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MEMORANDUM

TO: Attendees, 2015 SCOR Executive Committee Meeting

FROM: Ed Urban, SCOR Executive Director

RE: Background Book for Meeting

DATE: 7 November 2015

I am pleased to enclose the background book for the upcoming SCOR General Meeting in Goa, India. I hope that you have a chance to read it before the meeting, although I know that the time is limited and the background materials are extensive. Please be sure to review the annotated agenda following. I have tried to identify the actions that we need to consider at the meeting and have cross-referenced the agenda items to the pages where relevant background information can be found, so we can make the best use of our time together. Please skim the remainder of the book and focus on those sections that are most closely related to your interests and responsibilities. I hope that the book also will be a useful reference to you between SCOR meetings. The background book is also available on the Web, at http://www.scor-int.org/2015/2015EC.htm.

We will not be able to bring extra background books to the meeting, so please bring your copy if you requested one. Please let me know if you think other items should be made available to participants at the meeting.

I look forward to seeing each of you in Goa next month.

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42nd SCOR EXECUTIVE COMMITTEE MEETING

Goa, India
7-9 December 2015

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NM = Nominated Member

Schedule for Meeting

	Sun., Dec. 6	Mon., Dec. 7	Tues., Dec. 8	Wed., Dec. 9
9:00		Welcome, Logistics, and Introductions (1.1)	WG Proposals (cont.)	IQOE (3.5)
9:15				IOCCP (4.1)
9:30		President's Report (1.3)		
9:45		Exec. Dir.'s Report (1.4)		SOOS (4.2)
10:00		Appointment of Finance Committee (1.5)		
10:15		Preparations for 2016 SCOR Election (1.6)		JCS (4.3) Benthic Workshop (4.5)
10:30		**BREAK**	**BREAK**	**BREAK**
10:45				
11:00		SCOR Capacity Building Activities (5.0)	WG Proposals – Discussion of Proposals on Short List	ICSU (7.1) IGBP (7.1.1)
11:15				WCRP (7.1.2) SCAR (7.1.3) Future Earth (7.1.4)
11:30				
11:45				
12:00				
12:15		Second International Indian Ocean Expedition (3.6)		IABO (7.21) IAMAS (7.2.2) IAPSO (7.2.3)
12:30				InterRidge (7.3.1) IOCCG (7.3.2) GACS (7.3.3)
12:45				
13:00	SCOR Executive Committee Meets in Closed Session	**LUNCH**	**LUNCH**	**LUNCH**
13:15				
13:30				
13:45				
14:00		Current WGs (2.1)	WG Proposals – Fine- tune advice to WGs	IOC (6.1) GESAMP (6.2) PICES (6.3) POGO (7.4.1)
14:15				
14:30				
14:45				
15:00				
15:15				
15:30		**BREAK**	**BREAK**	**BREAK**
15:45				
16:00		WG Proposals – Beginning of Discussion to Develop Short List (2.2)	GEOHAB/GlobalHAB (3.1/4.4)	Membership (8.1)
16:15				Publications (8.2)
16:30			IMBER (3.2)	Finances (8.3) Report of Ad Hoc Finance Committee
16:45				
17:00			GEOTRACES (3.3)	SCOR-Related Meetings (9.0)
17:15				SCOR Executive Committee Meets in Closed Session
17:30			SOLAS (3.4)	
17:45				
18:00	SCOR Executive Committee Dinner			

42nd SCOR EXECUTIVE COMMITTEE MEETING

Goa, India

7-9 December 2015

ANNOTATED AGENDA

1.0 OPENING

1.1 Opening Remarks and Administrative Arrangements, p 1-1 ***Naqvi, Burkill, Urban***

1.2 Approval of the Agenda, p. 1-4 ***Burkill***

Additions or modifications to the agenda as distributed may be suggested prior to approval of the final version.

1.3 Report of the President of SCOR ***Burkill***

The President will briefly review his activities for SCOR since the SCOR Executive Committee Meeting in September 2014 in Bremen, Germany.

1.4 Report of SCOR Executive Director, p. 1-4 ***Urban***

The Executive Director will report on his activities for SCOR since the 2014 SCOR meeting, and on the current condition of SCOR.

1.5 Appointment of an *ad hoc* Finance Committee, p. 1-6 ***Burkill***

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

1.6 2016 Elections for SCOR Officers, p. 1-7 ***Fennell***

The SCOR President and all three Vice-President positions are open for nominations for the 2016 elections.

Action: Set up Nominations Committee.

2.0 WORKING GROUPS

2.1 Current Working Groups

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

2.1.1 SCOR/InterRidge WG 135 on Hydrothermal energy transfer and its impact on the ocean carbon cycles, p. 2-1 *Bharathi*

WG 135 published its first article this year:

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

The group has a second paper in progress, which would be helped by keeping the group active for another year and by providing their remaining funding for a writing meeting.

Action: Consider extending the group until the 2016 SCOR annual meeting and providing remaining support for a writing meeting.

2.1.2 WG 137: Patterns of Phytoplankton Dynamics in Ecosystems: Comparative Analysis of Time Series Observation, p. 2-3 *Ramaiah, Sun Song*

WG 137 published its special issue this year:

> Klais, R., J.E. Cloern and P.J. Harrison. 2015. Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems. *Estuarine, Coastal and Shelf Science* 162:1-160. Special issue from WG 137: http://www.sciencedirect.com/science/journal/02727714/162.

Action: Consider disbanding the group.

2.1.3 SCOR/IGBP WG 138: Modern Planktic Foraminifera and Ocean Changes, p. 2-8 *Naidu, Brussaard*

WG 138's final event was a workshop held on Catalina Island, California, USA on 30 August-4 September 2015. The meeting attracted 50 participants, including a large group of students from undergraduates to finishing PhDs. The abstract volume serves as a record from the meeting: http://www.eforams.org/img_auth.php/e/ed/SCORWG138_Catalina_2nd_circular.pdf.
The talks were videotaped and will be available later. The group continues to work on an ebook: http://www.eforams.org/index.php/WG138:E-book.

Action: Consider disbanding the group when its ebook is completed.

2.1.4 WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean, p. 2-10 *Naqvi*

Databases for metal-binding ligand measurements are being compiled by several members of the working group for four key bioactive trace elements: Co, Cu, Fe and Zn. A review paper is underway and will be completed once the databases are established. A large intercalibration exercise compared the interpretation techniques routinely used for determining ligand concentrations and conditional stability constants from titration data, with 15 participants using a simulated dataset. The results of this intercalibration were published in *Marine Chemistry* as part of a special issue (http://www.sciencedirect.com/science/journal/03044203/173). In April 2015, a highly successful two-day symposium was held in Sibenik, Croatia. Fifty-one people attended the symposium, including 24 students and postdocs. Twenty of the attendees also participated in a training workshop held the day before the symposium (see 04-09_17-25-01_HRT4_Zupanijska panorama Zadar-Pizeta.avi). Due to the success of the *Marine Chemistry* special issue and discussions at the final symposium, another special issue was initiated, in *Frontiers Marine Biogeochemistry* and the deadline for submissions to this issue is in December 2015. A total of 24 authors have confirmed their intention to contribute to this special issue.

Action: Consider continuing group for another year without funding.

2.1.5 WG 140: Biogeochemical Exchange Processes at the Sea-Ice Interfaces, p. 2-17 *Shapovalov*

The yearly meeting of WG140 took place after the Gordon Research Conference on Polar Marine Sciences in Lucca, Tuscany, Italy on 20 March 2015. 26 members of the BEPSII network, representing 12 countries, attended the meeting. The major activity in the coming year will be the continued submission of papers to the *Elementa* Special Feature (https://home.elementascience.org/special-features/biogeochemical-exchange-processes-at-sea-ice-interfaces-bepsii/). Since both mechanistic review papers and modeling applications will be published in this Feature, it is regarded as the main product of WG140. The group is discussing mechanisms to continue its work outside SCOR

Action: Consider continuing group for another year without funding.

2.1.6 WG 141 on Sea-Surface Microlayers, p. 2-35 *Burkill*

The Schmidt Ocean Institute has approved approximately one month of ship time (tentatively 9 October-12 November 2016) for a cruise of the R/V *Falkor* by a team representing the working group. The cruise will start in Darwin, Australia and finish in Guam. The focus of the cruise will be to study the role of the sea-surface microlayer on air-sea interactions. The group plans to meet next in February 2016 in conjunction with the Ocean Sciences meeting in New Orleans, Louisiana (USA).

Action: Consider funding for 2016 WG meeting.

2.1.7 WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders, p. 2-37 *Prakash, Burkill*

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

Action: Consider funding for 2016 WG meeting.

2.1.8 WG 143 on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4, p. 2-42 *Bange, Turner*

WG 143's 2nd meeting was held on 4 September, at GEOMAR in Kiel, Germany. It was agreed that additional samples should be taken from Boknis Eck (BE), as a coastal reference site. It was decided to have an intercomparison exercise for both discrete and underway measurements on 12-20 Oct. 2016: A total of 12 berths are available and ship time is already allocated. Prior to the 2nd intercomparison, a method/best practice recommendation/guideline will be distributed to ensure that all participating labs are using the same equations, doing the same corrections, apply the same form of calibration curves etc. A "toolbox" for dissolved N_2O/CH_4 concentration computations will be created, that can be used as standard routine in Matlab (or other software packages), and perhaps a video showing best practice for N_2O/CH_4 sampling.

Action: Consider funding for 2016 WG activities.

2.1.9 WG 144 on Microbial Community Responses to Ocean Deoxygenation, p. 2-47 *Ramaiah*

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

Action: Consider funding for 2016 WG meeting.

2.1.10 WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC), p. 2-53 *Urban*

WG 145 met in Šibenik, Croatia, on 12-13 April 2015, immediately following the closing symposium of WG 139. WG members have submitted 10 reviews of existing speciation calculation programs using a common questionnaire format focusing on the user interface. This material will be used to develop a first draft of desirable features in a "best practice" model, which will be discussed and refined at the WG's second meeting. The group is planning a variety of publications to announce its work and to encourage participation by the global ocean science community. The group plans to meet next on 21 February 2016 in conjunction with the Ocean Sciences meeting in New Orleans, Louisiana (USA).

Action: Consider funding for 2016 WG meeting.

2.1.11 WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5), p. 2-61 *Naqvi*

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

Action: Consider funding for 2016 WG meeting.

2.1.12 WG 147 on Towards comparability of global oceanic nutrient data (COMPONUT), p. 2-65 *Naik*

WG 147 has arranged for the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) to sell nutrient certified reference materials (CRMs) at cost to get them out to the global community. WG 147 has distributed a questionnaire to determine the demand for these nutrient CRMs. The questionnaire can be found at http://www.scor-int.org/Working_Groups/Nutrient_CRM_Questionnaire.docx and the summary of the results is at http://www.scor-int.org/Working_Groups/WG_147_Questionnaire_Results.pdf. There were 67 replies to the questionnaire as of 30 October 2015. The group also plans to conduct training on best practices for nutrient measurements in 2017 at the Royal Netherlands Institute for Sea

Research (NIOZ).
Action: Consider funding for 2016 WG meeting.

2.2 Working Group Proposals

2.2.1 Towards a Global Comparison of Zooplankton Production: Measurement, Methodologies and Applications (ZooProd), p. 2-70 *Sun Song*

Action: Consider as new SCOR working group.

2.2.2 SEAmount Faunal vulnerabilty to impacts of Ocean Acidification and Mining (SEAFOAM), p. 2-84 *Burkill*

Action: Consider as new SCOR working group.

2.2.3 BIOgeochemistry of COral REef systems (BIOCORE), p. 2-103 *Brussaard*

Action: Consider as new SCOR working group.

2.2.4 Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?, p. 2-110 *Miloslavich*

Action: Consider as new SCOR working group.

2.2.5 A Functional Trait Perspective on the Biodiversity of Hydrothermal Vent Communities (FDvent), p. 2-128 *Burkill*

Action: Consider as new SCOR working group.

2.2.6 Rheology, nano/micro-Fluidics and bioFouling in the Oceans (RheFFO), p. 2-143 *Fennel*

Action: Consider as new SCOR working group.

2.2.7 Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT), p. 2-162 *Smythe-Wright*

Action: Consider as new SCOR working group.

2.2.8 Global Assessment of Nutrient Export Through Submarine Groundwater Discharge (NExT SGD), p. 2-175 *Naqvi*

Action: Consider as new SCOR working group.

2.2.9 International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD), p. 2-192 *Turner*

Action: Consider as new SCOR working group.

2.2.10 The dynamic ecogeomorphic evolution of mangrove and salt marsh coastlines (DEMASCO), p. 2-214 ***Miloslavich***

Action: Consider as new SCOR working group.

3.0 LARGE-SCALE SCIENTIFIC PROGRAMS

SCOR currently sponsors six large-scale research projects; five of them are co-sponsored by other organizations. Each project has its own scientific steering committee (SSC) to manage the project on a day-to-day basis. SCOR and other co-sponsors are responsible to oversee the projects, which they do primarily through responsibility for the project SSC memberships and terms of reference, although sponsors also oversee the results of the projects' activities. Any proposed changes in membership or terms of reference are considered by the SCOR Executive Committee, in partnership with other co-sponsors, throughout the year. The SCOR Secretariat oversees the use of grant funds provided to the projects. SCOR uses solely grant funds for GEOHAB, IMBER, SOLAS, and GEOTRACES, but is providing SCOR support for IQOE and IIOE-2 until they are self-supporting.

3.1 IOC/SCOR Global Ecology and Oceanography of Harmful Algal Blooms Program, p. 3-1 *Enevoldsen, Sun Song*

GEOHAB continues to complete various synthesis products, including a final special issue and a summary for policymakers. SCOR and IOC have approved a follow-on project called GlobalHAB (see section 4.5).

Action: None. GEOHAB funding is provided by specific funding from an NSF grant to SCOR.

