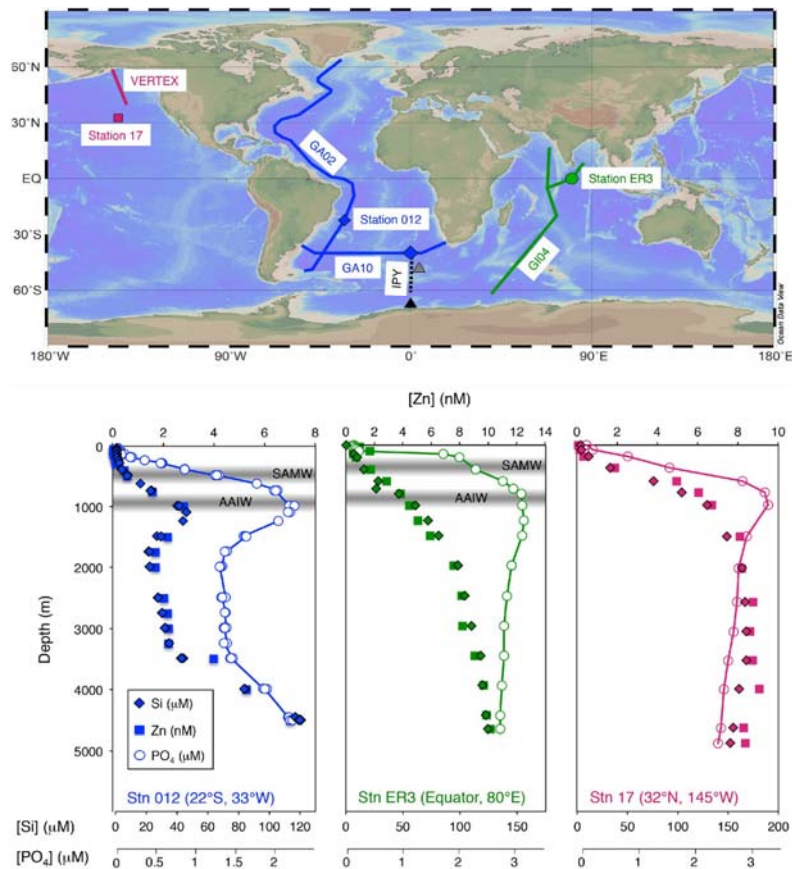
Hayes, C. T., Rosen, J., McGee, D., & Boyle, E. A. (2017). Thorium distributions in high- and low- dust regions and the significance for iron supply. *Global Biogeochemical Cycles*, 31, 1–20. DOI: <http://dx.doi.org/10.1002/2016GB005511>

#### [The coupled zinc-silicon cycle paradox illuminated](#)

The strong similarities between zinc (Zn) and silicon (Si) vertical profiles have led many studies to suggest the uptake of Zn in diatom frustules, followed by simultaneous remineralisation at depth. However, recent lab experiments have demonstrated that Zn, although essential for diatoms, is located in the organic part of the cell. These cells are characterized by particularly high Zn/P ratios in the Southern Ocean (up to 8 times greater than at low latitudes). Such contrasting observations have raised the question as to what processes could lead to such consistent Si-Zn relationship, given that Zn and Si uptake are obviously not controlled by the same biological process. Vance and co-workers (2017, see reference below) infer that the oceanic zinc distribution is the result of the interaction between the specific uptake stoichiometry in Southern Ocean surface waters and the physical circulation through the Southern Ocean hub.

Their approach couples in situ data collected in the different oceanic basins, experimental results from the literature and physical-biogeochemical coupled modelling on a global scale. This work emphasizes how the consideration of 1-D cycling only can bias the understanding of (macro and micro) nutrient behaviours, and therefore their paleo-applications, although 1-D cycling may also play an important role in Zn cycling.





**Figure 4.** Depth profiles of dissolved zinc, silica and phosphate in three different ocean basins (bottom), with the locations of each profile shown on the map (top). Both zinc and silicate show deep maxima whereas phosphate has a much shallower maximum, despite the fact that the oceanic biogeochemical cycle of Zn is dominated by uptake into the organic parts of diatom cells with phosphate. Vance *et al.* explain these features in terms of biological and physical processes in the Southern Ocean.

Reference:

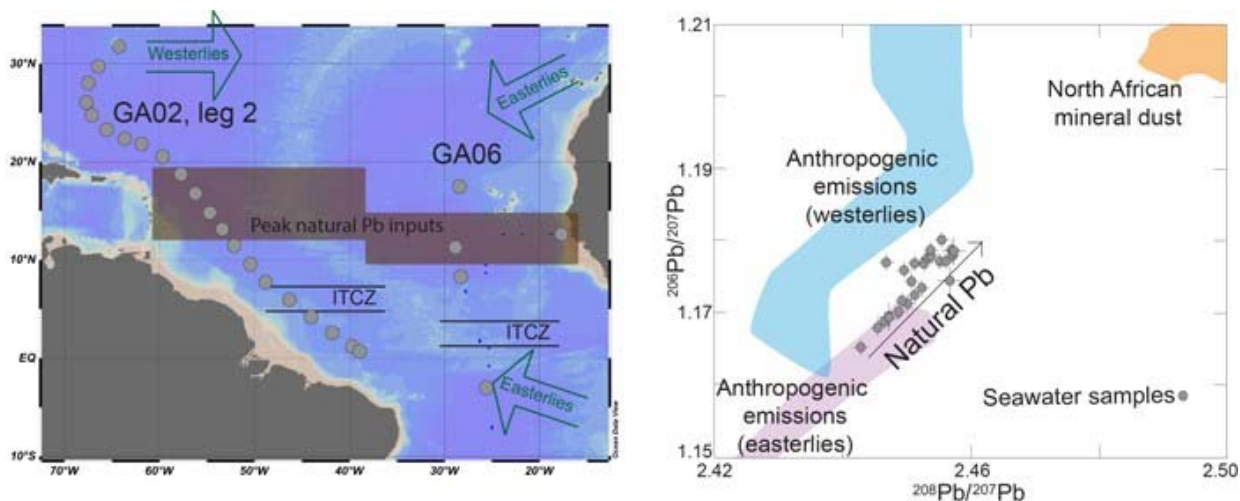
Vance, D., Little, S. H., de Souza, G. F., Khatiwala, S., Lohan, M. C., & Middag, R. (2017). Silicon and zinc biogeochemical cycles coupled through the Southern Ocean. *Nature Geoscience*. DOI: <http://dx.doi.org/10.1038/ngeo2890>

#### Testament of the efficiency of environmental policies

Human activities, such as the combustion of leaded petrol, emissions from non-ferrous metal smelting, coal combustion and waste incineration constitute major environmental lead (Pb) sources during the past century. This resulted in a considerable increase of anthropogenic Pb in the surface and deep waters of the North Atlantic, large enough to mask the natural lead signal.

Increased usage and then phasing-out of leaded-petrol since the mid-70's yielded a decrease of this contamination. By measuring lead concentrations and isotopes (excellent tracers of the different sources of lead) along the GEOTRACES sections GA02 and GA06, Bridgestock and his co-workers (2016, see reference below) reveal for the first time that natural lead can be detected again in the surface water of the North Atlantic. Indeed, significant

proportions of up to 30–50% of natural Pb, derived from mineral dust, are observed in Atlantic surface waters off the Sahara. This clearly reflects the success of the global effort to reduce anthropogenic Pb emissions.