3.2 SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research, p. 3-6 *Burkill*

IMBER is nearing the end of its first 10 years as a research project and is currently drafting a request for a 10-year extension of the project. IMBER held its fourth Imbizo open science meeting at the end of October 2014 in Trieste, Italy (see http://www.imber.info/index.php/Meetings/IMBIZO/IMBIZO-IV). The IMBER SSC met in Santa Cruz, California in June 2015 and will meet next in New Orleans, Louisiana, USA on 19-21 February 2016, in conjunction with the Ocean Sciences 2016 meeting. Carol Robinson (UK) has been approved by SCOR and IGBP as the incoming chair of the IMBER SSC. The status of the new IMBER Science Plan/Implementation Strategy will be presented at the meeting.

Action: None. IMBER funding is provided by specific funding from an NSF grant to SCOR.

3.3 GEOTRACES, p. 3-32 *Naqvi*

The GEOTRACES Data Management Committee and Scientific Steering Committee met at the University of British Columbia in June 2015. Nations participating in GEOTRACES were active this year. Canada, Germany, and the United States ran cruises in the Arctic Ocean this summer. Germany also carried out a section cruise in the Atlantic Ocean and Australia, Germany, Japan,

Netherlands, and United Kingdom are carrying out GEOTRACES process studies in various basins. GEOTRACES is beginning mid-term project synthesis activities with an open meeting at the Royal Society in London (https://royalsociety.org/events/2015/12/ocean-chemistry/) on 7-8 Dec. 2015 and a smaller meeting following at Chicheley Hall (https://royalsociety.org/events/2015/12/trace-metal-cycling/) on 9-10 Dec. GEOTRACES has released a timeline for data submission and quality control for the 2017 GEOTRACES Intermediate Data Product (http://www.geotraces.org/dp/intermediate-data-product-2017). The GEOTRACES SSC and Data Management Committee will meet next in Toulouse, France on 12-16 September 2016.

Action: None. GEOTRACES funding is provided by specific funding from an NSF grant to SCOR.

3.4 Surface Ocean – Lower Atmosphere Study (SOLAS), p. 3-60 *Sarma, Turner*

SOLAS is nearing the end of its first 10 years as a research project. Its new Science Plan has been reviewed and SOLAS is working on the response to reviewer's comments. SOLAS has signed an agreement with the Future Earth initiative for sponsorship. The SOLAS SSC met in Hamburg, Germany in September 2015 and will meet next in China in 2016. It held its 2015 Open Science Conference in Kiel, Germany in September 2015. SCOR provided support for developing country scientists to participate in this conference.

Action: None. SOLAS funding is provided by specific funding from an NSF grant to SCOR.

3.5 International Quiet Ocean Experiment (IQOE), p. 3-80 *Urban, Shapovalov*

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

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

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

Action: Consider 2016 support from SCOR to IQOE.

3.6 Second International Indian Ocean Expedition (IIOE-2), p. 3-82 *Burkill*

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

Action: Discuss potential sources of funding for IIOE-2 implementation, including SCOR support.

4.0 INFRASTRUCTURAL ACTIVITIES

4.1 IOC/SCOR International Ocean Carbon Coordination Project, p. 4-1 *Fennel*

IOCCP held its First International Summer Course on Best Practices for Selected Biogeochemical Sensors (oxygen, pH, pCO_2, nitrate), at the Sven Lovén Center for Marine Sciences in Kristineberg, Sweden on June 22-July 1, 2015. IOCCP's coordination of the Surface Ocean CO_2 Atlas (SOCAT) continues. SOCAT version 3 was released in September 2015 at the SOLAS Open Science Conference, including 14.5 million surface water fCO_2 observations from 3,630 data sets between 1957 and 2014. Efforts related to the Global Ocean Acidification Observing Network (GOA-ON) are the main IOCCP contribution to understanding of this multidisciplinary, multi-scale, global phenomenon. Two major GOA-ON activities developed with IOCCP leadership over the past 12 months are (i) Ocean Acidification Data Portal and (ii) Ocean Acidification Data Synthesis Products.

Actions: None. IOCCP funding is provided by specific funding from an NSF grant to SCOR.

4.2 SCAR/SCOR Southern Ocean Observing System (SOOS), p. 4-25 *Wainer*

The SOOS Scientific Steering Committee met in Hobart, Australia in June 2015. The group is working on its Implementation Plan and continues to plan and conduct workshops related to SOOS science. SOOS published its 3-Year Progress Report at http://soos.aq/resources/reports?view=product&pid=29 and has begun to issue reports as part of a Zenodo collection (see https://zenodo.org/collection/user-southern-ocean-observing-system?ln=en). This is for publications that would not be appropriate as peer-reviewed publications, but which are still useful to the community, should be widely available, and are accomplishments of the project. SOOS has continued to increase its sponsorship from organizations active in the Southern Ocean. Australia and the USA submitted a joint working paper to the Committee for Environmental Protection (CEP) at the 2015 Antarctic Treaty meeting. Titled "Shared science priorities and cooperation: systematic observations and modelling in the Southern Ocean", this report highlighted the importance of international contributions to SOOS. CEP nations agreed unanimously on the importance of SOOS and supported all recommendations from the paper.

Action: Consider 2016 funding for SOOS.

4.3 IAPWS/SCOR/IAPSO Joint Committee on Seawater, p. 4-33 *Smythe-Wright*

The Joint Committee on Seawater (JCS) exists to advise the International Association for the Properties of Water and Steam on issues related to seawater in industrial uses, as well as the continued scientific implementation of the TEOS-10 equations of state developed by WG 127. The group is managed by an Executive Committee of three people and includes another 17 members. The group meets opportunistically at events related to their three topics of interest: seawater salinity, pH, and the relative humidity of moist air. Occasional travel support is needed

by members of the JCS Executive Committee to represent the committee in pursuit of its mission.
Action: Consider funding for 2016.

4.4 GlobalHAB, p. 4-37 ***Enevoldsen, Sun Song***

GlobalHAB is the follow-on to the Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) project. SCOR and IOC have approved the project and NSF has provided support for the next three years. SCOR and IOC are in the process of considering the membership. The SSC will meet for the first time early in 2016.
Action: None. GlobalHAB funding is provided by specific funding from an NSF grant to SCOR.

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

SCOR supported a workshop convened by several seafloor ecologists (Paul Snelgrove, Simon Thrush, and Alf Norkko) to consider seabed ecosystem functioning on a global scale. The workshop brought together the interdisciplinary expertise necessary to address this issue and identify priority research topics. Twelve experts in seabed biology, chemistry, and geology from North America, Europe, Asia and New Zealand met for 2.5 days in September 2015, at the Stazione Zoologica in Naples, Italy. A detailed outline has been developed for the group's paper and a rough draft is being planned by the end of 2015.
Action: None

5.0 CAPACITY-BUILDING ACTIVITIES

5.1 SCOR Committee on Capacity Building, p. 5-1 ***Ittekkot***

The SCOR Committee on Capacity Building oversees all capacity-building activities for SCOR and bears primary responsibility for reviewing and approving requests from organizations for travel support for scientists from developing countries and countries with economies in transition. The committee has been working remotely in 2015 and is not planning a meeting this year, to free up funding for capacity building activities related to International Symposium on the Indian Ocean.
Action: Consider funding for 2016 activities of the committee. Consider any recommendations of the committee.

5.2 SCOR Visiting Scholars, p. 5-1 ***Ittekkot***

SCOR has sent 19 Visiting Scholars to 13 different countries in the first 7 years of the program. The program has resulted in a significant outcome for a moderate investment, including a four-year Research Camp at the University of Namibia that has been developed by a two-time SCOR Visiting Scholar, Kurt Hanselmann.
Action: None. Funding for this activity is provided by an NSF grant to SCOR.

5.3 POGO-SCOR Visiting Fellowships for Oceanographic Observations, p. 5-8 ***Urban***

SCOR has co-funded this program with POGO since 2001. The program has funded more than 125 fellows so far. A SurveyMonkey questionnaire has been developed to assess the long-term

impacts of this program.
Actions: None. Funding for this activity is provided by an NSF grant to SCOR.

5.4 NSF Travel Support for Developing Country Scientists, p. 5-14 ***Urban***
The current SCOR grant from the National Science Foundation for travel of developing country scientists to scientific meetings runs until 30 June 2017. The funding is used primarily for travel grants, but also for the SCOR Visiting Scholars and POGO-SCOR Fellowships. The SCOR Committee on Capacity Building has approved several batches of requests since the 2014 SCOR meeting.
Action: None. Funding for this activity is provided by an NSF grant to SCOR.

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1 Intergovernmental Oceanographic Commission (IOC), p. 6-1 ***Enevoldsen, Burkill***
SCOR continues to co-sponsor several activities with IOC, including IOCCP (see item 4.1), the finishing GEOHAB project (see item 3.1), the soon-to-start GlobalHAB project (see item 4.4), and the Second International Indian Ocean Expedition (see item 3.6).
Actions: None

6.2 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), p. 6-13 ***Urban***
NSF provided funds for SCOR to co-sponsor GESAMP Working Group 38 on Atmospheric Input of Chemicals to the Ocean. The group is in its second phase, in which a workshop was held, which may result in as many as 8 peer-reviewed publications. GESAMP has approved continued work of WG 38 and SCOR may again be requested to support this work through new funding from NSF.
Action: Approve continued involvement of SCOR, contingent on NSF funding.

6.3 North Pacific Marine Science Organization (PICES), p. 6-17 ***Batchelder, Sun Song***
SCOR has long-standing cooperation with PICES, which has helped SCOR-sponsored international projects with implementations in the North Pacific region. PICES has sponsored Associate Members of SCOR working groups of interest to PICES and has cooperated with SCOR in various capacity-building activities. SCOR provided support for developing country scientists to participate in SCOR-related sessions at the 2015 PICES annual meeting.
Actions: None

7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

7.1 International Council for Science ***Burkill***
ICSU is reviewing SCOR and SCAR in 2015 and 2016.
Actions: None

7.1.1 International Geosphere-Biosphere Program (IGBP), p. 7-1 *Burkill*

SCOR did not send a representative to the final IGBP Science Committee meeting in 2015. IGBP is working on synthesis of its second-phase activities and assisting Future Earth in its development. IGBP currently is co-sponsoring the SOLAS and IMBER projects, and WG 138. IGBP is planning a Landmark Synthesis Event at the American Geophysical Union (AGU) Fall Meeting, 14-18 December 2015, in San Francisco.

Action: None

7.1.2 World Climate Research Programme (WCRP), p. 7-4 *Fennel*

WCRP co-sponsors the SOLAS project. WCRP projects particularly related to SCOR interests include the CLIVAR project and the WCRP Grand Challenge on Regional Sea-Level Change and Coastal Impacts. SCOR is co-sponsoring and providing funding for the WCRP Polar Challenge (see http://www.wcrp-climate.org/index.php/polarchallenge).

Action: None

7.1.3 Scientific Committee on Antarctic Research (SCAR), p. 7-9 *Brussaard*

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

Action: Discuss whether SCOR should offer to help with other SCAR activities.

7.1.4 Future Earth Initiative, p. 7-15 *Burkill*

The Future Earth initiative continues development, including announcement of a permanent distributed network structure and awarding of a group of grants for fast-track initiatives/clusters, which are cross-cutting projects among several potential Future Earth co-sponsored projects. SCOR and Future Earth signed a letter of agreement and SCOR is working with Future Earth to develop a mutually acceptable working arrangement in relation to SOLAS and IMBER. SCOR also helped plan and conduct a workshop among marine projects in Kiel, Germany in March 2015, to help them plan cooperative activities and discuss how to give ocean science a higher profile in Future Earth.

Action: None.

7.2 Affiliated Organizations

7.2.1 International Association for Biological Oceanography (IABO), p. 7-19 *Miloslavich*

IABO has continued its work to coordinate the field of marine biodiversity research internationally, particularly through the series of World Conferences on Marine Biodiversity. SCOR provided support for developing country scientists to attend the third conference in the series, held in China in 2014.

Action: Identify areas of future cooperation with IABO.

7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS), p. 7-22 *Turner*

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.

Actions: Identify future areas of cooperation with IAMAS.

7.2.3 International Association for the Physical Sciences of the Oceans (IAPSO), p. 7-24 *Smythe-Wright*

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

7.3 Affiliated Programs

7.3.1 InterRidge - International, Interdisciplinary Ridge Studies, p. 7-28 *Urban*

InterRidge has been a long-time affiliated program of SCOR, and the two organizations are co-sponsoring WG 135 on Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles. The InterRidge IPO is in its final year in China and will be moving to a new location next year, depending on bids for the office. InterRidge operates on a subscription basis to support its IPO and recently reformed the subscription system. In the past year, InterRidge established a new working group on Ecological Connectivity and Resiliance.
Action: None.

7.3.2 International Ocean Colour Coordinating Group (IOCCG), p. 7-31 *Sun Song*

SCOR co-sponsors various IOCCG activities through support from the U.S. National Aeronautics and Space Administration. Currently, the SCOR/IOC GEOHAB project and IOCCG are co-sponsoring a project on applications of remote sensing to detection of harmful algal blooms. In the past year, IOCCG established a new working group on Ocean Colour Applications for Biogeochemical, Ecosystem, and Climate Modeling. SCOR recently provided support for developing country scientists to participate in the 2015 International Ocean Color Science Meeting.
Action: None.

7.3.3 Global Alliance of CPR Surveys (GACS), p. 7-35 *Burkill*

GACS is SCOR's newest affiliated program. GACS continues work toward fulfilling its goals of providing a global network of Continuous Plankton Recorder surveys and has achieved some success in helping establish new CPR surveys and providing training for people responsible for these new surveys. GACS will issue the next Global Status Report in 2016 and has been significantly involved in capacity building related to CPR survey techniques.
Action: None

7.4 Other Organizations

7.4.1 Partnership for Observation of the Global Oceans (POGO), p. 7-36 *Shapavolov*

SCOR and POGO have many areas of mutual interest and have a good history of cooperation over the 15 years of POGO's existence. The two organizations have co-sponsored a fellowship program for ocean observations since 2001 and currently are working together to develop the

International Quiet Ocean Initiative (see item 3.5). SCOR and POGO also work together in relation to global capacity building for ocean science.
Action: Consider whether SCOR should offer to help with any POGO initiatives.

8.1 Membership *Urban*

8.1.1 National Committees, **p. 8-1**
Report on Membership Changes since 2013 Executive Committee Meeting, **p. 8-1**
Member Nations and Nominated Members, **p. 8-2**
Membership in the Scientific Committee on Oceanic Research (SCOR), **p. 8-3**
Actions: None.

8.2 Publications Arising from SCOR Activities, p. 8-4 *Urban*

SCOR projects and working groups have produced many publications in the past year. Several SCOR working groups have special issues or significant papers under development, which will appear in the next year.
Action: None

8.3 Finances, p. 8-5 *Finance Committee, Urban*

The SCOR Executive Committee approved a Finance Committee consisting of Annalisa Griffa (Italy), Karen Heywood (UK), and Toshiro Yamagata (Japan). This committee will conduct its work during the SCOR meeting and will report on (1) findings related to the 2014 Audit report, (2) recommendations related for revisions to the 2015 SCOR budget, (3) recommendations for the 2016 SCOR budget, and (4) recommendations for dues levels in 2017.
Actions: Present (1) findings related to the 2014 Audit report, (2) recommendations related to revisions to the 2015 SCOR budget, (3) recommendations for the 2016 SCOR budget, and (4) recommendations for dues levels in 2017.

9.0 SCOR-RELATED MEETINGS

9.1 SCOR Annual Meetings

9.1.1 2015 Executive Committee Meeting: Goa, India, p. 9-1 *Naqvi*

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

9.1.2 2016 General Meeting: Sopot, Poland, p. 9-1 *Burkill*

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

9.1.3 2017 Executive Committee Meeting, p. 9-1 ***Burkill***

Discuss potential locations for 2017 SCOR annual meeting.

Action: None

9.2 Locations of Past SCOR Annual Meetings, p. 9-2

9.3 SCOR-Related Meetings Since the 2014 SCOR Executive Committee Meeting and Planned for the Future, p. 9-3

1.0 OPENING

1.1 **Opening Remarks and Administrative Arrangements** *Naqvi, Burkill, Urban*
1.1.1 Memorials for Scientists Involved With SCOR. **p. 1-1**

1.2 **Approval of the Agenda—**Additions or modifications to the agenda may be suggested prior to approval of the final version, **p. 1-4** *Burkill*

1.3 **Report of the SCOR President—**The President will briefly review activities since the SCOR General Meeting in September 2014, **p. 1-4** *Burkill*

1.4 **Report of SCOR Executive Director, p. 1-4** *Urban*

1.5 **Appointment of an *ad hoc* Finance Committee, p. 1-6** *Burkill*

1.6 **2016 SCOR Elections for SCOR Officers, p. 1-7** *Fennel*

1.0 OPENING

1.1 Opening Remarks and Administrative Arrangements *Naqvi, Burkill, Urban*

1.1.1 Memorials for Scientists Involved With SCOR *Burkill*

Katrina Edwards

Katrina Edwards was a Full Member of SCOR/InterRidge WG 135 on Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles

Katrina J. Edwards, March 15, 1968 - October 26, 2014 (from https://astrobiology.nasa.gov/articles/2014/10/29/in-memoriam-katrina-edwards/)

The astrobiology community deeply mourns the passing of Katrina Edwards, a geomicrobiologist and very bright light in many of our lives. Please see the blog set up by her family for more information on her life and work, and to contribute remembrances of Katrina.

Katrina Jane Edwards passed away peacefully on October 26, 2014, after a long illness. She was born March 15, 1968, in Columbus, Ohio, the third of five children raised by Timothy and Sandra Edwards and big sister Laura Edwards. Katrina completed her secondary education at Columbus Alternative High School. She spent several years assisting her father and siblings in general airport operations at the Delaware Municipal Airport, eventually becoming chief flight instructor. Katrina then received her undergraduate degree from The Ohio State University and went on to earn her Ph.D. from the University of Wisconsin-Madison.

Katrina was bright, vibrant and at the helm of her chosen field. A gifted scientist, she was professor of biological sciences, earth sciences and environmental studies at the University of Southern California. Prior to that, she was associate scientist in marine chemistry and geochemistry at Woods Hole Oceanographic Institution.

A pioneer in oceanographic research, Katrina's discoveries centered on life forms beneath the ocean floor, also called "intraterrestrial life." As an innovator in geomicrobiology, Katrina worked with other scientists on integrated ocean drilling, including spearheading and leading an international deep biosphere project in the mid-Atlantic. She also headed the U.S. National Science Foundation-supported Fe-Oxidizing Microbial Observatory Project on Loihi Seamount. In 2012, she was recognized with the A.G. Huntsman Award for Excellence in Marine Science and was the third woman to receive this distinction in the foundation's 32-year history. Perhaps her most significant professional accomplishment was "raising" the next generation of geomicrobiologists through teaching and mentoring a multitude of students and post-doctoral professionals on expeditions and in her classes and research labs.

Katrina was preceded in death by her sister Laura Ruth Edwards, who died in 2005. She will be missed mightily by her three children (Ania, Katya, and Nakita Webb), siblings (Ben, Melanie, and Nina Edwards), cousins, many nieces and nephews, and parents (Timothy and Sandra Edwards). She is survived by them—along with the many friends and colleagues who loved her spontaneity and sense of humor and respected her undeniable genius. Her strength and spirit live on especially in her children—as well as all who came to know her during her 46 years.

Kon-Kee Liu

Dr. Kon-Kee Liu, an internationally renowned geochemist in ocean research, passed away August 12, 2015 in Chang Gung Memorial Hospital in Linkou, Taiwan. He was 65. The cause was liver and kidney failure.

Dr. Liu was born on May 2, 1950 in Taipei, Taiwan. From an early age, he was drawn to science, and in high school, decided on chemistry as his would-be major in college. Known to friends and colleagues as KK, Dr. Liu received his BS at National Tsing Hua University in Taiwan and Ph.D. in geochemistry at University of California, Los Angeles. He was a post-doctorate research fellow at the California Institute of Technology. In his 40-year career, Dr. Liu mentored countless students, organized large field campaigns, and dedicated his scholarly endeavors to the global environmental change research.

Most recently he served as co-Chair of the IMBER-LOICZ Continental Margin Working Group. He was a professor at National Central University's Graduate Institute of Hydrological and Oceanic Sciences in Taiwan. His many publications, in the words of IMBER (Integrated Marine and Biogeochemistry and Ecosystem Research), "provide a lasting legacy of his widespread influence."

Dr. Liu was also a devoted Christian and committed to living a faithful and productive Christian life. His faith never wavered in the face of adversity. In 1986, when his first wife Lily received the devastating diagnosis of terminal cancer, KK and Lily remained steadfast in their love for God. Over the decades, KK and his wife Margaret were an integral team in their local church, organizing fellowship groups and prayer meetings. Their shared faith sustained them in times good and difficult, especially during KK's final weeks in the hospital.

In addition to his wife Margaret, Dr. Liu is survived by his children, Jerry and his wife Niann Torng Chen, Joseph, Joshua, his parents, and his brother Phil.

It is the family's wish that in this time of sorrow, KK's friends and colleagues can draw strength from Psalm 90:12: "Teach us to realize the brevity of life, so that we may grow in wisdom". The Bible described KK’s present state: Instead, they were longing for a better country—a heavenly one. Therefore God is not ashamed to be called their God, for He has prepared a city for them. (Hebrews 11:16). In faith, we look forward reuniting with KK in the Heavenly City.
A memorial service is planned for 10:00 am on Saturday, August 29 at the Hoping Presbyterian Church in Taipei, Taiwan.

Luis Cappuro

Luis Cappuro participated in the first SCOR meeting in 1957, and was SCOR President in 1964-1968. He also participated in SCOR's 50th anniversary meeting in 2008.

Roland von Glasow

(from https://www.uea.ac.uk/environmental-sciences/news-and-events/-/asset_publisher/c54bKX3qxxfy/blog/professor-roland-von-glasow)

The UEA community is deeply saddened by the unexpected death of their colleague and friend, Professor Roland von Glasow.

Roland was a pillar in the School of Environmental Sciences. He recently conceived the Centre for Ocean and Atmospheric Sciences (COAS) at UEA, unifying physical and biogeochemical sciences under one umbrella. His leadership in the School as director of COAS and joint sector head was precious and well appreciated by us all.

Roland's research ambitions were exciting and always original. In his recent work, Roland pioneered the design and building of a sea ice chamber in the School as part of his prestigious European Research Council grant for the purpose of conducting controlled experimentation on halogen gas flux across the sea ice boundary. This unique facility shows just how much he was able to think beyond current possibilities, and actually invent the way to conduct new research. Roland's research interests in atmospheric chemistry focused on reactive halogen chemistry in the troposphere, at the air-sea boundary and also in gas emissions from volcanoes.

Roland joined UEA in 2007 having studied and worked at the University of Mainz and Max-Planck-Institute in Mainz, Germany, the Scripps Institution of Oceanography, San Diego, and at the University of Heidelberg, Germany. He was a member of the first international SOLAS summer school (2003) jointly led by colleagues at UEA, which initiated many students to the joys of interdisciplinary research. He quickly went on and led international projects himself, including the Halogens in the Troposphere task force of SOLAS/IGAC, and the fast track initiative on air-sea interactions in megacities and the coastal zone of IGBP. He was a member of numerous scientific committees, generously giving his time and sharing his enthusiasm for research.

Roland was also an avid hiker, climber and triathlete.

Professor Kevin Hiscock, Head of the School of Environmental Sciences, said: "We were deeply saddened to learn of Roland's unexpected death. Roland was a very supportive colleague whose warm personality made him a popular figure in the School and beyond. Roland leaves a wife, Wendy, and two young daughters to whom we extend our deepest sympathy."

We will be working to support the continuation of his work, and help students and colleagues pursue some of his unique ideas.

1.2 Approval of the Agenda (see Tab 0) ***Burkill***

The agenda can be rearranged at the meeting to accommodate the schedules of presenters and to add items to it.

1.3 Report of the SCOR President ***Burkill***

The SCOR President will present a report at the meeting that describes his activities on behalf of SCOR since the 2014 SCOR Annual Meeting in Bremen, Germany.

1.4 Report of SCOR Executive Director ***Urban***

This has been another busy year for the SCOR Secretariat. SCOR-supported groups continue their good work.

Finances—SCOR's finances remain healthy, although some countries have had trouble paying their dues this year and last. Income from dues is important for funding the central administration of SCOR, namely the costs of the Secretariat and the annual SCOR meetings. Dues also fund some costs of working groups and other SCOR activities that are not funded from grants. SCOR depends on grant funding for large-scale research projects, ocean carbon activities, and some working groups.

National Members—The number of countries involved in SCOR has remained stable this year. There was some rotation of Nominated Members (see Tab 8).

Publications and Outreach—The SCOR Web site is the major vehicle for providing up-to-date information about SCOR to the international ocean science community and I make changes to the site several times each week, as I receive new information. The site is checked for "dead links" monthly. SCOR activities yielded many publications in the primary literature and other venues this year, as noted in Tab 8. Because SCOR's reputation is significantly affected by the quality of documents resulting from SCOR activities, I spend a significant amount of my time writing, reviewing, and/or editing publications.

I have reserved a booth for SCOR at the Ocean Sciences meeting in New Orleans in February 2016. As at the 2014 Ocean Sciences meeting, the booth will provide an opportunity for SCOR-sponsored projects to gain visibility. SCOR will pay to have five posters formatted by a professional graphic artist and printed as a roll-up banner. One will be for SCOR and the four others for SCOR projects. The booth will provide an opportunity for these projects to distribute information and to meet with people who drop by.

The SCOR Twitter account has 74 followers (as of 27 Oct. 2015) and I continue to Tweet when there are news items that I think would interest the broader community. There is almost no overlap between SCOR's Twitter followers and people on the SCOR email list.

Meetings—Between the 2014 and 2015 SCOR annual meetings, 11 SCOR working groups met

(WGs 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147). The Scientific Steering Committees of GEOHAB, IMBER, SOLAS, and SOOS also met.

Outreach to Scientists from Developing Nations and Capacity-Building Activities—SCOR continues to invest funding and effort in expanding our capacity-building activities. In addition to the continuation of the travel grant program, SCOR appoints up to three SCOR Visiting Scholars each year. The second of four annual Research Camps was held at the University of Namibia (UNAM) campus in Henties Bay this year. This concept grew out of Kurt Hanselmann's two visits to UNAM as a SCOR Visiting Scholar and a subsequent grant from the Agouron Institute to SCOR for this activity.

I met with scientists at the Ocean University of Sri Lanka, the Sri Lankan oceanography agency (NARA), and the U.S.-Sri Lanka Fulbright Commission in March 2015 to present SCOR capacity building opportunities and to discuss the participation of institutions in Sri Lanka in the Second International Indian Ocean Expedition (IIOE-2).

Service to International Ocean Research Projects—SCOR helps SCOR-sponsored research projects in many different ways, including providing funds from the U.S. National Science Foundation, the U.S. National Aeronautics and Space Administration, and other sources, providing travel support for developing country scientists and scientists from countries with economies in transition to special events of the projects, providing IPO-type support until an IPO can be funded, providing access to the Conference Manager software for management of open science meetings, and leasing the GoToMeeting audio conferencing system for the projects.