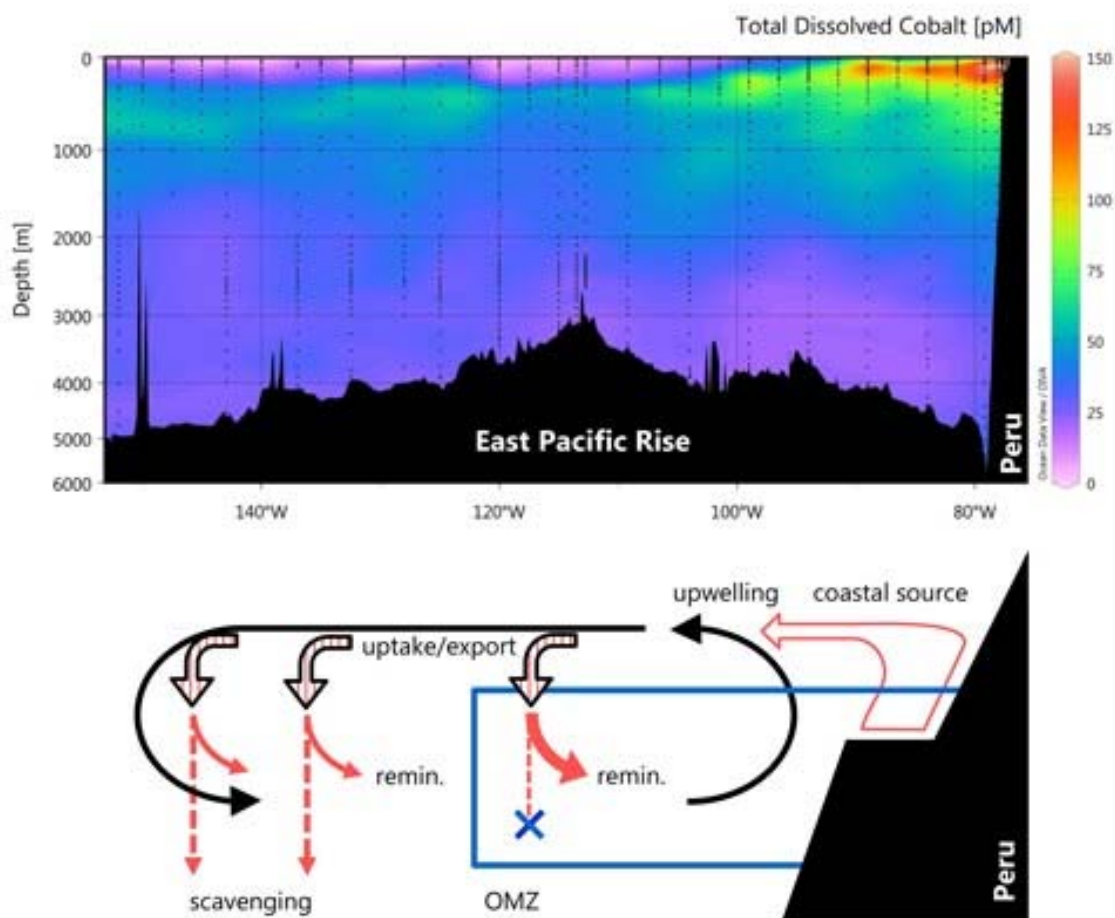
**Figure 5.** Locations of the surface seawater samples analyzed in this study (left). The brown shaded box shows the area found to contain the highest amounts of naturally sourced lead (Pb) resulting from the deposition of North African mineral dust. Significant inputs of natural Pb can be identified by higher Pb isotope ratio values  $^{206}\text{Pb}/^{207}\text{Pb}$  and  $^{208}\text{Pb}/^{207}\text{Pb}$ ; right).

Reference:

Bridgestock, L., van de Flierdt, T., Rehkämper, M., Paul, M., Middag, R., Milne, A., Lohan, M.C., Baker, A.R., Chance, R., Khondoker, R., Strekopytov, S., Humphreys-Williams, E., Achterberg, E.P., Rijkensberg, M.J.A., Gerringa, L. J.A., de Baar, H. J. W. (2016). Return of naturally sourced Pb to Atlantic surface waters. *Nature Communications*, 7, 12921. DOI: <http://dx.doi.org/10.1038/ncomms12921>

#### Oxygen biogeochemistry exerts a strong influence on cobalt cycling

This is an important result of the US GEOTRACES East Pacific Zonal Transect (EPZT) cruise (GP16) discussed by Hawco and his co-workers (2016, see reference below). The distribution of dissolved cobalt and labile cobalt along this section is closely tied to the oxygen minimum zone. This work also shows that (1) elevated concentrations of labile cobalt are generated by input from coastal sources and reduced scavenging at low oxygen; (2) atmospheric deposition and hydrothermal vents along the East Pacific Rise are contrastingly minor sources of cobalt; (3) high cobalt waters are further upwelled and advected offshore and; (4) phytoplankton export returns cobalt to low-oxygen water masses underneath. These processes result in covariation of dissolved cobalt with oxygen and phosphates, schematically represented in the Figure below.



**Figure 6.** In the South Pacific Ocean, high levels of cobalt are harbored in waters that are devoid of dissolved oxygen (upper panel, warm colors). This plume of cobalt stems from the Peru coast and is enhanced by degradation of cobalt-bearing phytoplankton in these waters, and by the absence of removal processes (scavenging) when oxygen is low (lower panel).

Reference:

Hawco, N. J., Ohnemus, D. C., Resing, J. A., Twining, B. S., & Saito, M. A. (2016). A dissolved cobalt plume in the oxygen minimum zone of the eastern tropical South Pacific. *Biogeosciences*, 13(20), 5697–5717. DOI: <http://dx.doi.org/10.5194/bg-13-5697-2016>

## 2. Activities

### 2.1 GEOTRACES intercalibration activities

The Standards and 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. Greg Cutter, who has stepped down from the committee last year, is still completing some tasks associated with aerosol intercalibrations.



Maeve Lohan and Walter Geibert serve as co-chairs. Since the S&I Committee meeting at Stanford University from 27 to 29 April 2016, the S&I committee held several meetings.

- In person:  
23-26 January 2017 (London Imperial College)
- Virtual meetings  
(GoToMeeting): 28  
November 2016  
20 March 2017  
24 April 2017
- Virtual S&I-Data Management Committee (DMC) co-chair meetings: 7  
February 2017.  
26 April 2017

In addition, the committee is in constant communication via email and through a shared online resource, and the co-chairs are in regular personal exchange with members of the DMC and BODC at the respective locations.

The main task of the committee in the past year was the continued preparation for IDP2017, which also included the intercalibration of data that were included in IDP2014 but had not been intercalibrated yet. The aim was to have all datasets in IDP2017 seen and evaluated by the S&I Committee, according to defined intercalibration criteria. This aim was achieved for all but one dataset on 30 April 2017, and the committee is still working to have all data in IDP2017 assessed.

The submission procedure has been improved by providing a dedicated e-mail address for the S&I Committee ([sic@geotraces.org](mailto:sic@geotraces.org)) and by reorganizing and updating the content on the GEOTRACES web page, strongly supported by the IPO in Toulouse. The improvements of the submission procedure 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 intercalibration procedure was designed and put on the website (<http://www.geotraces.org/sic/about-s-i/flow-chart-s-i-data-quality-assessment>). This is part of the continuous improvements in defining and communicating the procedures that are in place to ensure consistent quality of the GEOTRACES data products. A 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. All deadlines for data submission for IDP2017 have now passed.

This year we have also produced with the community intercalibration procedures for BioGEOTRACES, which includes the following parameters:

1. HPLC Pigments
2. Single cell trace metals
3. Targeted Metaproteomics

A new committee member responsible for BIOEGOTRACES will join the S&I committee next year.

The S&I Committee received approximately 750 parameters from the Atlantic, 250 parameters from the Pacific, nothing submitted from the Indian Ocean, 32 parameters from past IPY cruises, 44 parameters from process studies and 32 parameters from GEOTRACES-compliant datasets for the final IDP2017 deadline. During the meetings of the S&I Committee, all datasets were introduced by the assigned committee members, and discussed by the full committee. In nearly all cases, questions of the committee about data quality could be easily resolved and only a small and limited number of parameters did not pass intercalibration, mostly due to issues with sampling methods.

It is important in this context to refer newly joining contributors to the existence of the GEOTRACES cookbook, for which an updated version (3.0) is in preparation for release in summer 2017. A number of intercalibration reports were of outstanding quality, providing excellent detail on intercalibration procedures. Continuous exchange with submitters and the community clearly results in a better understanding of the requirements for the intercalibration process and benefits data quality and comparability in GEOTRACES.

Coverage in the Atlantic and especially the Pacific is now strongly improved from IDP2014. The first datasets on biochemical parameters (BioGEOTRACES) have been submitted and will be intercalibrated for IDP2017. For some important sections, no data or very little data were submitted for IDP2017, in spite of many attempts to raise awareness of the submission procedure. Progress has been made with including hydrography, DIC, SF<sub>6</sub>, CFC's and some sensor datasets, where a defined intercalibration procedure developed by these communities is used, e.g., CLIVAR.

### ***Other Activities***

Prof. Jim Moffett is now responsible for GEOTRACES consensus material. In the past year more data has been submitted for this, extending the number of elements that can have consensus material. We hope that next year this will be published on the website. Prof. Eric Achterberg has also collected consensus material from GA08. These samples have now been distributed to laboratories around the world to generate consensus data. We hope in the next year these materials will be available for use by the community.

A small intercalibration exercise for labile particulate materials was undertaken this year so that labile particulate data could be included in IDP2017. This consisted of groups using a specific leach to apply this to 3 different CRM's. Four different laboratories who routinely carry out this work took part in this exercise resulting in labile particulate material being intercalibrated for IDP2017.

## **2.2 Data management for GEOTRACES**

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanographic Data Centre (BODC), with the head office located in Liverpool; the GEOTRACES Data Manager (Chris Daniels) 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/](http://www.bodc.ac.uk/geotraces/cruises/section_maps/)) and upcoming cruises on the programme page (<http://www.bodc.ac.uk/geotraces/cruises/programme/>)
- liaising with the Data Management Committee and Standards and Intercalibration Committee to ensure 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

Chris Daniels is the GEOTRACES Data Manager since January 2017. He took the position of Abigail Bull who left to take a different role. Since Chris started on his role he has focused entirely on processing data to be included in the IDP2017.