Support of Project Offices—SCOR currently provides partial support for three project offices, as subawards to one of SCOR's grants from NSF:

- International Ocean Carbon Coordination Project (IOCCP)—This office is located in Sopot, Poland, at the Institute of Oceanology of the Polish Academy of Sciences. SCOR pays the salary and benefits for the project director, Dr. Maciej Telszewski. IOC helps support the cost of the office and provides activity funding for IOCCP, and the host institution provides in-kind support.
- GEOTRACES Data Assembly Centre—This office is located at the British Oceanographic Data Centre. SCOR pays for some salary support and other expenses related to the office, for the GEOTRACES Data Manager. The office receives occasional support from other countries whose scientists are involved in GEOTRACES.
- GEOTRACES International Project Office—This office is located in Toulouse, France at the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, SCOR support pays for about half of the office cost, including some salary support for the GEOTRACES Executive Officer, Ms. Elena Masferrer-Dodas. SCOR funds are supplemented by funds from other countries whose scientists are involved in GEOTRACES.

Partnerships With Other Organizations—Maintaining existing partnerships and developing new ones depends on SCOR having the ability to commit funding to joint activities and to send representatives to partners' meetings. We have strong partnerships with IGBP, IOC, PICES,

POGO, and SCAR. We are developing a working relationship with the Future Earth initiative, particularly in relation to the SOLAS and IMBER projects. This year, Peter Burkill and I represented SCOR at the IOC General Assembly in June.

Staffing—Currently, I am working full-time for SCOR and Elizabeth Gross is working about one-quarter time as a contractor to handle many financial duties. I handle the regular duties related to the SCOR Secretariat each year, but this year I also did the following:

- Handled the report production for two project science plans, for the International Quiet Ocean Experiment (IQOE) and the Second International Indian Ocean Expedition (IIOE-2). This involves all the tasks that would normally be done by a publisher, including arranging editing and formatting, finding high-resolution graphics and arranging permissions to re-use the graphics, proof-reading, and distribution of the finished product.
- Writing and submitting a three-year continuation of the SCOR science proposal to the U.S. National Science Foundation. This proposal was successful, providing continued funding for GEOTRACES, GlobalHAB, IMBER, IOCCP, SOLAS, SCOR working groups and other activities through 31 August 2018.
- I have provided staffing support for the International Symposium Planning Committee for the International Symposium on the Indian Ocean in Goa, India on 30 Nov.-4 Dec.
- I co-authored a publication on “Determining priority variables ("ecosystem Essential Ocean Variables" - eEOVs) for observing dynamics and change in Southern Ocean
- Ecosystems”, submitted to the *Journal of Marine Systems,* in review.
- I wrote an invited article for the *CLIVAR Exchanges* newsletter on the history of the International Indian Ocean Expedition.

I continue to manage all SCOR Secretariat activities and oversee the finances of SCOR activities, pursue new funding for SCOR activities, represent SCOR at various meetings, help edit various publications, and work on the SCOR Web site and Newsletter.

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

The Executive Committee has appointed the 2015 Ad Hoc SCOR Finance Committee before the meeting, so the committee members can receive and review SCOR financial information in advance. Participation on the Finance Committee is limited to Nominated Members who are attending the meeting, but who are not members of the SCOR Executive Committee. This ensures that a group independent from the Executive Committee and SCOR Secretariat staff can make recommendations to the Executive Committee about SCOR finances. The members of this year’s Finance Committee are Annalisa Griffa (Italy), Karen Heywood (UK), and Toshio Yamagata (Japan).

1.6 2016 Elections for SCOR Officers ***Fennel***

The election process for new SCOR officers will begin at the SCOR meeting in Goa.

2.0 WORKING GROUPS

2.1 Current Working Groups

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

2.1.1 SCOR/InterRidge WG 135 on Hydrothermal energy transfer and its impact on the ocean carbon cycles, p. **2-1** *Bharathi*

2.1.2 WG 137: Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation, **p. 2-3** *Ramaiah, Sun Song*

2.1.3 SCOR/IGBP WG 138: Modern Planktic Foraminifera and Ocean Changes, **p. 2-8** *Naidu, Brussaard*

2.1.4 WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean, **p. 2-10** *Naqvi*

2.1.5 WG 140: Biogeochemical Exchange Processes at the Sea-Ice Interfaces, **p. 2-17** *Shapovalov*

2.1.6 WG 141 on Sea-Surface Microlayers, **p. 2-35** *Burkill*

2.1.7 WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders, **p. 2-37** *Prakash, Burkill*

2.1.8 WG 143 on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4, **p. 2-42** *Bange, Turner*

2.1.9 WG 144 on Microbial Community Responses to Ocean Deoxygenation, **p. 2-47** *Ramaiah*

2.1.10 WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC), **p. 2-53** *Urban*

2.1.11 WG 146 on Radioactivity in the Ocean, 5 decades later (RiO5), **p. 2-61** *Naqvi*

2.1.12 WG 147: Towards comparability of global oceanic nutrient data (COMPONUT), **p. 2-65** *Naik, Naqvi*

2.2 Working Group Proposals

2.2.1 Towards a Global Comparison of Zooplankton Production: Measurement, Methodologies and Applications (ZooProd), **p. 2-70** *Sun Song*

2.2.2 SEAmount Faunal vulnerabilty to impacts of Ocean Acidification and Mining (SEAFOAM), **p. 2-84** *Burkill*

2.2.3 BIOgeochemistry of COral REef systems (BIOCORE), **p. 2-103** *Brussaard*

2.2.4 Changing Ocean Biological Systems (COBS): how will biota respond to a changing ocean?, **p. 2-110** *Miloslavich*

2.2.5 A Functional Trait Perspective on the Biodiversity of Hydrothermal Vent Communities (FDvent), **p. 2-128** *Burkill*

2.2.6 Rheology, nano/micro-Fluidics and bioFouling in the Oceans (RheFFO), **p. 2-143** *Fennel*

2.2.7 Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT), **p. 2-162** *Smythe-Wright*

2.2.8 Global Assessment of Nutrient Export Through Submarine Groundwater Discharge (NExT SGD), **p. 2-175** *Naqvi*

2.2.9 International Quality Controlled Ocean Database: Subsurface temperature profiles (IQuOD), **p. 2-192** *Turner*

2.2.10 The dynamic ecogeomorphic evolution of mangrove and salt marsh coastlines (DEMASCO), **p. 2-214** *Miloslavich*

2.1 Current Working Groups

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

Terms of Reference:

- Synthesize current knowledge of chemical substrates, mechanisms and rates of chemosynthetic carbon fixation at hydrothermal systems as well as the transfer of phytoplankton-limiting micronutrients from these systems to the open ocean.
- Integrate these findings into conceptual models of energy transfer and carbon cycling through hydrothermal systems which would lead to quantification of primary production in view of a future assessment of the contribution of these systems to the global-ocean carbon cycle.
- Identify critical gaps in current knowledge and proposing a strategy for future field, laboratory, experimental and/or theoretical studies to bridge these gaps and better constrain the impact of deep-sea hydrothermal systems on ocean carbon cycles.

Co-chairs:
Nadine Le Bris (France) and Chris German (USA)

Other Full Members

Wolfgang Bach	Germany	Peter R. Girguis	USA
Loka Bharathi	India	Xiqiu Han	China-Beijing
Nicole Dubilier	Germany	Louis Legendre	France
Katrina Edwards	USA	Ken Takai	Japan

Associate Members

Philip Boyd	New Zealand	George W. Luther III	USA
Thorsten Dittmar	Germany	Tom McCollom	USA
Françoise Gaill	France	W.E. Seyfried, Jr.	USA
Toshitaka Gamo	Japan	Stefan Sievert	USA
Julie Huber	USA	Margaret K. Tivey	USA
Bob Lowell	USA	Andreas Thurnherr	USA

Executive Committee Reporter:

At the SCOR General Meeting in 2014, it was approved to disband WG 135 when its publications were completed. The first publication appeared since then:

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

A second publication is being prepared and should be submitted by the end of 2015. The group would like to be extended until the 2016 SCOR meeting.

2.1.2 WG 137: Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation (2009) *Ramaiah, Sun Song*

Terms of Reference:

- Identify existing long time series of phytoplankton data in coastal oceans around the world.
- Facilitate migration of individual data sets to a permanent and secure electronic archive. (Requirements for development of a fully stocked phytoplankton database greatly exceed the resources of this WG. However, we expect to produce a small working proto-type, based on the existing archive (to be identified) to demonstrate the value of sharing data through an international database.)
- Develop the methodology for global comparisons for within-region and within-time period data summarization (e.g., spatial, seasonal, and annual averaging, summation within taxonomic and functional group categories). The goal is to clarify what level of detail provides the optimal tradeoff (i.e., information gain vs. processing effort).
- Based on the above, develop priorities and recommendations for future monitoring efforts and more developed re-analysis of existing data sets.
- We will carry out a global comparison of phytoplankton time series using (in parallel) a diverse suite of numerical methods. We will examine:
  - Synchronies in timing of major fluctuations, of whatever form.
  - Correlation structure (scale and spatial pattern) for particular modes of phytoplankton variability (e.g. changes in total biomass, species composition shifts, among different geographic distribution).
  - Amplitude of variability, both for total biomass and for individual dominant species, and a comparison to the amplitude of population fluctuations.
  - Likely causal mechanisms and consequences for the phytoplankton variability, based on spatial and temporal coherence with water quality time series
- Through comparative analysis, we will address the 3 guiding questions.

Co-chairs:

Kedong Yin (China-Beijing) and Hans W. Paerl (USA)

Other Full Members

Susan I. Blackburn	Australia	Todd O'Brien	USA
Jacob Carstensen	Denmark	Clarisse Odebrecht	Brazil
James E. Cloern	USA	N. Ramaiah	India
Paul J. Harrison	China-Beijing	Katja Philippart	Netherlands
Ruixiang Li	China-Beijing	Adriana Zingone	Italy
Abigail McQuatters-Gollop	UK		

Associate Members

Robert Le Borgne	N. Caledonia	Snejana P Moncheva	Bulgaria
Perry Elgin	USA	Xosé Anxelu G. Morán	Spain
Alan Jassby	USA	Grant Picher	South Africa
Jorma Kuparinen	Finland	Theodore J. Smayda	USA
Juha-Markku Leppänen	Finland	Wiltshire, Karen	Germany
Thomas Malone	USA	Sinjae Yoo	South Korea

2-4

Executive Committee Reporter: Sun Song

SCOR WG 137
Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observations

Co-Chairs: Kedong Yin and Hans Paerl

Report

September 3, 2015

I. Summary of Activities

1. Meeting Summary

During the first meeting in October 2010, participants presented their systems and proposed research questions and other relevant subjects. In the second meeting, the focus was on presenting new products: comparisons and synthesis of different data sets from different regions, and new approaches to examine multiple data sets. In this third meeting, participants discussed how to address and approach the research questions raised in the previous meetings and were given take-home assignments for preparing papers. The participants in the fourth meeting presented their synthesized work and decided to publish a special issue for WG137 research in *Estuarine, Coastal and Shelf Science.* WG 137 also decided to continue the WG activity and discussed places for having the future plan for the meetings and research. In the fifth meeting, participants summarized their findings and discussed the future plans.

2. Meeting Places and Dates

Meeting	Place	Dates	Financial support	Remarks
1st	Hangzhou, China	October 17-20, 2010	SOA, China	Independent meeting
2nd	Sorrento, Italy	September 27-30, 2011	Stazione Zoologica, Italy	Independent meeting
3rd	Hiroshima, Japan	October 12-14, 2012	PICES, partial	A joint SCOR/PICES Workshop W7, PICES Annual Meeting 2012
4th	San Diego, USA	November 2-4, 2013	None	A joint SCOR/CERF Workshop, and a CERF Session SCI-62

				CERF 2013 Biennial Conference
5th	Zhuhai, Guangdong China	November 3-7, 2014	Sun Yat-sen University, Guangzhou China	Independent

II. Achievement in Terms of References

We have accomplished what we outlined in the Terms of References (Appendix 1).

1. We have collected many data sets of phytoplankton in the coastal oceans around the world.
2. We have facilitated migration of individual data sets to a website: www.wg137.net. Now, WG137 datasets have also become part of IGMETS (www.IGMETS.net), an IOC program.
3. We also achieved Terms of Reference No. 3-5, demonstrated by the recently published WG137 Special Issue in the *Estuarine, Coastal and Shelf Science* (see below).

III. Outcome and Scientific Products

1. WG137 has made substantial achievements, not only in its compiling datasets, but also in promoting phytoplankton as an essential part of the ocean ecosystems, emphasizing the values and importance of phytoplankton monitoring programs.

   a) In the PICES Annual Meeting 2012 in Hiroshima, Japan in 2012, Hans Paerl represented WG137 and gave a plenary speech: "Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Utilizing long-term data to distinguish human from climatic drivers of ecological change."

   b) In the PICES Annual Meeting 2012 in Hiroshima, Japan, Bill Li of the Bedford Institute of Oceanography, Canada, on behalf of the joint effort between ICES WG on Phytoplankton and Microbial Ecology and WG137, gave a plenary presentation: "An ecological status report for phytoplankton and microbial plankton in the North Atlantic and adjacent seas."

   c) In the CERF 2013 Biennial Conference, WG137 organized a joint SCOR/CERF Workshop, and the CERF Session SCI-62. The session attracted 22 abstracts and ran for a full day, with the room filled during the session.

2. The datasets on phytoplankton compiled by WG137 are very valuable. Recently, IOC has formed an "International Group for Marine Ecological Time Series (IGMETS)", to which WG137 has made a great contribution.

3. IOC has an interest in forming an International Group on Phytoplankton: Climate Change and

Global Trends of Phytoplankton in the Oceans, which will continue WG137 subjects related activities using the datasets compiled by WG137.

4. WG137 produced a special issue in *Estuarine, Coastal and Shelf Science*, including the following papers:

Estuarine, Coastal and Shelf Science
Volume 162, Pages 1-160 (5 September 2015)
Special Issue: Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems
Edited by Riina Klais, James E. Cloern and Paul J. Harrison

- Hans W. Paerl, Kedong Yin, Todd D. O'Brien. 2015. SCOR Working Group 137: "Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems": An introduction to the special issue of *Estuarine, Coastal and Shelf Science* 162:1-3.
- Riina Klais, James E. Cloern, Paul J. Harrison. 2015. Resolving variability of phytoplankton species composition and blooms in coastal ecosystems. *Estuarine, Coastal and Shelf Science* 162:4-6
- Nathan S. Hall, Anthony C. Whipple, Hans W. Paerl. 2015. Vertical spatio-temporal patterns of phytoplankton due to migration behaviors in two shallow, microtidal estuaries: Influence on phytoplankton function and structure. *Estuarine, Coastal and Shelf Science* 162:7-21
- Charles L. Gallegos, Patrick J. Neale. 2015. Long-term variations in primary production in a eutrophic sub-estuary: Contribution of short-term events. *Estuarine, Coastal and Shelf Science* 162:22-34
- Clarisse Odebrecht, Paulo C. Abreu, Jacob Carstensen. 2015. Retention time generates short-term phytoplankton blooms in a shallow microtidal subtropical estuary. *Estuarine, Coastal and Shelf Science* 162:35-44
- R.J. Gowen, Y. Collos, P. Tett, C. Scherer, B. Bec, E. Abadie, M. Allen, T. O'Brien.2015. Response of diatom and dinoflagellate lifeforms to reduced phosphorus loading: A case study in the Thau lagoon, France. *Estuarine, Coastal and Shelf Science* 162:45-52
- L.W. Harding Jr., J.E. Adolf, M.E. Mallonee, W.D. Miller, C.L. Gallegos, E.S. Perry, J.M. Johnson, K.G. Sellner, H.W. Paerl. 2015. Climate effects on phytoplankton floral composition in Chesapeake Bay. *Estuarine, Coastal and Shelf Science* 162:53-68
- Anna Godhe, Chethan Narayanaswamy, Riina Klais, K.S. Venkatesha Moorthy, Rengaswamy Ramesh, Ashwin Rai, H.R. Venkataswamy Reddy. 2015. Long-term patterns of net phytoplankton and hydrography in coastal SE Arabian Sea: What can be inferred from genus level data? *Estuarine, Coastal and Shelf Science* 162:69-75
- Lumi Haraguchi, Jacob Carstensen, Paulo Cesar Abreu, Clarisse Odebrecht. 2015. Long-term changes of the phytoplankton community and biomass in the subtropical shallow Patos Lagoon Estuary, Brazil. *Estuarine, Coastal and Shelf Science* 162:76-87
- Abigail McQuatters-Gollop, Martin Edwards, Pierre Helaouët, David G. Johns, Nicholas J.P. Owens, Dionysios E. Raitsos, Declan Schroeder, Jennifer Skinner, Rowena F. Stern. 2015. The Continuous Plankton Recorder survey: How can long-term phytoplankton datasets contribute to the assessment of Good Environmental Status? *Estuarine, Coastal and Shelf Science* 162:88-97

- Jacob Carstensen, Riina Klais, James E. Cloern. 2015. Phytoplankton blooms in estuarine and coastal waters: Seasonal patterns and key species. *Estuarine, Coastal and Shelf Science* 162:98-109
- Kalle Olli, Hans W. Paerl, Riina Klais. 2015. Diversity of coastal phytoplankton assemblages – Cross ecosystem comparison. *Estuarine, Coastal and Shelf Science* 162:110-118
- Peter A. Thompson, Todd D. O'Brien, Hans W. Paerl, Benjamin L. Peierls, Paul J. Harrison, Malcolm Robb. 2015. Precipitation as a driver of phytoplankton ecology in coastal waters: A climatic perspective. *Estuarine, Coastal and Shelf Science* 162:119-129
- Paul J. Harrison, Adriana Zingone, Michael J. Mickelson, Sirpa Lehtinen, Nagappa Ramaiah, Alexandra C. Kraberg, Jun Sun, Abigail McQuatters-Gollop, Hans Henrik Jakobsen. 2015. Cell volumes of marine phytoplankton from globally distributed coastal data sets. *Estuarine, Coastal and Shelf Science* 162:130-142
- Hans Henrik Jakobsen, Jacob Carstensen, Paul J. Harrison, Adriana Zingone. 2015. Estimating time series phytoplankton carbon biomass: Inter-lab comparison of species identification and comparison of volume-to-carbon scaling ratios. *Estuarine, Coastal and Shelf Science* 162:143-150
- Adriana Zingone, Paul J. Harrison, Alexandra Kraberg, Sirpa Lehtinen, Abigail McQuatters-Gollop, Todd O'Brien, Jun Sun, Hans H. Jakobsen. 2015. Increasing the quality, comparability and accessibility of phytoplankton species composition time-series data. *Estuarine, Coastal and Shelf Science* 162:151-160

In addition to the contributions in the Special Issue, individual and combined members of WG 137 have, over the past 4 years, published numerous peer-reviewed manuscripts (based on WG-137 compiled data sets) in aquatic, ecological, biogeochemical as well as high-profile journals, including *Science*, *PLOS One*, *Transactions of the Royal Society*, *Reviews of Geophysics*, *Limnology and Oceanography*.

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

(2010) ***Naidu, Brussaard***

Terms of Reference:

1. Synthesize the state of the science of modern planktic foraminifera, from pioneering to ongoing research including their spatial and temporal distribution in the world ocean their calcification mechanisms and shell chemistry and their eco-phenotypical and genotypical variability as a peer-reviewed publication in an open-access journal (**deliverable 1**).
2. Provide guidelines (cookbooks) in terms of species identification, experimental setup for culture studies, laboratory treatment prior to geochemical analysis (**deliverable 2**) by identifying existing gaps in the available knowledge in order to direct future research.
3. Establish an active Web-based network in cooperation with ongoing (inter)national research programmes and projects to guarantee an open-access world-wide dissemination of results, data and research plans (**deliverable 3**).
4. Document the work of the group in a special issue of an open-access journal (**deliverable 5**) in connection with a specialized symposium with special emphasis on modern ocean change i.e. thermohaline circulation and ocean acidification, during one of the AGU or EGU conferences, ideally held at the joint EGU/AGU meeting (envisaged for 2013 or 2014) and/or at the FORAMS 2014 meeting in Chile (**deliverable 4**).

Co-chairs:
Gerald Ganssen (Netherlands) and Michal Kucera (Germany)

Other Full Members

Jelle Bijma	Germany	Divakar Naidu	India
Jonathan Erez	Israel	Daniela Schmidt	UK
Elena Ivanova	Russia	Howard Spero	USA
Margarita Marchant	Chile	Richard Zeebe	USA

Associate Members

Caroline Cleroux	USA/France	Dirk Kroon	UK
Kate Darling	UK	Stefan Mulitza	Germany
Lennart de Nooijer	Netherlands	Frank Peeters	Netherlands
Steve Eggins	Australia	Michael Schulz	Germany
Baerbel Hoenisch	USA	Kazuyo Tachikawa	France
Sangmin Hyun	Korea	Rashieda Toefy	South Africa
Zhimin Jian	China-Beijing	Jaroslaw Tyszka	Poland
Thorsten Kiefer	Switzerland		

Executive Committee Reporter: Corina Brussaard

From: Michal Kucera [mailto:mkucera@marum.de]
Sent: Friday, September 04, 2015 10:09 PM
To: Ed Urban <ed.urban@scor-int.org>
Subject: SCOR WG138 Catalina workshop

Dear Ed,

The final workshop of our WG138 is just over and I feel I have to share some of the highlights with you right away. The meeting attracted 50 participants, including a large group of students from a couple of undergrads to finishing PhDs. We combined lectures, talks and lab training and the resulting total immersion into foram science was a truly remarkable experience. When we were asked by SCOR to incorporate such summer school into our mandate, I was not sure if we would make it, but the result proved you right - there was a huge need for this event and we now have an enthused group of young researchers on the way home, with a network and experience of a lifetime (not to speak of snorkeling with sharks and similar minor side-highlights).

Since you were collecting such information last time, I am pleased to let you know that this time we also reached the community from developing countries. Among the participants were Elena Ivanova from Russia, Margarita Marchan from Chile and Divakar Naidu from India.

The second reason I write is to provide a link to the abstract volume, which turned out really nice and we used it a bit to serve as a material record from the meeting (printed courtesy of Beta analytics), containing information about the WG and some of our achievements:

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

Third, in the spirit of our keen interest in new media, we arranged for all talks to be videoed. They will be professionally synchronised with the presentations and uploaded via UC Davis (at no cost...). We will seek permissions from all speakers to make these public. If this is of interest to SCOR, let me know and I will provide you with more details and the link. Half of the talks were lecture-style (for the students) so this will certainly be a very interesting resource.

We are now working on the final report, which we hope to finish before Goa.

All the best
Michal

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

Terms of Reference:

1. To inform the Ocean Sciences community of this WG and related objectives via a widely distributed publication in *EOS* or analogous journal.
2. To summarize published results on all aspects of metal-binding ligands in the oceans (e.g., distributions, chemical structure, sources, sinks, stability constants), and to contribute to the organic ligand database for use in biogeochemical models and for those working in the field (including results from ongoing GEOTRACES, SOLAS and CLIVAR efforts). The summary will be included in a review paper published after year 2, as well as in the database on the proposed website.
3. To expand upon the ligand intercalibration programme, initiated by GEOTRACES, to evaluate key analytical issues with currently employed methodologies and determine how to best link ongoing efforts in trace metal and organic geochemistry to assess natural metal-binding ligand.In a recent intercalibration the preservation of samples for Fe and Cu-organic speciation by freezing at -20°C as been found suitable and will enable to make samples taken during GEOTRACES cruises available to interested scientists. A large intercalibration will thus be possible in the future without additional joint cruises or sampling exercises, but could be performed with samples from several 'normal stations' of a GEOTRACES leg. Results from intercalibration efforts will be presented in a manual available via download from the proposed WG website.
4. To identify how best to incorporate published and future data into biogeochemical models.
5. To debate the nature of sampling strategies and experimental approaches employed in laboratory and field efforts in workshops and meeting discussions that are needed to enhance our understanding of the links between the provenance, fate, distribution, and chemistry and biological functions of these organic metal-binding ligands in the oceans.
6. To recommend future approaches to ligand biogeochemistry in a designated symposium, including ongoing GEOTRACES field efforts (i.e., regional surveys and process studies), integration of CLE-ACSV and organic geochemistry techniques, and the need for rapid incorporation of this research in biogeochemical models. Such future recommendations will also be included in the aforementioned downloadable manual on the WG website.
7. To establish a webpage for this SCOR working group, to promote a forum for discussion of ideas and results in form of a blog, soliciting input from the trace metal biogeochemistry, organic geochemistry and modeling communities and provide a platform to propose special sessions on trace metal-binding ligands at international meetings such as Ocean Sciences, AGU and/or EGU.
8. To produce conclusions resulting from the outcome of the above objectives in the form of a Website, a journal special issue or book, and a report to SCOR.

Co-chairs:
Sylvia Sander (New Zealand), Kristen Buck (USA), and Maeve Lohan (UK)

Other Full Members

Kathy Barbeau	USA	Ivanka Pizeta	Croatia
Ronald Benner	USA	Alessandro Tagliabue	France
Martha Gledhill	UK	Rujun Yang	China-Beijing
Katsumi Hirose	Japan		

Associate Members

Philip Boyd	New Zealand	James Moffett	USA
Ken Bruland	USA	François Morel	USA
Peter Croot	UK	Micha Rijkenberg	Netherlands
Jay Cullen	Canada	Mak Saito	USA
Thorsten Dittmar	Germany	Barbara Sulzenberger	Switzerland
Christine Hassler	Australia	Stan van den Berg	UK
Rick Keil	USA		

Executive Committee Reporter: Wajih Naqvi

SCOR Working Group 139:

Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean

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 the 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. http://www.iupac.org/publications/ci/2012/3404/pp4_wg139.html

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 are being compiled by several members of the working group. Four key bioactive trace elements were chosen: Co, Cu, Fe and Zn. The four champions who agreed to collate the data were: Mak Saito for Co, Jim Moffett for Cu, Micha Rijkenberg for Fe and Maeve Lohan for Zn. The iron-binding ligand database is the furthest developed and an additional database for the raw titration data used to calculate iron-binding ligands has recently been initiated. This compilation of unprocessed titration data will be especially useful for the development and testing of new interpretation methods, which members of this working group have shown is exceedingly important. The review paper is underway and will be completed once the databases are established.

3. **To expand upon the ligand intercalibration programme, initiated by GEOTRACES, to evaluate key analytical issues with currently employed methodologies and determine how to best link ongoing efforts in trace metal and organic geochemistry to assess natural metal-binding ligand. In a recent intercalibration the preservation of samples for Fe and Cu-organic speciation by**

freezing at -20°C has been found suitable and will enable to make samples taken during GEOTRACES cruises available to interested scientists. A large intercalibration will thus be possible in the future without additional joint cruises or sampling exercises, but could be performed with samples from several 'normal stations' of a GEOTRACES leg. Results from intercalibration efforts will be presented in a manual available via download from the proposed WG website.

Several successful intercalibration activities have been pursued as part of this working group. A large intercalibration of the interpretation techniques routinely used for determining ligand concentrations and conditional stability constants from titration data was conducted with 15 participants using a simulated dataset. The results of this intercalibration identified some limitations of interpretation tools and highlighted the importance of interpreting multiple window titration data as a whole instead of individually. These results were published in *Marine Chemistry* as part of a special issue (http://www.sciencedirect.com/science/journal/03044203/173) produced by this working group (Pizeta et al. 2015). This intercalibration also served to expose the wider electrochemistry community to powerful new interpretation tools developed by participants in this working group, which are now freely available to download from our working group website (http://neon.otago.ac.nz/research/scor/achievements.html). Three different interpretation tools are freely available:

1. ProMCC developed by Dario Omanović, Cédric Garnier and Ivanka Pižeta (https://sites.google.com/site/mccprosece/),
2. KINETEQL developed by Bob Hundson (https://sites.google.com/site/kineteql/home/about-kineteql), and
3. an R script developed by Micha Rijkenberg and Loes Gerringa (http://www.researchgate.net/publication/275016798_R_script_for_analysis_of_organic_metal_complexation_characteristics_version_15042015).