### **Data overview**

The data management of the GEOTRACES Project is a large undertaking with a total of 95 cruises (including all cruise legs) associated with the project (this takes into account all section cruises, process studies and compliant data). More than 800 Scientists have taken part in the GEOTRACES cruises, with 15 different nations having run a major GEOTRACES IPY/ section/ process study cruises.

*Summary of completed GEOTRACES cruises to date:*

<b>Section cruises</b>	<b>IPY cruises</b>	<b>Process studies</b>	<b>Compliant data</b>
35 cruises (including all legs) with 27 sections	11	28 (including all legs) with 24 sections	9

In addition, 2 intercalibration cruises have been completed.

### **2.3 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.

From October to December 2016, the IPO has hosted Bob Anderson, US GEOTRACES project office director and past co-chair of the GEOTRACES SSC. The main purpose of his visit was working on the development of the Intermediate Data Product 2017 parameter list.

This year, we want to highlight the following new products:

- GEOTRACES eNewsletter Special Issue – Discovery Digest

The GEOTRACES IPO has introduced a new type of newsletter, a sort of “discovery digest”, which is designed to highlight the progress in a given GEOTRACES-relevant topic. The first one was published in March 2017 and it was devoted to recent discoveries in the oceanic cycle of iron. This issue is

available here: <http://www.geotraces.org/outreach/geotraces- eNewsletter/listid-12/mailid-768-geotraces- discovery-digest>

Following the publication of this special issue, the GEOTRACES IPO has received several spontaneous congratulation and thank you messages from the GEOTRACES community. At the time of writing this report, the issue has received more than 1,300 hits.



- New query capability for the GEOTRACES Publications database

A dynamic querying capability for the GEOTRACES publications database is currently being developed with the help of the Data Service of the Observatoire Midi-Pyrenees (SEDOO) in Toulouse, France. Once available, it will be possible to make advanced searches within the GEOTRACES publication database. This system will also improve the Intermediate Data Product system to link the original publications associated with the given tracer and cruise.

- Video presenting the GEOTRACES Programme

Short video interviews to SSC members were held during last SSC meeting, which was hosted by the GEOTRACES IPO in Toulouse. The IPO is currently working with Jean-Hugues Babary from Centre for the Development of the Pedagogy at the Université Paul Sabatier and the journalist Jean François Hait editing the videos.

- GEOTRACES website (<<http://www.geotraces.org>>)

A new menu devoted to Standards and Intercalibration activities has been added on the GEOTRACES site. Facebook and Twitter feeds will be added on the GEOTRACES homepage in order to give more visibility to all the activity in these two media.

- Publicity articles

An article introducing GEOTRACES has been published on the Journal of the Atlantic Society of Oceanographers, OKEANOS (Spain) with the aim of promoting GEOTRACES research in Spain. The volume (in Spanish) is available here: <http://es.calameo.com/read/0050684378fc854b0db53>

From the regular tasks we want to highlight the following:

- Meeting and Workshop organisation

The IPO hosted the 2016 DMC and SSC meetings in Toulouse (12-16 September 2016) and organised the Workshop “Exploring GEOTRACES Data with ODV” and the GEOTRACES Indian Ocean Planning Workshop which were held in Japan (June 2016). Minor assistance was also provided to the organisation of the joint GEOTRACES/OCB Workshop: “Biogeochemical cycling of trace elements within the ocean: A synthesis workshop”, the “Arctic-GEOTRACES Early Career Researcher Networking Event (ASLO 2017)” and the “IDP2017 Parameter Committee meetings.” Please read section “GEOTRACES Workshops” for further information about the workshops.

- Policy advice

The IPO is actively involved in the G7 Oceans Initiative. It has coordinated the topic « Ocean Chemistry ». The development of a coordinated action plan for research vessels and the need for coordinated programmes coupling physics, chemistry and biology has been the top priorities the IPO has advocated for. SCOR is included as external expert in this process.

The IPO has assisted Roger François (University British Columbia, Canada) and Peter Croot (NUI-Galway, Ireland) in their initiative of approaching the Arctic Monitoring and Assessment Programme (AMAP) with the objective of establishing a joint Arctic workshop. Unfortunately, AMAP had no funding available to dedicate to this joint workshop.

- Capacity Building

During Bob Anderson’s visit to the GEOTRACES IPO, support was provided to colleagues in Korea who want to initiate a Korean GEOTRACES programme. Korea has a new ship (*RV ISABU*) and has purchased the most-up-to-date clean sampling system so there is high expectation that Korea could successfully carry out GEOTRACES missions. A proposal for funding a Korean GEOTRACES programme has been submitted to the Korea Institute of Marine Science and Technology Promotion (KIMST).

- Some statistics

30 new highlights published (135 in total)  
5 eNewsletter published, including one special issue (bimonthly 25 in total)  
140 new peer-reviewed papers included in the GEOTRACES Publication Database (818 in total)  
135 new articles published on the GEOTRACES website  
122 announcements sent through the GEOTRACES mailing list  
112 new posts on Facebook and 371 likes (top post reach 1,6K)  
240 tweets and 431 followers (top tweet reach 3,1K)  
94 new subscribers on the GEOTRACES website

The IPO thanks Olivier Boebion (IT system administrator at Observatoire Océanologique de Villefranche sur Mer, France) for all his assistance with the GEOTRACES web site.

## 2.4 GEOTRACES Workshops

Six GEOTRACES workshops were held in the past reporting year including:

Exploring GEOTRACES data with Ocean Data View (Goldschmidt 2016 Workshop), 26 June 2016, Yokohama, Japan.

46 participants from 13 different nations participated in this hands-on workshop which goal was to teach standard and advanced ODV methods for the exploration and scientific analysis of environmental data. The GEOTRACES Intermediate Data Product 2014 (IDP2014) was used as example dataset. Participants learned 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 of the wide range of derived variables available in ODV was given and a number of variables often needed in geochemical research were described and applied.

The workshop started 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.

For further information: <http://www.geotraces.org/meetings/geotraces-events/eventdetail/263/-/exploring-geotraces-data-with-ocean-data-view>



**Figure 7.** Participants of the Workshop "Exploring GEOTRACES with Ocean Data View".



GEOTRACES Indian Ocean Planning Workshop, 29 June 2016, Yokohama, Japan

35 GEOTRACES scientists met in Yokohama (Japan) to discuss the GEOTRACES Indian Ocean implementation plan. This was an occasional workshop held during the Goldschmidt conference in Japan.

As a result of the Workshop, the following up-coming GEOTRACES cruises in the Indian Ocean were identified: India (2 cruises completed in autumn 2016 and winter 2017), Germany (cruise in 2018) and Australia (cruise in 2018). Other nations (France and South Africa) are currently planning cruises in the Indian Ocean.

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

More than 100 investigators from 12 nations participated in this workshop focused on setting priorities for exploiting GEOTRACES data to advance scientific objectives at the interface between marine geochemistry and marine ecology. This workshop was the second foundational workshop of the GEOTRACES synthesis of results strategy. It was jointly sponsored by the GEOTRACES programme and the Ocean Carbon and Biochemistry activity of the U.S. Carbon Cycle Science Program.

Workshop activities were organised around three scientific themes:

- 1) Biological uptake and trace element bioavailability,
- 2) Abiotic cycling and scavenging, including particulate and dissolved speciation, and
- 3) Export, recycling and regeneration

Following a series of plenary talks designed to stimulate discussion on these topics, workshop participants spent most of the workshop in smaller groups that identified critical knowledge gaps in each of these areas, as well as strategies to meet those needs. Participants defined six topics to be pursued in greater detail in synthesis papers that combine GEOTRACES data with results from other programmes, such as those involving molecular biology. These activities will inform and improve models used to predict how marine ecosystems are going to respond to future environmental changes, including pollution and global warming.

The plenary presentations (PDF files) from the Workshop can be opened and downloaded directly from the agenda available on the workshop web site: <http://web.whoi.edu/geotraces-synthesis/agenda/>

Main recommendations and anticipated products from the meeting are listed below:

- Explore Redfieldian concepts of elemental stoichiometry using GEOTRACES TEI data
- Estimate Bioavailability of Fe with oceanographic data using “bioavailability envelope” concept of Lis et al., ISME Journal, 2015
- New hypothesis for light and Fe co-limitation in deep chlorophyll maxima
- A Synthesis Paper on “Paradigms of ligand composition and cycling and the degree of confidence in them” will be produced
- Compare radionuclide-based methods ( $^{234}\text{Th}/^{238}\text{U}$ ;  $^{228}\text{Th}/^{228}\text{Ra}$ ;  $^{230}\text{Th}/^{234}\text{U}$ ;  $^{210}\text{Po}/^{210}\text{Pb}$ ; Pu/Np) to estimate the downward flux of particulate C, N, P, biogenic Si,  $^{232}\text{Th}$ , Al, Cd, Fe, Co, Cu, and Mn
- Combine measured TEI distributions with calculated AOU and preformed TEI concentrations to discriminate among effects of abiotic scavenging, biotic uptake and regeneration, and physical transport

A complete list of products is available in the Appendix II to the National Reports to SCOR. For further information: <http://web.whoi.edu/geotraces-synthesis/>

First GEOTRACES-TARA meeting, 5 December 2016, video-conference.