With a growing consensus on ideal interpretation tools for determining ligand characteristics from titration data, the next step is to conduct an intercalibration for generating the titration data itself. A large volume of filtered seawater has been collected for this purpose from the Gulf of Mexico, and will be distributed to interested analysts for measurement in spring 2016. A similar exercise is planned with water collected from the Southern Ocean. Both of these cruises were funded by the U.S. National Science Foundation.

A discussion on the merits of an analytical intercalibration of commercially available model ligands and ligand mixtures was debated, but this effort is still in the early planning stages.

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

Trace metal-binding ligands play a fundamental role in trace metal residence times and bioavailability and it is therefore essential to represent this organic complexation correctly in biogeochemical models. At present, iron is represented in climate models using three different approaches: (1) Threshold Models that use a threshold ligand concentration, (2) Explicit Models that use a vast range of parameters, and (3) Equilibrium Models that use either a simple case whereby single ligand class concentrations and conditional stability constants are used or a more complex case using two ligand classes, their formation and disassociation constants and photolability. 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 if trace metals compete for the same class of ligands. It was decided that a speciation database for bioactive trace elements would be a helpful starting point (see point 2). A paper published by Volker and Tagliabue (2015) in the *Marine Chemistry* special issue examined how organic iron-binding ligands could be represented in a biogeochemical ocean model (http://www.sciencedirect.com/science/article/pii/S0304420314002229).

Furthermore, a new SCOR WG 145 'MARCHEMSPEC – Modelling Chemical Speciation in Seawater to Meet 21stCentury Needs' has been established, which 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. To represent the users of chemical models in this WG, SCOR WG 139 co-chair Sander has also been appointed vice-chair in the new WG 145.

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 has met annually from 2012-2014 in February, coinciding with the February ocean sciences/aquatic sciences meetings hosted by AGU and ASLO. Notes from each of these meetings are posted on our website (http://neon.otago.ac.nz/research/scor/meetings.html). To incorporate updates from the broader community, the co-chairs of this Working Group have also chaired a special session related to the working group at each of the ASLO conferences in 2012, 2013 and 2014. In all three cases, sufficient submissions allowed for both oral and poster sessions at the conferences. At all three sessions presentations were given from trace metal biogeochemists, organic geochemists and biogeochemical modellers, indicating the success of this working

group in bringing together new research approaches for determining trace metal speciation. In addition, an open Town Hall Meeting, held during the 2014 Ocean Sciences meeting, was attended by 47 people and served to highlight accomplishments of the working group to date and engaged broader community participation in the ongoing working group activities. This town hall meeting also advertised the symposium and sought feedback in how this symposium would be run. This led to the addition of a training workshop prior to the symposium.

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.**

In April 2015, the final year of this working group, a highly successful two-day symposium was held in Sibenik, Croatia. 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 postdocs, 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 analysing 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. A best practices manual reflecting the recommendations gained through this working group is underway. Drafts of the manual will be made available to the community on our website and advertised on our email list to elicit feedback. We anticipate that the manual will continue to be updated over time as this community continues making advancements.

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 webpage 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 are hosted at the Bermuda Institute of Ocean Sciences (scorwg139members@bios.edu and scorwg139all@bios.edu), and soon at the University of South Florida. 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/). A 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). Due to the success of the *Marine Chemistry* special issue and discussions at the final symposium, another special issue was initiated. This second special issue is currently underway in *Frontiers Marine Biogeochemistry* and the deadline for submissions to this issue is in December 2015. A total of 24 authors have confirmed their intention to contribute to this special issue.

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

Terms of Reference:

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

Co-chairs:
Jacqueline Stefels (Netherlands) and Nadja Steiner (Canada)

Other Full Members

Gerhard Dieckmann	Germany	Lynn Russell	USA
Elena Golubeva	Russia	Paul Shepson	USA
Delphine Lannuzel	Australia	Jean-Louis Tison	Belgium
Sang Heon Lee	Korea	Martin Vancoppenolle	Belgium

Associate Members

Kevin Arrigo	USA	Paty Matrai	USA
Jeff Bowman	USA	Christine Michel	Canada
Clara Deal	USA	Lisa Miller	Canada
Bruno DeLille	Belgium	Jun Nishioka	Japan
Scott Elliot	USA	Daiki Nomura	Norway
Michael Fischer	Germany	Benjamin Saenz	USA
Agneta Fransson	Norway	Veronique Schoemann	Netherlands
Francois Fripiat	Belgium	Lise-Lotte Soerensen	Denmark
Claire Hughes	UK	Letizia Tedesco	Finland
Delphine Lannuzzel	Australia	David Thomas	UK
Maurice Levasseur	Canada	Maria van Leeuwe	Netherlands
Brice Loose	USA	Roland von Glasow	UK
		Chris Zappa	USA
		JiaYun Zhou	Belgium

Executive Committee Reporter: Sergey Shapovalov

SCOR WG 140
Biogeochemical Exchange Processes at the
Sea-Ice Interfaces (BEPSII)
- Annual Report 2015 -

The yearly meeting of WG140 took place after the Gordon Research Conference on Polar Marine Sciences in Lucca, Tuscany, Italy on 20 March 20 2015. 26 members of the BEPSII network, representing 12 countries, attended the meeting. The group consisted of 50:50 established versus early-career scientists and 50:50 female and male participants. A full report of the meeting is presented in **Annex I**.

Participants of the BEPSII meeting in Lucca, Italy, 20 March 2015

Overview of activities

Task Group 1 on Methodologies and Intercomparisons (Leads: Lisa Miller and Lynn Russell) has three primary goals:

1. Methodological review;
2. Provide recommendations for intercomparisons and intercalibration projects; and
3. Guide of Best Practices.

The activities of TG1 to meet these goals were the following:

1.1 A review on sea-ice methodologies has been published in *Elementa: Science of the Anthropocene*. Reference: Miller et al. (2015) Methods for biogeochemical studies of sea ice: The state of the art, caveats, and recommendations. (**Annex II**) This paper is the first of a Special Issue in *Elementa* on sea-ice biogeochemistry that was initiated by BEPSII (see below).
1.2 While it is not the aim of BEPSII to organize such a campaign within the current project period, it is the aim to stimulate discussion, design sampling strategies for method intercalibration and intercomparison projects of various parameters, and seek opportunities to organize these projects on a reasonable time scale. Finding the resources to organize such a project is difficult; it is expensive (remote places; logistically difficult to get to) and concerns a multi-disciplinary and multi-national group of scientists. Several field stations are under discussion and will be further looked into. Currently, the best options seem to be Saroma-Ko, Japan; Cambridge Bay, Canada; and Tvarminne, Finland.
1.3 One of the goals of the intercalibration campaign will be to obtain better insights into current methodologies, in order to go beyond the currently published methods review. Most urgently, intercomparisons are needed for primary production measurements in ice, melting procedures and their impact on biochemical components and gas flux measurements from ice. In the meantime, method testing and improvement by individual members is being stimulated and is a continuing effort (**Annex IV**)

Task Group 2 on Data (Leads: Klaus Meiners and Martin Vancoppenolle) has two primary goals:

1. Produce new data inventories by collation of existing data;
2. Provide recommendations for standardized protocols and databases.

The activities of TG2 to meet these goals were:

2.1 The collection of chlorophyll-*a* data from the Arctic is taking shape under Canadian/German lead. The respective paper will be submitted to *Geophysical Research Letters*, in which also the first chlorophyll-collation paper by Meiners et al. was published. The Antarctic database will be further extended with data from land-fast ice. Other parameters have been worked on over the past year and new ones were proposed during the March meeting. These include the inorganic carbon system, macronutrients, dissolved and particulate organic carbon, iron and algal biodiversity. Since the amount of data for these quantities is much less than for chlorophyll-a, the data inventories will be combined with mechanistic reviews under task 2 of TG3 (see below).
2.2 The ASPeCt log-sheet – an Excel file with a standardized protocol for ice-core metadata is published on the BEPSII website. Scientists will be encouraged to consistently use the template, which will greatly help future data access and interpretation. Furthermore, a MatLab toolbox to easily extract and analyse log-sheets is currently being developed.

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

1. Recommendations from modellers to observationalists,
2. Review papers on major biogeochemical processes
3. Intercomparison of 1-D models and publication of a review,
4. Application in regional models with links to global and regional climate modelling.

The activities of TG3 to meet these goals were:

3.1 A paper on "What sea-ice biogeochemical modellers need from observationalists" has been submitted to *Elementa* as part of the BEPSII special issue.
3.2 The open-access journal *Elementa – Science of the Anthropocene* was chosen to publish a special feature on sea-ice biogeochemistry: https://home.elementascience.org/special-features/biogeochemical-exchange-processes-at-sea-ice-interfaces-bepsii/. The editor-in-chief of the Ocean Sciences section, Jody Deming, attended the Lucca meeting in March. The BEPSII Special Feature will contain a collection of synthesis papers reviewing particular biogeochemical processes in sea ice and respective model applications, but also research papers are accepted. Currently, 22 contributions are planned (**Annex III**) of which 1 is published and 6 additional have been submitted.
3.3 A 1-D model intercomparison of a seasonal cycle of ice algae is currently slowed down due to parental leave by the lead author, but will be picked up in November. There are 10 groups contributing. The goal is to evaluate outcomes on biomass and primary production over a seasonal cycle, both in the Arctic and the Antarctic.
3.4 Global and regional model intercomparisons are still mostly focusing on pelagic production and acidification. However, regional modeling of sea ice algae is currently expanding. An intercomparison is likely beyond the time frame of the current WG140.

Status of fulfilling terms of reference

The Terms of Reference of BEPSII are as follows:

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

ToR1 is covered by the activities of TG1 and part of TG2. It has been fulfilled with the publication of the review paper on methodologies in *Elementa* (activity 1.1). Also activities 1.2, 1.3 and 2.2 contribute to this ToR. Given the substantial difficulty to work on and with sea ice, both from an organizational and financial perspective, progress in method standardization is slow and the ambition to finalize this goal within the timeframe of WG140 is not realistic. A continued effort for testing and intercalibrating sea-ice methods is needed. As the BEPSII community is still young and constantly growing, there is a strong wish to continue this collaboration and to develop international projects to fulfill these goals.

ToR2 is well underway with activities 2.1 and 3.2. The *Elementa* Special Feature will be a major end product of BEPSII.

ToR3 is currently being implemented in the 1-D exercise described under activity 3.3. A fully integrated sea-ice biogeochemistry module in global climate models cannot be expected within the life span of WG140. However, up-scaling of individual parameters, such as the inorganic carbon cycle, is currently underway. Based on results from activity 3.2, 3.3 and 3.4, we expect to make recommendations indicating which processes and variables might need to be considered in global climate models.

ToR4 is the most ambitious goal of WG140 and can only be achieved in collaboration with the modeling community at large. Analysis on the role of sea ice biogeochemistry in climate simulations is expected to be performed as a regional downscaling effort (regional models with sea-ice biogeochemistry will be forced with output from global CMIP5 models). This is one of the last activities to be undertaken and will extend past the current BEPSII period in close collaboration with FAMOS (Forum for Arctic Modeling and Observational Synthesis). Significant progress has been made with respect to the implementation and application of sea ice algae models on regional scales. Publicly accessible sea-ice algae codes are now available as part of the Biogeochemical Flux Model (BFM, http://www.bfm-comminity.eu) and the Los Alamos CICE model and will be made available as part of the General Ocean Turbulence Model-*Framework for Aquatic Biogeochemical Models* (GOTM-FABM). All models are developed and maintained by BEPSII Full and Associate members.

Plans for the coming year in relation to the terms of reference and capacity building

1. The major activity in the coming year will be the continued submission of papers to the *Elementa* Special Feature (**Annex III**). Since both mechanistic review papers and modeling applications will be published in this Feature, it is regarded as the main product of WG140.
2. The planned 1-D model intercomparison will take place in the coming year. The instructions for model runs are being finalized and datasets to run the models for both the Arctic and Antarctic are currently collated. Timeline: Runs in December; discussion at next BEPSII meeting in March 2016. Paper writing afterwards. (L. Tedesco, M Vancoppenolle et al.).
3. Large-scale data collections are still on-going: Arctic ice biomass (Ilka Peeken, C. Michel et al.), Antarctic fast ice biomass (K. Meiners et al.), inorganic carbon (B. Delille et al.), inorganic macro-nutrients (F. Fripiat et al.), iron (D. Lannuzel and V. Schoemann), dissolved and particulate organic carbon (A. Roukaert, F. Fripiat et al.), algal biodiversity (M. van Leeuwe, J. Rintala et al.).
4. The SCOR WG140 platform has been extremely helpful in setting up this new network of observationalists and modelers on sea ice biogeochemistry. There is a strong need *and* wish to continue this successful network, explore new ways to collaborate and further develop our understanding of the sea-ice system. In order to discuss options and opinions to continue BEPSII, a discussion session is being held during the SOLAS Open Science Conference in September, in Kiel, Germany (leads: Lisa Miller and Martin Vancoppenolle). The format of a working group or forum under the mutual umbrellas of SOLAS and CLiC will be investigated. CliC is a co-sponsor of the discussion session.

5. The last BEPSII meeting under the umbrella of SCOR-WG140 is planned for March 2016 in Paris, France. This time a dedicated meeting with science presentations and (parallel) discussion sessions to plan the future is planned.

   Special requests for extra funding for outreach and/or capacity building activities

   The costs for publication of a Special Feature in *Elementa* is expected to be around €1000 per article. A contribution from SCOR will be more than welcome.