This meeting is one of the first products of the joint GEOTRACES/OCB Workshop described above. [TARA](#) is a French non-profit organisation that manages voyages to study and understand the impact of climate change and the ecological crisis facing the world's oceans.

The meeting explored collaborations between GEOTRACES and TARA programmes and start mining through the existing “omic” data of the TARA, in order to link metrics from sequences with the GEOTRACES data.



East Asia GEOTRACES Workshop, Trace Element and Isotope study in the Northwestern Pacific and its marginal seas, 16-18 January 2017, Sapporo, Hokkaido, Japan

The East Asia GEOTRACES Workshop was held on 16-18 January 2017 in Sapporo, Japan. The main goals were: to evaluate the current status of trace elements and their isotopes (TEI) studies in the Northwestern Pacific Ocean and its marginal seas, and to identify important scientific questions and directions for future regional collaborative studies. For three days a total of 56 registered scientists from China, Germany, Korea, Russia, Taiwan, United States and Japan, took part in the workshop. The workshop consisted of 5 plenary talks, 17 keynote talks and 25 short topics talks related to GEOTRACES & BioGEOTRACES. Early-career researchers were especially encouraged to give a talk, which was very successful. During the workshop regional scientific results, future cruise plans and possible collaborations were discussed. A succeeding workshop is planned for 2018 in China.

For further information: <http://geotraces.jp/EAGW2017/>.



**Figure 8.** Participants of the East Asia GEOTRACES Workshop.



Arctic-GEOTRACES Early Career Researcher Networking Event (ASLO 2017), 26 February 2017, Honolulu, Hawaii

The U.S., European and Canadian [Arctic GEOTRACES cruises](#) in 2015 offered a unique and quasi- synoptic view of the Arctic Ocean. Twenty seven early career scientists came together to kick off the ASLO Aquatic Sciences meeting in Honolulu, Hawai'i on 27 February 2017 to discuss emerging areas of international scientific collaboration within the Arctic GEOTRACES programme. The workshop was a special chance for early career scientists to meet their international counterparts and engage initial discussions of interdisciplinary research topics between programmes.



**Figure 9.** Participants of the Arctic-GEOTRACES Early Career Researcher Networking Event at ASLO 2017.

## **2.5 GEOTRACES Summer School**

The first GEOTRACES summer school will be held in Brest, France, from 20th to 26th August 2017. It will bring together over 60 students and 20 world-leading international scientists.

The summer school aims at teaching the skills and knowledge necessary for a good understanding of the biogeochemical cycles of trace metals. It will allow PhD students and early career researchers to see how their work fits within the international community of GEOTRACES.

General lectures will be given by international experts in the field of the GEOTRACES programme and practical workshops in the laboratory will be ran throughout the week.

This summer school is supported by LabexMER (<https://www.labexmer.eu/fr>) and SCOR. At the time this report is written 110 candidatures to participate in the summer school have been received.

GEOTRACES gratefully acknowledges support from SCOR.

For further information: <https://geotraceschool.sciencesconf.org/>



## 2.6 Special sessions at international conferences featuring GEOTRACES findings

Several GEOTRACES special sessions were held in major international conferences including:

2016 Goldschmidt Meeting, 26 June–1 July, 2016, Yokohama, Japan. For further information: <http://goldschmidt.info/2016/>

*GEOTRACES-sessions:*

\*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/>

*GEOTRACES-session:*

\*Trace element and isotope exchange at ocean boundaries

Convenors: Will Homoky (Oxford), Torben Stichel (Southampton) & Susan Little (Imperial)

VII Congresso Brasileiro de Oceanografia (CBO 2016), 5 - 9 November 2016, Salvador - Bahia, Brazil. For further information: <http://www.cbo2016.org/>

*GEOTRACES-session:*

\*MS5 – GEOTRACES – Brasil

Coordination: Vanessa Hatje (UFBA)

*GEOTRACES-training course:*

\*MC11 – Ocean Data View para iniciantes (Training Workshop)

Speaker: Leticia C. da Cunha (UERJ)

Third Xiamen Symposium on Marine Environmental Sciences (XMAS), 9-11 January 2017, Xiamen, China. For further information: <http://mel.xmu.edu.cn/conference/3xmas>

*GEOTRACES-session:*

\*Biogeochemical Cycling of Trace Elements in the Ocean: GEOTRACES and Beyond Convenors:

Martin Frank, Jing Zhang, Zhimian Cao

ASLO 2017, Aquatic Sciences Meeting, 26 February - 3 March 2017, Honolulu, Hawaii, USA. For further information: <http://www.sgmeet.com/aslo/honolulu2017/default.asp>

*.GEOTRACES-sessions:*

\*004 - Biogeochemical Cycling of Trace Elements and Isotopes in the Arctic Ocean

Convenors: Greg Cutter, Roger Francois, David Kadko, William Landing, Michiel Rutgers Van der Loeff

\*025 - Linking atmospheric deposition to the biogeochemistry of aquatic and marine systems

Convenors: Clifton Buck and Rachel Shelley

029 - REE marine geochemistry in the 21st century: A tribute to the pioneering research of Henry Elderfield (1943-2016)

Convenors: Karen H. Johannesson and Johan Schijf

PAGES Open Science Meeting, 9-13 May 2017, Zaragoza, Spain. For further information: <http://www.pages-osm.org>

*GEOTRACES-session:*

\*12. Trace elements and their isotopes as geochemical proxies of past ocean conditions Convenors:

Catherine Jeandel, Robert Anderson, Susan Little, Thomas Marchitto and Daniel Sigman.

***Forthcoming:***

IUPAC 2017 - World Chemistry Congress, 9-14 July 2017, Sao Paulo, Brazil. For further information: <http://www.iupac2017.org/>

*GEOTRACES-session:*

\*5.8 Trace elements cycling, processes and fluxes across interfaces

Energy, Water and Environmental Sciences (EE)

Symposium Organizers: Roberto M. Torresi and Daniel Belanger.

Co-organizer: Vanessa Hatje

Goldschmidt 2017, 13- 18 August 2017, Paris, France. For further information: <http://goldschmidt.info/2017/>

*GEOTRACES- sessions:*

\*10i: Cycles of Trace Elements and Isotopes in the Ocean: GEOTRACES and Beyond Convenors: Tim Conway, Geraldine Sarthou, Tianyu Chen, Gregory de Souza, Aridane G. González, Kristen Buck, Tina van de Flierdt, Walter Geibert, Zhimian Cao, Catherine Jeandel

\*10o: The Role of Scavenging in the Ocean: Chemical Processes, Environmental Controls and Modeling

Convenors: Yves Plancherel, Phoebe Lam

\*10g: Submarine Groundwater Discharge: Forms, Delivery, Timing, Processes, Pathways and Scaling of Biogeochemical Fluxes

Convenors: Hans Dürr, Nils Moosdorf, Michael Böttcher, Hannelore Waska, Jing Zhang, Walter Geibert

\*10h: Non-Conventional Stable Isotopes in the Ocean: Novel Applications, Technological Advances and Future Applications

Convenors: Horner Tristan, Pearce Christopher, Philip Pogge von Strandmann, Kathleen Scheiderich, Juan Carlos Silva-Tamayo

\*10k: Atmosphere-Ocean Interactions and Impacts on Ocean Chemistry and Biology Convenors: Adi Torfstein, Sophie Bonnet, Eyal Rahav, William Landing

\*10m: Insights into Ocean Processes Through the Application of Radioactive Tracers Convenors: Paul Morris, Guizhi Wang, Virginie Sanial

\*17g: Paleoceanographic and Paleoclimate proxies: Their standing on Elderfield's proxy development Curve

Convenors: Marie-Laure Bagard, Marie Boye, Oscar Branson, Sambuddha Misra, Guillaume Paris, Kauzyo Tachikawa

## 2.7 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.

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.

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.

<b>Nation</b>	<b>Status</b>	<b>System/ Carousel</b>	<b>Bottles</b>	<b>Depth</b>
Australia	Complete	Powder coated aluminium, autonomous 1018 intelligent rosette system	12 x 10-L Teflon-lined Niskin- 1010X	6000 m; 6 mm Dynex rope
Australia	2nd system (complete)	Polyurethane powder- coated aluminium autonomous Seabird rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	12 x 12-L Teflon-lined OTE external- spring Niskin-style bottles	1750 m 9mm Dyneema rope or 200 m 6 mm Dyneema rope with coupling to 6000 m CTD wire
Brazil	Complete	GEOTRACES WATER SAMPLER - 24-bottle sampler for use with 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, winch planned	Powder coated aluminium with titanium pressure housings and fittings	27 x 12-L OTE GO-Flo	8000 m; conducting Kevlar
India	Complete	Powder coated aluminum 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	7000 m; Vectran conducting 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-19plusV2 CTD unit. Powder coated aluminium with Ti parts and pressure housing. Fires at pre- programmable depths	12 X 5-L Teflon-lined Niskin-X	2000 m 0.5-inch Kevlar wire
USA – Polar Programs	Complete	Powder coated aluminium with titanium pressure housings and fittings	12 X12-L Niskin-X	3000 m; conducting Kevlar

### 3. Plans for coming year

The release of the **Intermediate Data Product 2017 (IDP2017)** at the Goldschmidt Meeting 2017 (13- 18 August 2017, Paris, France) will continue to be the top priority for the first trimester of the next reporting period. After the release of the IDP2017, GEOTRACES will focus on seeking feedback from and promoting the use of the IDP2017 data the broad oceanographic community.