   Challenges or opportunities the group will experience in the coming year

   The major task for the coming year will be the finalization of all papers within the *Elementa* Special Feature.

   The other challenge will be to explore new avenues for continued support of the activities and collaborations started within WG140. For both the planning and organization of intercalibration field campaigns and the upscaling of model intercomparisons a BEPSII 2.0 is needed. There is much support from the community for the continuation of this new and highly successful collaboration between modelers and experimentalists. The network is a very good mix between junior and senior scientists from all over the world. The group now consists of approximately 85 scientists from 16 countries. Avenues for continuing the network are through the current SOLAS and CLiC programs, but this will not provide funding for actual field campaigns. Other institutions, like the EU funding schemes, need to be explored, but this is likely a longer-term effort.

ANNEX I

Minutes SCOR-WG 140 (BEPSII) Meeting
Lucca, Italy Friday March 20, 2015

Present: Steve Ackley (USA), Jeff Bowman (USA), Bruno Delille (B), Agneta Fransson (NO), Francois Fripiat (B), Klaus Meiners (AUS), Lisa Miller (CAN), Sebastian Moreau (B), Janne-Markus Rintala (FIN), Lynn Russell (USA), Jacqueline Stefels (NL), Nadja Steiner (CAN), Letizia Tedesco (FIN), Jean-Louis Tison (B), Martin Vancoppenolle (FR), Maria van Leeuwe (NL).

New to the group: Melissa Chierici (NO), Jody Deming (USA), Hakase Hayashida (CAN), Nicolas-Xavier Geilfus (DEN), Jennifer Jackson (CAN), Ollie Legge (UK), Eva Leu (NO), Eric Mortenson (CAN), Christiane Uhlig (GER), Pat Wongpan (NZ).

Welcome & Goal

Aim of the meeting was to recap where we are and to discuss what is still missing, what are the next steps, and what is our future.

1. Update on crosslinks (related projects)

OASIS (mail info McNeill): not too much on-going; there is currently no official structure. OASIS members have taken the initiative to prepare a Future Earth call for proposals: lead is Faye McNeill. Their pre-proposal was grouped by FE with two other Arctic-related proposals (one of which was social science related to governance, the other very solution-oriented coastal geography). FE gave the three groups a little bit of money and an assignment to come up with a proposal for how Future Earth should engage in a broad sense with ongoing Arctic-related activities. The new proposal is called ArcticSTAR, and focuses on Arctic research founded in Future Earth principles of transdisciplinarity and stakeholder engagement. It seems likely that FE will approve this; however, FE does not really have the funding at this time to make the value of such a designation go beyond the abstract power of the FE stamp of approval. Among the goals of ArcticSTAR is the one to build a "community of practice" (i.e., research coordination network) and bring researchers from multiple disciplines together in workshops, hold summer schools to promote working across disciplines, etc. including social scientists and stakeholders. McNeill: “The tough thing is we are kind of back at the drawing board in terms of finding funding for those activities - becoming an official FE initiative, if and when it happens, will be a "hunting license" for us to go to other agencies to raise funds for the workshops and other activities. Maybe down the road we would be in a position to serve as a parent organization for other groups the way that IGAC is, but we would not be able to do much in terms of passing along funding to them for at least a few years I think.”

PICES (Lisa Miller): would be supportive of an intercalibration in Japan, but is not able to provide money for it.

ASPeCT (Steve Ackley): Has recently been accepted as a SCAR expert group, but they still need to write the terms of reference. There is a wish to include more ecology in the ASPeCT aims. The ASPeCT icecore database, and its extension towards more biological and chemical parameters, is an important connection with BEPSII. Also the ship-based observation database contains a wealth of information on sea-ice coverage.

2. Summary presentations of task groups

TG1 (Lisa Miller/Lynn Russell)
Progress on Terms of reference for TG1:
Methods review: Published, January 2015 in *Elementa*.

Intercalibration experiments:
Many ideas are still gestating, but no concrete progress has been achieved. The issue is primarily one of resources; the community is talking, generating ideas, and willing to work together, but 'seed' funding to get it all rolling is proving elusive.

Summary of report from Daiki:
For the intercalibration experiment, so far (after IGS Hobart), Daiki and Jun sought funds for the experiment, but there is no appropriate fund (appropriate meaning that travel money is provided for joining scientists and for shipping equipment between abroad and Japan, etc.). Maybe we ask too much. If joining scientists can find the money for coming over and shipping equipment to Saroma themselves, it can be arranged. Accommodation prices etc. will be cheap in Saroma, so, money for lodging will not be an important issue.

The design of a gas flux intercalibration experiment is still under discussion. The idea is to compare tower and chamber measurements, as was recently tried out during a campaign with people from the Norwegian Polar Institute, measuring CO_2 and CH_4 in both set-ups.

Additional sites have been proposed:
Cambridge Bay:
Contact/lead: Brent Else (belse@ucalgary.ca).
Central Canadian Arctic Archipelago

Pros: Confidence in sea-ice formation
Location of new Canadian High Arctic Research Station (CHARS)
Easy access by commercial transportation, with several passenger flights daily and cargo flights several times each week.
Ample housing (houses for rent, hotel rooms)

Cons: Research station is not yet built (expected to be 'functional' in 2017)
For now, the only 'lab' is a trailer with a sink that could maybe be borrowed
Level of logistical support (skidoos, etc.) still uncertain

Station Nord:
Contact/lead: Nix Geilfus (geilfus@bios.au.dk)
Northeast Greenland

Pros: Lots of ice, both land-fast and pack
Ample lab facilities and lodging (about $300/day w/board)

Cons: Travel is expensive (approx. $3000 round trip from Longyearbyen)

Jeff Bowman: Ideas for the genomics portion of the intercalibration experiment. From his own data analysis on bacterial genomes (16sRNA), Jeff started to recognize specific metabolic pathways. This opens the possibility to distinguish between bacterial functional types. Hence, emphasis needed on:

- Ecosystem functions
- Diversity of the sea ice microbial community
- Metabolic processes not yet picked up in either biogeochemical or molecular studies

Francois Fripiat will pursue on his previous outline of a field-campaign and will write a first draft of a proposal (for the next BESPII meeting). This proposal will be dedicated to an intercalibration of methods in sea ice biogeochemistry (e.g., primary production, gas content and exchanges, …) and the elaboration of a best sampling scheme (parameters, resolution, …) for modeling purposes. This proposal can form the basis of an application for a new SCOR working group.

Updated list of potential intercalibration sites/facilities:
Prices in approximate 2013 US dollar equivalents.

Site	**Transport (roundtrip)**	**Lab/Other Facilities (most charge fees)**
Alert	3000 from Trenton	Various (labs, trucks, no wireless)
Ny Alesund (Svalbard)	1700 from Tromso	Various
Longyearbyen	800 from Tromso	Various
Station Nord (Villum)	3000 from Longyearbyen	Various (labs, boats, 5 snowmobiles)
Cambridge Bay	Several flights/day	Labs being built; trailers w/sinks for rent
Saroma-ko Lagoon	40 from Memanbetsu	Various (labs, jetskis, hot springs)
SERF @ Manitoba	100 from Winnipeg	Ice pool (artificial SW) for $100/PI/d
IOS @ Victoria	200 from Vancouver	Clean rooms, etc.
Tvarminne	100 from Helsinki	Various (labs, tanks, boats, saunas)
McMurdo	NSF-only/infrequent	Various
Barrow	800 from Seattle	Various (labs, transport, guards)
CRREL @ Hanover, NH	200 from Boston	Wave tank

Manual of best practice:
First we need an intercalibration to be able to go beyond the currently published methods review. The idea is to do this through a growing document and/or videos on the website.
Jody: *Elementa* has a new feature: "practice bridge" which supports videos of practices, which might be useful.

TG2 (Klaus Meiners/Martin Vancoppenolle)
Progress on data compilations and analyses:

1. Collation of DIC and TA started and is in progress (lead Delille et al.) The CO_2 dataset consists currently of 172 stations. The main issue is to discuss the TA:DIC anomaly as the result of degassing. There are still many datasets that need to be added. For the collation of data, the ASPeCT-BIO format and algorithms of Meiners et al. are used.
2. Antarctic database (ASPeCt-Bio) is currently being further analysed to identify drivers of integrated biomass and vertical Chla distribution in particular ice thickness, the influence of snow, snow-ice thickness ratios, on-shelf versus off-shelf location. Potential paper on relationship between ice thickness (snow thickness) versus integrated Chla planned (lead: Vancoppenolle)
3. Collation of Arctic pack ice chlorophyll-a data has progressed. Ilka Peeken (AWI) has collated European data and has sent these to Christine Michel, who is compiling Canadian data and will be leading the write-up.
4. Collation of Arctic and Antarctic iron data has progressed well, paper planned (lead Lannuzel). Data from approximately 100 ice cores are available; which is the total from both Poles + Baltic. Preliminary conclusions: in remote areas, Fe is coming from the water; in the Baltic from the atmosphere. Melting sea ice is seeding surface waters with Fe.
5. Collation of Antarctic macro-nutrient data is progressing well; only a few datasets are still missing (lead: Francois Fripiat). FF will start to interpret the data in summer 2015 (comparison between datasets, ice types and properties, methodological biases, …). Intriguing is the very high concentrations of PO_4 observed.
6. Collation of POC/DOC planned (lead: Fripiat with PhD student Arnout Roukaert). AR is a Ph.D. student working on primary production and N-uptake in sea ice at the Vrije Universiteit Brussel.
7. We have also started collation of Antarctic fast-ice chlorophyll-a data (lead: Meiners. Follow the ideas/layout of Leu et al. paper on ice algal phenology in Pan Arctic fast ice *(Progress in Oceanography*, in press)

Additional points to consider:
Jackson: There might be loads of data from industry available, although mostly physical data. If there is an interest for it, she can look into it.
Info from Rysgaard: A new Danish datacenter, the Isaaffik Arctic Gateway, will be launched soon: http://www.isaaffik.org. For the moment it is only metadata, but it should ultimately also include biogeochemical sea-ice data.

TG3 (Nadja Steiner/Clara Deal)

Task 1: Publication: What sea-ice biogeochemical modelers need from observationalists, will be submitted right after this meeting as part of the *Elementa* special feature for BEPSII.

Task 2: Review papers on major bgc processes in Special feature of *Elementa* (Editor-in-Chief: Jody Deming, present at the meeting)

A collection of synthesis papers reviewing particular biogeochemical processes in sea ice and respective model applications is in full swing. A minimum of 4 papers submitted to *Elementa* is needed by the end of May; after this we can extend the deadline until whatever date we need. Not only reviews can be submitted, but also research papers. All information on planned papers should be sent to Nadja. A list of papers in preparation is below. We expect around 20 papers to be published in the special feature:

0. Miller et al Methods paper – published.... See Annex III for other planned papers

Other issues discussed:

- A previously anticipated review on halogens is not needed. A new review just came out.
- Jen Jackson will investigate the option to link with work of Elena on mixed layer parameterisations.
- Jodie Deming: Can contributions directly submitted to *Elementa* be part of the BEPSII issue? In principle they can, if complimentary to the other papers, but the request should go through the BEPSII coordinators who can then decide.
- *Elementa* offers the option to do a video introduction of the group & BEPSII goals.
- Nice pictures of fieldwork to brighten-up the BEPSII Feature can be send to Nadja.

Task 3: Intercomparison of 1D models

1-D model inter comparison of ice algae seasonal cycle is currently slowed down due to maternity leave by lead author, however will be picked up in November.
Data sets are not chosen yet, but it is anticipated to have one for each Pole: Resolute Bay for the Arctic? and Terre d'Adelie (1997) for the Antarctic. 10 models are involved. Timeline: Runs in December; discussion at next BEPSII meeting. Paper afterwards.

Other potential model analyses were discussed separately in connection with Task 2.

Task 4 - Application in regional models with links to global and regional climate modeling:
Global and regional model intercomparisons are still mostly focusing on pelagic production and acidification. However, regional modelling of sea ice algae is currently expanding. An intercomparison is likely beyond the time frame of the current BEPSII.

3. BEPSII's future

Next year will be the last opportunity to meet under the SCOR umbrella. And although we are well on our way to fulfill the ToRs, we have the feeling that this community just started and that

many of the topics BEPSII has touched upon can benefit from an additional in-depth and interdisciplinary approach. Given the fact that the community consists of many young scientists, there is scope for a strong continuation. Therefore, it is time to develop new ideas and strategies to continue on.

The obvious topic for a BEPSII 2.0 initiative could be to organise a sea-ice intercalibration campaign, for which we are already discussing its potential layout under the current Task Group 1. The funding of the field campaign itself will need to come from science foundations, but support for the network (including modelers) will benefit from additional sources.

Potential umbrella's for a BEPSII 2.0:

- the AntERA program of SCAR (contact Julian Gutt), but this will be mainly Antarctic science. Jacq will join their meeting in Sept. 2015 and will probe this avenue.
- the ArcticSTAR initiative as described under agenda item 1.
- Another SCOR proposal: This is an option but will need to be very specific, with distinctively different terms of reference from WG 140 (BEPSII 1.0). This would have some chance of success, although would probably be hindered a bit if reviewed as a continuation of WG 140.
- A Task Group under SOLAS. There is a good spirit about continuation of SOLAS; sea ice is an explicit part in the new science plan. We will ask for endorsement. To start with, a discussion session at the SOLAS OSC in Kiel has been proposed, Sept. 7-11; abstract deadline: 27 May. There we can probe the interest from SOLAS and discuss new avenues (action Lisa).
- Associated with being a SOLAS TG, BEPSII could form a bridge between SOLAS and CLIC. ASPeCT is also connected to CLIC. CLIC has no biogeochemistry yet, but would like to. Good source for meeting support. Is bipolar. Approach Jenny Baesemann, who is coordinator of CLIC (JS: Not any more! She is now executive director of SCAR) (action Lisa).
- Become a project under the umbrella of IASC?? (ask Marit??)
- Applying for a COST action? (only European, but international collaboration is encouraged): 2x/yr, continuous submission. JS sends around guidelines to EU partners.