In addition, GEOTRACES will continue to **implement the field programme** and its **GEOTRACES synthesis of results strategy** with the third foundational workshop to be held in 2018 in partnership with Past Global Changes project (PAGES). This workshop will be centred on geochemical tracers used as paleoceanographic proxies.

### Acknowledgements

Once more, we wish to express our gratitude to SCOR and Ed Urban for the continuous support and valuable advice to the implementation of the GEOTRACES programme.

Written and compiled by:

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2017



## Appendix 9

### International Quiet Ocean Experiment (IQOE)

Since the 2016 SCOR annual meeting, IQOE has continued to ramp-up its activities and fill out the memberships of its working groups. A summary of accomplishments follows.

#### IQOE Science Committee Meeting

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 a 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), Jennifer Miksis-Olds (USA), Hanne Sagen (Norway), Steve Simpson (UK), 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.

The IQOE Science Committee (SC) met for the second time on 27-28 January 2017 in London, UK. As with the first meeting, several stakeholders attended the meeting to help the IQOE SC work on project implementation. The meeting included updates of ongoing IQOE activities, reports on national IQOE-related activities, and a special session on global soundscape modeling.

The 2018 IQOE Science Committee meeting will be held on 13-14 March 2018. The location is not yet decided. In case the IPO bid is approved (see below), it could be important to meet at the new IPO location.



### Meeting of IQOE Strategy Group

The IQOE Strategy Group (primarily co-chairs, sponsors and staff of IQOE) met in Woods Hole, Massachusetts, USA on 11-12 July 2017. The meeting reviewed the status of IQOE implementation and discussed fund-raising for the project. The meeting also featured an afternoon session with high-level U.S. agency representatives to discuss U.S. IQOE activities, and presentations from U.S. Department of Transportation staff working on the issue of sound in air from human activities and another individual who creates videos explaining scientific activities. The developer of the new IQOE Website met with the Strategy Group by phone to explain the structure of the new Website and to get input on some design decisions.

### IQOE Working Groups

1. **Standardization:** 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. IQOE formed a working group 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. The IQOE Working Group on Standardization is well underway and has a Web page at [http://www.scor-int.org/IQOE\\_WGs\\_Standardization.htm](http://www.scor-int.org/IQOE_WGs_Standardization.htm). The group has already met twice by phone and had begun work on its terms of reference. The group will create an inventory of existing standards relevant to IQOE. The group will recommend best practices for IQOE to adopt, not develop IQOE-specific standards. The group will generate a first overview of existing procedures and facilities for calibrating acoustic receivers. A list of worldwide calibration facilities is being prepared. The group will work with the POGO working group (see below) to construct a global database and Web site of past and current passive acoustic monitoring systems.
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. This working group is in the process of being formed.
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. This group is in the process of being formed and the co-chairs are planning the first meeting of the group.
4. **Acoustic Measurement of Ocean Biodiversity Hotspots:** Coral reefs are some of the most biodiverse areas of the global ocean, are important to human society, and are in danger from global, regional and local changes. 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. The group has been approved by the IQOE SC, will begin its work through a questionnaire to members of the group and conference calls, and is planning an in-person meeting for later this year. Its Web page is at [http://www.scor-int.org/IQOE\\_WGs\\_Coral\\_Reefs.htm](http://www.scor-int.org/IQOE_WGs_Coral_Reefs.htm). The IQOE Strategy Group noted that there are other ocean biodiversity hotspots (e.g., kelp forests, mangrove areas) and requested that the title and purview of the group be generalized to ocean biodiversity hotspots. The name of the group was changed to the title above.

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. The group is also working on an acoustic Essential Ocean Variable (EOV) and updating the list of acoustic observing systems in Appendix 2 of the *IQOE Science Plan*. The POGO working group met in conjunction with the Acoustical Society of America meeting in Boston, Massachusetts, USA in June 2017. The POGO IQOE WG has written an acoustic EOV for submission to the GOOS Biology and Ecosystems expert panel; a WG consensus draft of the acoustic EOV is currently under review by the panel, with submission of a final draft to the GOOS Steering Committee intended in time for consideration at its September 2017 meeting. While the time series of acoustic pressure measurements is a

physical variable, it is used to estimate many critical biological and ecological parameters. In part because of its physical basis, ocean acoustic measurements are at a more mature readiness level than most biological EOVs and we hope that an acoustic EOV will help the integration of ocean acoustics into observing systems commensurate with its importance to many oceanographic disciplines. The POGO WG is also working with the Web designer to implement a searchable database of passive acoustic observing systems on the IQOE Website. This database will update Appendix 2 from the IQOE Science Plan and will allow input of new information by system operators.

#### IQOE Web Site

An IQOE Web site has been developed with basic information about the project (see [www.iqoe.org](http://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 is being added when available. Renewal of the IQOE Web site is in progress.

#### Funding

SCOR budgeted US\$10,000 for IQOE implementation activities in 2017 and an additional \$10,000 was provided by the Monmouth University-Rockefeller University (MURU) consortium. These funds were used to support the January 2017 meeting of the IQOE Science Committee. \$50,000 in additional funds will be provided for the nine-month period of 1 August 2017 to 31 March 2018 by the MURU Consortium for IQOE Working Group meetings and the 2018 meeting of the IQOE Science Committee.

#### International Project Office (IPO)

We have had a serious offer for hosting of an International Project Office (IPO) for IQOE in Europe and the potential host is in the process of seeking national funding for the IPO.

Submitted by Ed Urban, SCOR Executive Director and Sophie Seeyave, POGO Executive Director

## Appendix 10

### Second International Indian Ocean Expedition (IIOE-2)

#### Summary

IIOE-2 is a large, complex, multi-disciplinary and multi-dimensional project that is sponsored by UNESCO-IOC, IOGOOS as well as SCOR. Each of these sponsors has its own characteristics and one of the many challenges is to harness the strengths and resources of each to deliver IIOE-2 optimally. This report covers the main activities and successes of IIOE-2 over the period late 2015 to mid-2017. The main focus of IIOE-2 in this early period has been on setting up the programme and getting it operational. After the lead taken by SCOR in producing the *Science Plan*, the emphasis in IIOE-2 has recently been on the infrastructure as well as scientific data gathering. International project offices have been set up in Australia and in India. The latter is based at INCOIS, Hyderabad, India where a project database is now functional. INCOIS also hosts the IIOE-2 website and produces an informal periodic publication, *Ocean Bubble* that allows scientists to try out ideas and seek collaboration. An SSC led by co-chairs from each of the sponsors is operational; it meets in person once per year and electronically every quarter. Data collection is underway, with a total of 22 projects from 10 countries as well as 10 cruise expeditions endorsed as part of IIOE-2. One of the main focuses of IIOE-2 lies with the societal relevance, as well as the fundamental understanding gained by the projects and cruises. SCOR is requested to provide \$25k for SC meetings in 2017-2018.

#### Introduction

IIOE-2 is the youngest of SCOR's large-scale projects and, politically, is its most complex. It was launched in 4<sup>th</sup> December 2015 in Goa, India at the end of an international conference on the Indian Ocean attended by some 450 scientists. It has a unique claim that its first cruise, aboard ORV *Sagar Nidhi* of MoES India, sailed the very same day the project began! In fact, the *Sagar Nidhi* cruise remains an ideal model for IIOE-2 with the Indian hosts offering half the scientific berths to scientists outside India. These were readily taken up and will undoubtedly create an international cohort of collaboration for the future.

IIOE-2's complexity arises because it, like IIOE, is not 'overseen' by a single organisation. SCOR partners with two other organisations, UNESCO-IOC and IOGOOS, to deliver IIOE-2. SCOR has led the partnership in developing the research aspects of IIOE-2 and has also paid for the workshops and also publication of the *Science Plan*. UNESCO-IOC can uniquely reach out to a larger audience than SCOR could achieve, and harness the capabilities of all the governments in the region. IOGOOS has unique skills in observational oceanography together with longer-term funding opportunities that underpin the moorings and satellites in the region. So IIOE-2 is a hybrid project that is harnessing the skills and characteristics of all three sponsors to deliver IIOE-2. The challenge is, of course, to maximize use of the strengths of each organisation while minimizing conflicts that could arise because of their different ways of operating.

#### Mission

The Mission of IIOE -2 is '*to advance our understanding of the Indian Ocean and its role in the Earth System in order to enable informed decisions in support of sustainable development and the well-being of humankind*'. At its core, IIOE-2 is an international project with formal participation by six countries with national IIOE-2 committees (Australia, France, Germany, India, UK, USA) and a number of other countries (Bangladesh, China, Indonesia, Japan, Kenya, Korea, Madagascar, Norway, Russia & South Africa), that have IIOE-2 activities without a national committee. This international community collaborates in research from coastal environments to the deep sea over the period 2015-2020, to generate new scientific understanding on the Indian Ocean. This will be used for future sustainable development and expansion of the Indian Ocean's blue economy.

#### Guidance and Governance

Delivery of IIOE-2's mission is guided by its *Science Plan* (Hood et al. 2015) and achieved using the criteria outlined in its *Implementation Strategy* (IPC 2015). The *Science Plan* identified six Science Themes, each of which provide a broad platform for addressing research questions at the cutting edge of current knowledge. Seven Working Groups were defined in the *Implementation Strategy* and these function orthogonally across the Science Themes. During the past year, chairs of Science Themes and Working Groups were appointed as shown in Table 1.

**Table 1: The delivery of IIOE-2 is developed and co-ordinated by six Science Themes and seven Working Groups shown here together with their chairs or co-chairs.**

<b>A) Science Theme</b>	<b>Chair/ Co-Chairs</b>	<b>B) Working Groups</b>	<b>Chair/ Co-Chairs</b>
<i>1: Human Benefits and Impacts</i>	Dr Ben Milligan (Australia/UK)	<i>1: Science &amp; Research</i>	Prof Hermann Bange (Germany)
<i>2: Boundary Currents</i>	Prof P Vinayachandran (India) & Prof Yukio Masumoto (Japan)	<i>2: Data and Information Management</i>	Ms Cyndy Chandler (USA) & Dr Harrison Ong'Anda (Kenya)
<i>3: Monsoon Variability</i>	Prof Adrian Matthews (UK) & Prof Joaquim Goes (USA)	<i>3: Capacity Development</i>	Dr Nasser Zaker (Iran) & Dr Zainal Arifin (Indonesia)
<i>4: Circulation, climate variability</i>	Dr Jerme Vialard (France) & Dr Amit Tandon (USA)	<i>4: Operational Co-ordination</i>	Dr Shailesh Nayak (India)
<i>5: Extreme Events &amp; their impacts</i>	Prof Chari Pattiaratchi (Australia/Sri Lanka)	<i>5: Outreach and Communication</i>	Dr Faiza Al-Yamani (Kuwait)
<i>6: Unique features of the Indian Ocean</i>	Dr Jerome Dymont (France)	<i>6: Translating Science for Society</i>	Dr Rezah Badal (Mauritius)
		<i>7: Sponsorship and Resources</i>	Dr Nick D'Adamo (JPO) & Dr Rajan Sivaramakrishnan (JPO)

The Governance of IIOE-2 is overseen by the SC (Figure 1). This body has co-chairs from each of the three sponsors (UNESCO-IOC (Vladimir Ryabinin), IOGOOS (Satheesh Shenoi) as well as SCOR (Peter Burkill).

**Table 2. This shows the full Steering Committee structure of IIOE-2.**

Steering Committee	Core Group	CO-CHAIRS			Heads of the two JPOs - Nick D'Adamo & Rajan Sivaramakrishnan, as ex-officio members
		Dr. Vladimir Ryabinin v.ryabinin@unesco.org	Dr. Peter Burkill peter.burkill@plymouth.ac.uk	Dr. Satheesh Shenoi shenoi@incois.gov.in	
		STRATEGIC EXECUTIVE LEVEL			
		Ben Milligan (Chair ST1), P N Vinayachandran/Yukio Masumoto (Co-Chairs ST2), Adrian Matthews/Joaquim Goes (Co-Chairs ST3), Jerome Vialard/Amit Tandon (Co-Chairs ST4), Chari Pattiaratchi (Chair ST5), Jerome Dymont (Chair ST6), Hermann Bange (Chair WG01), Cynthia Chandler/Harrison O. Ong'Anda (Co-Chairs WG02), Nasser H. Zaker/Zainal Arifin (Co-Chairs WG03), Shailesh Nayak (Chair WG04), Faiza Al-Yamani (Chair, WG5), Rezah M. Badal (Chair WG6) and Nick D'Adamo/Rajan Sivaramakrishnan (Co-Chairs WG07) plus Johnson Kazungu (Chair, IOC Africa), M. A. Atmanand (Chair, IOCINDIO), Somkiat Khokiattiwong/Kentaro Ando (Co-Chairs IOC WESTPAC)			
	Stakeholder Group	REGIONAL COORDINATION LEVEL			
One representative per each IIOE-2 'National committee'					
SCIENCE DELIVERY LEVEL					
		One representative (i.e. PI) per each 'major' IIOE-2 scientific research initiative, including a representative of the Early Career Scientists Network from the Capacity Development Working Group			

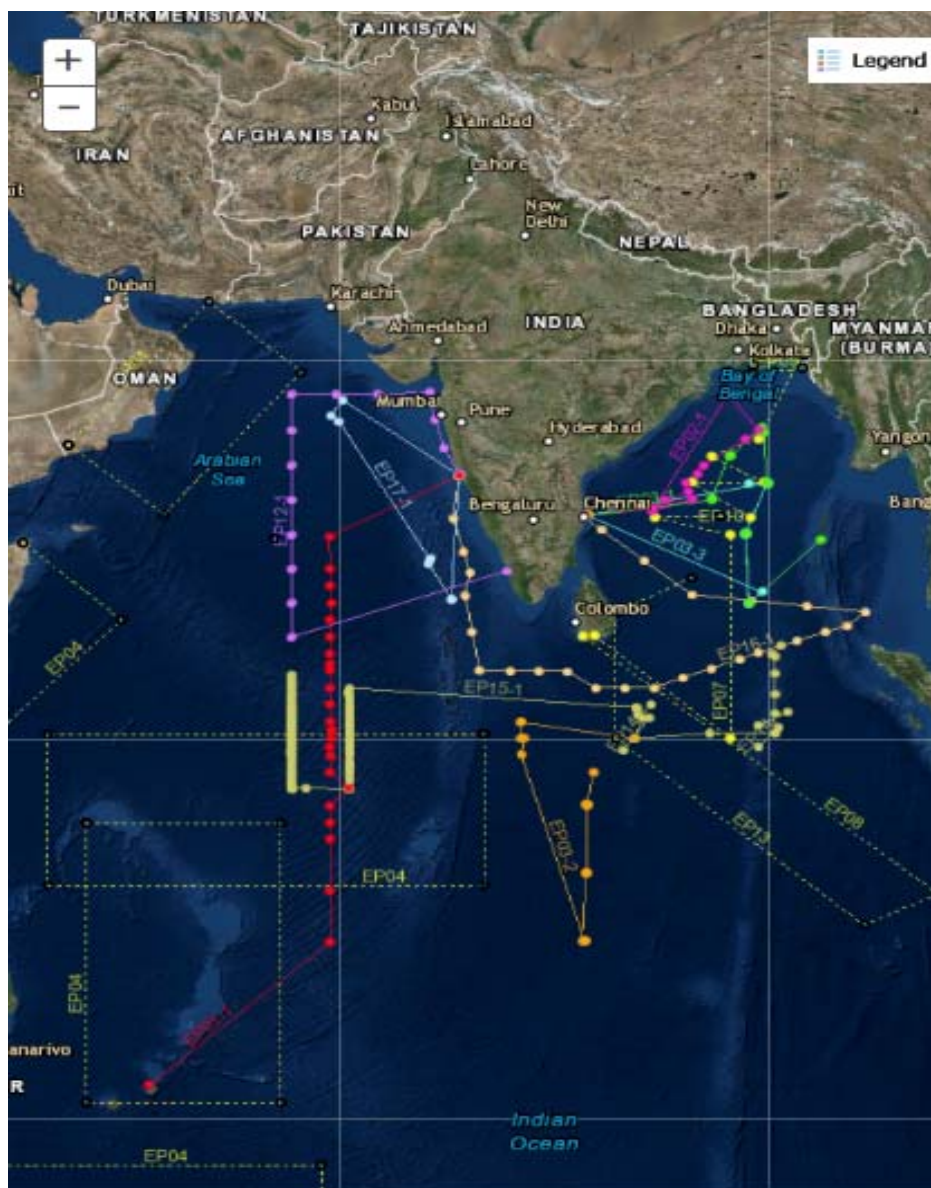
The co-chairs work closely with the chairs of the Science Themes and Working Groups identified in Table 1 and the regional bodies of UNESCO IOC. The full SC also includes representatives of the National Committees and each major science research initiative. The full SC meets once per year while the core group meets electronically every quarter. The SC met for the first time face-to-face in Perth from 2<sup>nd</sup> to 4<sup>th</sup> February 2107. The minutes of that meeting are available at [http://www.iioe-2.incois.gov.in/IIOE-2/SC\\_Meeting1.jsp](http://www.iioe-2.incois.gov.in/IIOE-2/SC_Meeting1.jsp)

#### Joint Project Offices

The two project offices in Perth and Hyderabad have had a full year of activities, advocating IIOE-2 and providing support to the project. The latter includes maintaining the website (<http://www.iioe-2.incois.gov.in/IIOE-2/index.jsp>) and printing Ocean Bubble (<http://www.iioe-2.incois.gov.in/IIOE-2/Bubble.jsp>). Both offices are funded by their national governments and by IOC. Ed Urban also gives support on SCOR's behalf.

#### Research Activities

Early research activities of IIOE-2 centre on fieldwork, principally cruises, and these are shown in Figure 1.



**Figure 1: IIOE-2 Research Cruises that either have or will take place in the near future. Many of these research cruises are associated with projects and these are displayed in Table 3.**



**Table 3. Projects endorsed as contributing to IIOE-2. Those struck through have yet to secure funding.**

Month & Year of Endorsement	Endorsement Number	Projects	Principal Investigator (PI)	Country
July, 2017	IIOE2-EP22	NEKTON INDIAN OCEAN MISSION 2018-2021	Oliver Steeds, UK	UK
July, 2017	IIOE2-EP21	PHYSICAL STUDY OF THE NORTH WESTERN INDIAN OCEAN AND OF THE ADJACENT SEAS: PHYSINDIEN	Xavier Carton, France	France
July, 2017	IIOE2-EP20	KIOST INDIAN OCEAN STUDY	TaeKeun Rho, Republic of Korea	Republic of Korea
May 2017	IIOE2-EP19	GO-SHIP OBSERVATION OF SECTIONS I8N AND I7S BY R/V MIRAI	Katsuro Katsumata, Japan	Japan
May, 2017	IIOE2-EP18	IMPACT OF CLIMATE VARIABILITY ON THE INDIAN OCEAN: ROLE OF GELATINOUS ZOOPLANKTON STRUCTURING FOOD WEB STRUCTURE AND COMMUNITY ASSEMBLAGES	Bijoy Nandan Sivasankaran, India	India
May, 2017	IIOE2-EP17	REAL-TIME METEOROLOGICAL AND OCEANOGRAPHIC DATA COLLECTION USING MOORED BUOY NETWORK IN INDIAN SEAS (OON-INDIA)	R. Venkatesan, India	India
March, 2017	IIOE2-EP16	BIOGEOCHEMISTRY OF TRACE ELEMENTS AND ISOTOPES IN THE INDIAN OCEAN (GEOTRACES-INDIA)	Sunil K. Singh, India	India
March, 2017	IIOE2-EP15	EQUATORIAL CURRENTS AND UNDERCURRENT IN THE INDIAN OCEAN	Victor Neiman, Russia	Russia
March, 2017	IIOE2-EP14	GEOLOGY AND GEOPHYSICS OF THE EASTERN INDIAN OCEAN (GEODYNAMICS, TECTONICS AND EVOLUTION OF UNIQUE INTRAPLATE FEATURES)	Oleg Levchenko, Russia	Russia
February, 2017	IIOE2-EP13	EASTERN INDIAN OCEAN UPWELLING RESEARCH INITIATIVE (EIOURI)	Weidong Yu, China	Multinational
February, 2017	IIOE2-EP12	DUST STIMULATED NITROGEN FIXATION IN THE ARABIAN SEA- AN ASSESSMENT OF HNLC REGION HYPOTHESIS (DUSTNIF)	Arvind Singh, India	India
January, 2017	IIOE2-EP11	INTERNATIONAL BUOY PROGRAMME FOR THE INDIAN OCEAN (IBPIO)	Shaun Dolk, USA	Multinational
December, 2016	IIOE2-EP10	UNDERSTANDING THE UPWELLING SYSTEM AND OXYGEN MINIMUM ZONE PROCESSES IN THE NORTHERN INDIAN OCEAN: PAST, PRESENT AND FUTURE	Hermann Bange, Germany	Germany
November, 2016	IIOE2-EP09	BIOGEOCHEMICAL CYCLING AND HYPOXIA IN THE BAY OF BENGAL COASTAL ZONE; THE ROLE OF SEDIMENT DISCHARGE (HYBOB)	Greg Cowie, UK	UK-USA
October, 2016	IIOE2-EP08	THE CHALLENGER OCEAN GLIDER MISSION: INDIAN OCEAN	Charitha Pattiaratchi, Australia	Australia-USA
October, 2016	IIOE2-EP07	BIOGEOCHEMISTRY-ATMOSPHERE PROCESSES IN THE BAY OF BENGAL: A CONTRIBUTION TO IIOE-2 (BIOCAT-IIOE2)	Hermann Bange, Germany	Germany
September, 2016	IIOE2-EP06	A COUPLED BIO-PHYSICAL, ECOSYSTEM-SCALE, EXAMINATION OF AUSTRALIA'S INTERNATIONAL INDIAN OCEAN EXPEDITION 110°E LINE	Lynnath Beckley, Australia	Australia-USA
September, 2016	IIOE2-EP05	PELAGIC ECOSYSTEM PROCESSES, NITROGEN SOURCES AND SOUTHERN BLUEFIN TUNA LARVAL ECOLOGY IN THE INDO-AUSTRALIAN BASIN	Lynnath Beckley, Australia	Australia-USA
August, 2016	IIOE2-EP04	WESTERN INDIAN OCEAN UPWELLING RESEARCH INITIATIVE (WIOURI)	Michael Roberts, UK-South Africa	Multinational
February, 2016	IIOE2-EP03	RESEARCH MOORED ARRAY FOR AFRICAN-ASIAN-AUSTRALIAN MONSOON ANALYSIS AND PREDICTION (RAMA)	Ravichandran, India	India-USA
January, 2016	IIOE2-EP02	AIR-SEA INTERACTIONS IN THE NORTHERN INDIAN OCEAN: REGIONAL INITIATIVE (ASIRI)	Ravichandran, India	India-USA
December, 2015	IIOE2-EP01	FIRST SCIENTIFIC CRUISE UNDER IIOE-2	Vinayachandran, India	Multinational

In addition to the above, the UK government announced in the last few weeks that it is to fund a major initiative in the Indian Ocean (Figure 2). This is lead by Mike Roberts (UK/ South Africa) and the early stages will focus on the WIOURI component of IIOE-2 and involve Kenya, South Africa and Tanzania. This initiative is likely to take place

over a period that will stretch beyond the current period (2015-2020) of IIOE-2.

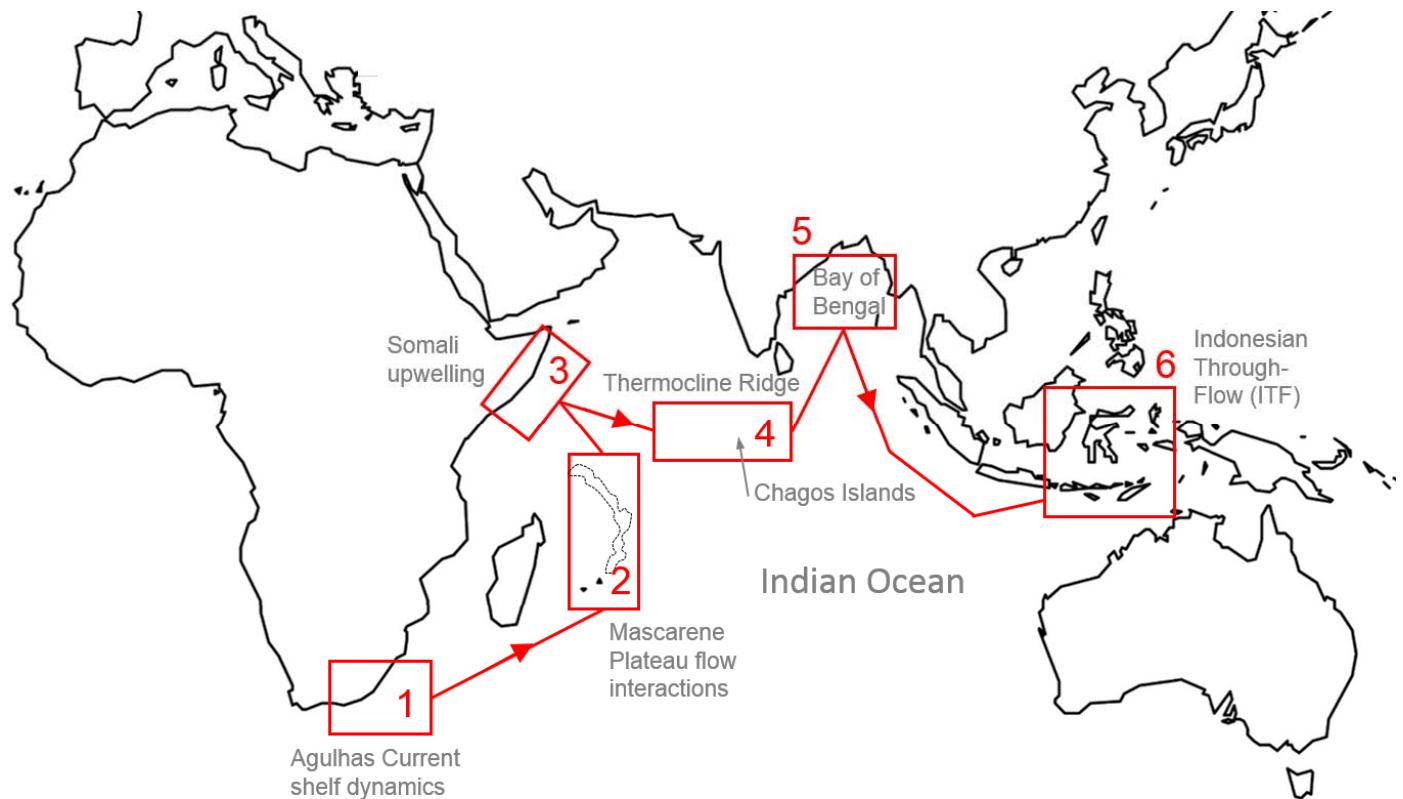


Figure 2: Proposed track of RRS DISCOVERY for a funded UK IIOE-2 initiative lead by Mike Roberts.

#### Early Career Scientists (ECS)

This is an important strand of IIOE-2. This group met in Perth on 4<sup>th</sup> February 2017, led by Danielle Su of Australia. The SSC agreed that each chair of WG or ST should encourage participation by a member of the ECS.

#### Meetings

The larger meetings involving IIOE-2 are shown in Table 4. In addition smaller electronic meetings involving the SC are held quarterly.

**Table 4: Past and future meetings involving IIOE-2.**

Date	Location	Organisation	Function
2-4 Feb 2017	Perth Australia	IIOE-2 SC	First face to face meeting of SC to plan IIOE-2. SC Chairs were funded by SCOR.
30 May – 2 June 2017	Busan, Korea	ECS Conference	Build international cohort of ECS. Self funded.
27 Aug 2017	Cape Town, South Africa	IAPSO-IAMAS-IAGA Symposium	Includes IIOE-2 session
4 – 6 Sep 2017	Cape Town, South Africa	SCOR AGM	Receive IIOE-2 report
11 Sep 2017	La Jolla, USA	Indian Ocean Community	Workshop for US scientists and others
19-23 March 2018	Lombok, Indonesia	IIOE-2 SC	Second face-to-face meeting to continue SC planning. SC Chairs to be funded by SCOR.

### Communication

IIOE-2 website is now fully operational (<http://www.iioe-2.incois.gov.in/IIOE-2/index.jsp>) and is a great resource as well as being a communications platform for IIOE-2. Ocean Bubble (<http://www.iioe-2.incois.gov.in/IIOE-2/Bubble.jsp>), an informal periodical devoted to IIOE-2, has just released Issue 7.

### Requests to SCOR

I request that SCOR funds US\$25,000 to underpin meetings of the SC in 2018 meeting. The main meeting will be in Indonesia from 19 to 23 March. The dates and location of this meeting have been confirmed by our Indonesian hosts. The funds are to allow SC Chairs to attend the meeting and also for WG 1 (Science & Research chair Hermann Bange) that coordinates IIOE-2's Research Themes to meet.

### Acknowledgements

IIOE-2 involves a very large number of participants all of whom contribute to its success. It is a particular pleasure to acknowledge all the scientists of the SSC including particularly the JPO scientists, Nick D'Adamo and Rajan Sivaramakrishnan who take responsibility for the day-to-day running of this large complex project.

### References

- Hood R et al (2015). The Second International Indian Ocean Expedition (IIOE-2) Science Plan. Scientific Committee on Oceanic Research pp101.
- IPC (2015). Implementation Strategy for the Second International Indian Ocean Expedition 2015-2020 (Ed N D'Adamo). pp36



Appendix 11  
2016 Audited SCOR Statement of Activities  
Year Ended 31 December 2016

	Unrestricted	Temporarily Restricted	Total
<b>SUPPORT AND REVENUE</b>			
Grant and Contract Revenue	\$810,540	\$ -	\$810,540
Contribution Revenue	21	55,732	55,753
Membership dues	357,155	-	357,155
Meeting registration fees and misc. income	4,878	-	4,878
Interest income	22		22
<b>NET ASSETS RELEASED FROM RESTRICTIONS</b>			
Satisfaction of program restrictions	30,785	(30,785)	-
<b>TOTAL SUPPORT AND REVENUE</b>	<b>1,203,401</b>	<b>24,947</b>	<b>1,228,348</b>
<b>EXPENSES</b>			
<b>PROGRAM SERVICES</b>			
Scientific programs	833,382	-	833,382
Travel and subsistence programs	83,460	-	83,460
Other conferences and meetings	15,004	-	15,004
<b>TOTAL PROGRAM SERVICE EXPENSES</b>	<b>931,846</b>	<b>-</b>	<b>931,846</b>
<b>SUPPORT SERVICES</b>			
Management and general	323,059	-	323,059
<b>TOTAL EXPENSES</b>	<b>1,254,905</b>	<b>-</b>	<b>1,254,905</b>
<b>CHANGE IN NET ASSETS</b>	<b>(51,504)</b>	<b>24,947</b>	<b>26,557</b>
<b>NET ASSETS, beginning of year</b>	<b>266,945</b>	<b>25,972</b>	<b>292,917</b>
<b>NET ASSETS, end of year</b>	<b>215,441</b>	<b>50,919</b>	<b>266,360</b>

Appendix 12  
SCOR-Related Meetings (2017-2020)

<b>2017</b>		
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	<a href="#">4th African Discovery Camp for Research-based Training Science for the Sustainable Use and Management of Marine Ecosystems and their Resources</a>	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
19-21 June	SOLAS Scientific Steering Committee	Bologna, Italy
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	<a href="#">SCOR Executive Committee Meeting</a>	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
<b>2018</b>		
10 February	WG 154: Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs (P-OBS)	Portland, Oregon, USA
11 February	WG 143: Dissolved N <sub>2</sub> O and CH <sub>4</sub> measurements: Working towards a global network of ocean time series measurements of N <sub>2</sub> O and CH <sub>4</sub>	Portland, Oregon, USA
11 February	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	Portland, Oregon, USA
11 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
14-15 February	WG 147: Towards Comparability of Global Oceanic Nutrient Data (COMPONUT)	Portland, Oregon, USA
11 March	WG 153 on Floating Litter and its Oceanic TranSport Analysis and Modelling (FLOTSAM)	San Diego, Calif., USA

13-14 March	IQOE Science Committee	Bremerhaven, Germany
19-23 March	IIOE-2 Steering Committee	Lomboc, Indonesia
10-12 April	GlobalHAB Scientific Steering Committee	Villefranche-sur-Mer, France
16-18 April	WG 148: International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD)	Oostende, Belgium
16-19 April	IMBeR Scientific Steering Committee	Hobart, Tasmania, Australia
16 April-11 May	<a href="#">5th Research Discovery Camp</a>	Henties Bay and Swakopmund, Namibia
2-4 May	SOLAS Scientific Steering Committee	Victoria, BC, Canada
6-9 May	SOOS Scientific Steering Committee	Hangzhou, China
2-3 June	WG 155 on Eastern boundary upwelling systems (EBUS): diversity, coupled dynamics and sensitivity to climate change	Washington, DC, USA
15-17 June	WG 152 on Measuring Essential Climate Variables in Sea Ice (ECV-Ice)	Davos, Switzerland
13-15 July	WG 149 on Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?	Waterville, New Hampshire
23-25 July	GEOTRACES Scientific Steering Committee Meeting	Taipei, Taiwan
23 July-4 August	<a href="#">SOLAS Summer School 2018</a>	Cargese, Corsica, France
1-8 August	<a href="#">IMBeR CLIMECO 6 Summer School</a>	Yogyakarta, Indonesia
2-7 September	GICPWS/BIPM/IAPWS Seawater Workshops (sponsored by the Joint Committee on Seawater)	Prague, Czech Republic
4-6 September	<a href="#">SCOR General Meeting</a>	Plymouth, UK
14-16 November	SCOR-InterRidge Workshop on Mid-Ocean Ridges and Other Geological Features of the Indian Ocean	Goa, India
<b>2019</b>		
Spring	WG 153 on Floating Litter and its Oceanic Transport Analysis and Modelling (FLOTSAM)	Utrecht, The Netherlands
21-25 April	<a href="#">SOLAS Open Science Conference 2019</a>	Sapporo, Japan
17-21 June	IMBeR Open Science Conference 2019	Brest, France
23-25 September	SCOR Annual Meeting	Toyama, Japan
<b>2020</b>		
February	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	San Diego, Calif., USA