For all these organizations it will be important to have (new) Terms of References.
Brainstorming of such new ToR resulted in the following list of ongoing and new deliverables:

1. Develop and conduct intercalibration campaigns.
2. Guide of best Practice
3. Develop guidelines and encourage technology innovations for sea-ice biogeochemical monitoring and observing systems
4. Review papers on major biochemical processes (special issue)
5. Inventory of available data
6. Recommendations for database improvements and quality control
7. Intercomparison of sea-ice biogeochemical models on multiple scales

8. Analysing the role of sea ice biogeochemistry in climate simulations.

4. Any Other Business

- *2016 meeting*: Instead of a fringe meeting we need this final meeting to be a dedicated BEPSII meeting of 3 days.
  Suggested dates: March 14-18 or mid April 2016
  Where: Groningen/Amsterdam? Paris? Lamont? Liege?
  Needed: Large room + 2 break-out rooms for approximately 40p.
- *Outreach* (webpage, Facebook): website on google is easy to upload & manage (https://sites.google.com/site/bepsiiwg140/home). Jayun will maintain the site. Facebook: Francois will send an email to everybody to update the Facebook page (together with Jiayun): with a special emphasis on educational contents.
  Please visit the sites and give input!

- Julian Gutt has invited us to provide a *"Scientific Highlight"* for the SCAR-AntERA website. (action Jacq)
- SCOR reimbursement form: Nadja sent around.
- SCOR report (due end of August).
- Bruno for Roland von G.: RvG has a new project funded by the ERC: it will involve sea ice-snow interaction experiments in new chambers, focusing on CO_2, CH4, DMS, NO_x, OC and halogens. The experiments should lead to improved modeling of the atmosphere and aerosols. Collaboration is welcome.

17:00 End of meeting

ANNEX II

Methods for biogeochemical studies of sea ice: The state of the art, caveats, and recommendations

Lisa A. Miller, Francois Fripiat, Brent G.T. Else, Jeff S. Bowman, Kristina A. Brown, R. Eric Collins, Marcela Ewert, Agneta Fransson, Michel Gosselin, Delphine Lannuzel, Klaus M. Meiners, Christine Michel, Jun Nishioka, Daiki Nomura, Stathys Papadimitriou, Lynn M. Russell, Lise Lotte Sørensen, David N. Thomas, Jean-Louis Tison, Maria A. van Leeuwe, Martin Vancoppenolle, Eric W. Wolff, and Jiayun Zhou

The relationship between sea ice bacterial community structure and biogeochemistry: A synthesis of current knowledge and known unknowns

Jeff S. Bowman

pdf can be found on the Elementa website:
https://home.elementascience.org/special-features/biogeochemical-exchange-processes-at-sea-ice-interfaces-bepsii/.

ANNEX III

List of Elementa papers

1. Miller et al Methods paper – already published....

Submitted:

2. Title: What sea-ice biogeochemical modellers need from observationalists
Authors: N. Steiner, C. Deal, D. Lannuzel et al.....

3. Title: Closing the O2 (and CO2) budget under a growing ice sheet
Authors: Moreau, S., Kaartokallio H., Zhou J., Kotovitch M., H. Kuosa, Goosse H., Dieckmann G. S., Thomas D., Tison J.-L., Delille. B

4. Title : Measurements of air-ice CO2 fluxes over artificial sea ice emphasize the role of bubbles in gas transport
Authors : Marie Kotovitch1,2, Sébastien Moreau3, Jiayun Zhou1,2, Jean-Louis Tison2, Gerhard Dieckmann4, David Thomas5, and Bruno Delille1

5. Title: The structure and activity of sea ice bacterial communities: Biogeochemical implications and known unknowns
Author: Jeff Bowman

6. C:N ratios in Arctic sea ice
Authors: A. Niemi et al.

7. A bio-optical model for photosynthesis in sea ice.
Authors: Müller, S., Uusikivi, J., Vähätalo, A., Majaneva, M., Majaneva, S., Autio, R., Rintala, J.-M.

To Be Submitted:

8. Title: Thermally-forced cycling of DMS, DMSP, and DMSO in Antarctic spring sea ice
Authors: Brabant, F., Carnat, G., Dumont, I., Becquevort, S., Vancoppenolle, M., Ackley, S.F., Fritsen, C., Delille, B., and Tison, J.-L.
Anticipated submission: Fall 2015

9. Title: Seasonal and vertical variability of DMS and DMSP in Arctic first-year sea ice
Authors: Carnat, G., Tison, J.-L., Gilson, G., Delille, B., Brabant, F., Levasseur, M., Geilfus, N.-X., and Papakyriakou, T.
Anticipated submission: Fall 2015

10. Title: First long-term large-scale estimates of primary production in Baltic sea ice
Authors: Tedesco, L., Miettunen, E., An, B.Y., Haapala, J., Kaartokallio, H. and H. Kuosa

11. Title: Coupling between inorganic carbon and biological parameters in melting AA sea-ice
Authors: Fransson, Chierici, Torstensson, Wulff
Anticipated submission: December 2015

12. Title: Iron in sea ice: a review
Authors: D. Lannuzel, M. Vancoppenolle, P. van der Merwe, V. Schoemann, M. Grotti, J. Nishioka and K.M. Meiners
Anticipated submission: Fall 2015

13. Title:Temporal changes in biogeochemical properties of Antarctic sea-ice during spring in the western Weddell Sea with emphasis on DMS(P).
Authors: Jacqueline Stefels, Matthias Steffens, David Thomas, John Dacey, Stathys Papadimitriou, Gerhard Dieckmann, ...
Anticipated submission: January-February 2016

14. The role of the sea-ice carbon pump for the marine carbon budget.
Authors: Grimm, R., Notz, D. Rysgaard, S., Glud, R.N.
Anticipated submission: September 2015

15. The role of sea ice DIC and TA boundary conditions on the sea ice carbon pump in a global blue-white-green ocean modeling system
Authors: Moreau S., Vancoppenolle M., Goosse H., et al.
Anticipated submission: September 2015

16. Modelling DMS in sea ice
Authors: H. Hayashida, E. Mortenson, N. Steiner, A. Monahan
Anticipated submission: November 2015

17. Modelling the carbon cycle in sea ice areas
Authors: E. Mortenson, H. Hayashida, N. Steiner, A. Monahan
Anticipated submission: November 2015

18. Title: Antarctic sea ice nutrients compilation
Authors: Francois Fripiat et al.
Anticipated submission: January-February 2016.

19. 1D sea ice algae model intercomparison
Authors: Letizia Tedesco et al.
Anticipated submission: March 2016

20. Sea ice - pelagic coupling
Authors: Letizia Tedesco et al.
Anticipated submission: February-March 2016

21. Title: Algal species composition in sea ice: functional groups for modelers.

Authors: van Leeuwe, M.A., Rintala, J.M., Assmy, P., and J. Stefels
Anticipated submission: February-March 2016

22. Title: Incorporation of iron and organic matter into young Antarctic sea ice and during its initial growth stages.
Authors: Julie Janssens, Klaus M. Meiners, Jean-Louis Tison, Gerhard Dieckmann, Bruno Delille and Delphine Lannuzel

ANNEX IV

List of papers contributing to BEPSII

Publications in prep:

Arctic sea ice chlorophyll review
Authors: C. Michel, A. Niemi, M. Gosselin ...
To be submitted to GRL.

The Future of the Subsurface Chlorophyll-a Maximum in the Canada Basin - A Model Intercomparison N. S. Steiner, W. Williams,T. Sou, C. Deal, J. M. Jackson, M. Jin, E. Popova, A, Yool
To be submitted to JGR Oceans, FAMOS special issue.

Published contributions:

Rintala, Janne-Markus, Jonna Piiparinen, Jaanika Blomster, Markus Majaneva, Susann Müller, Jari Uusikivi, Riitta Autio (2014) Fast direct melting of brackish sea-ice samples results in biologically more accurate results than slow buffered melting. *Polar Biology*. DOI 10.1007/s00300-014-1563-1

Tedesco L, Vichi M (2014) Sea Ice Biogeochemistry: A Guide for Modellers. *PLoS ONE* 9(2): e89217. doi:10.1371/journal.pone.0089217

2.1.6 WG 141 on Sea-Surface Microlayers (2012) *Burkill*

Terms of Reference:

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

Co-chairs:
Michael Cunliffe (UK) and Oliver Wurl (Germany)

Other Full Members

Anja Engel	Germany	Mohd T. Latif	Malaysia
Sanja Frka	Croatia	Caroline Leck	Sweden
Sonia Giasenella	Brazil	Gui-Peng Yang	China-Beijing
Bill Landing	USA	Christopher Zappa	USA

Associate Members

David Carlson	UK	Anna Lindroos	Finland
Alina Ebling	USA	Kenneth Mopper	USA
Werner Ekau	Germany	Alexander Soloviev	USA
Blaženka Gašparović	Croatia	Robert Upstill-Goddard	UK
Karstan Laß	Germany	Svein Vagle	Canada
Miguel Leal	USA		

Executive Committee Reporter: Peter Burkill

WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders (2012) ***Prakash, Burkill***

Terms of Reference:

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

Co-chairs: Arne Körtzinger (Germany) and Ken Johnson (USA)

Other Full Members

Herve Claustre	France
Denis Gilbert	Canada
Wajih Naqvi	India
Steven Riser	USA
Virginie Thierry	France
Bronte Tilbrook	Australia
Hiroshi Uchida	Japan
Xiaogang Xing	China-Beijing

Associate Members

Steve Emerson	USA
Katja Fennel	Canada
Hernan Garcia	USA
Nicolas Gruber	Switzerland
Dong-Jin Kang	Korea
Satya Prakash	India
Osvaldo Ulloa	Chile

Executive Committee Reporter: Peter Burkill

SCOR WG 142 Annual Report 2014/2015

SCOR WG 142: "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders"

1. Activities During Reporting Period

1.1 2nd Working Group Meeting

About 12 months after the 1st meeting, SCOR WG 142 held its 2nd meeting, on 16-17 March 2015 at the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) in Plouzané, near Brest/France. The schedule of the meeting (see attached minutes) was organized around the 5th Euro-Argo User Workshop and immediately prior to the 16th Argo Steering Team. This assured better attention of the WG meeting, saved tremendously on the SCOR travel budget, and allowed WG member to attend the other meetings.

The WG meeting served two main purposes: (i) to inform the group about new developments in the state of the art and quality control (QC) aspects of major biogeochemical sensors for floats and gliders (chl *a* and bio-optical parameters, nitrate, pH, pCO_2); and (ii) to discuss an official recommendation of SCOR WG 142 regarding in-air measurements as a regular in-situ calibration routine for oxygen optodes. Due to the brevity of the WG meeting, the latter had been prompted by providing each group member ahead of the meeting with short summary papers by Bittig/Körtzinger, Bushinsky/Emerson, and Johnson on relevant new field evidence. This allowed the group to directly jump into an informed discussion of this main topic.

The major outcome of the meeting was a clear agreement among group members to prepare and publish a recommendation to the Argo community to implement an in-air measurement routine during float surfacings as an independent and reliable method to in-situ calibrate/correct oxygen optodes data from floats. Based on the evidence provided (Körtzinger, 2005; Bittig & Körtzinger, 2015; Johnson et al., subm.) such a QC routine would remove any calibration biases, as well as drift issues, to an overall accuracy of approximately 1%. This would be a tremendous improvement over the current situation, but it may also have implications for sensor manufacturers as the current Sea-Bird oxygen optode SBE-63 is not set up to perform in-air measurements. We plan to inform the wider Argo and marine biogeochemistry community about this recommendation through an *Eos* article.

1.2 Round-Robin-Experiment with Aanderaa Oxygen Optode

The Round-Robin Experiment was initiated in April 2012 by the calibration of six Aanderaa optodes (3830, 4330, 4330F) at GEOMAR. These optodes were then sent around consecutively to five other labs before they were returned for re-calibration to GEOMAR (GEOMAR → CMAR → MPI Bremen → IFREMER→ →AADI →JAMSTEC → GEOMAR). The results show a clear temporal drift as well as some inter-laboratory differences. A detailed analysis of this beautiful data set is underway (Bittig et al., manuscript in prep.) and will provide further qualitative and quantitative insight in the character of the known long-term optode drift.

1.3 Improved Understanding of Oxygen Optode Characteristics

A significant body of published work (e.g., Bittig et al., 2014; 2015a; 2015b; Bushinsky and Emerson, 2013; D'Asaro and McNeill, 2013; McNeill and D'Asaro, 2014; Johnson et al., 2015; Takeshita et al., 2014) addressing all major characteristics of oxygen optodes (temperature sensitivity, pressure sensitivity, response time, long-term stability, laboratory calibration, in-situ calibration, in-air calibration etc.) is or will soon be available. This will allow SCOR WG 142 to fully define best operation and QC practices for optode-based oxygen measurements on floats and gliders as the major group deliverable.

1.4 Implementation of Oxygen QC Procedures in Standard Argo Routines

A dedicated session on Oxygen QC Procedures was organized by members of the SCOR WG 142 at the Argo Data Management meeting held in Ottawa in November 2014 to review existing and future real-time and delayed-mode QC procedures. Real-time QC tests for oxygen data, defined and validated by the Argo Data Management Team in 2012 (Wong et al., 2014), are now implemented in most Argo Data Assembly Centers (Table 1):

AOML	BODC	CORIOLIS	CSIO	CSIRO	INCOIS	JMA	KMA	KORDI	MEDS	NMDIS
done	Done	Done	?	done	done	no	End of 2014	no floats	No (no more active floats)	No floats

Table 1: Status of implementation of Real Time QC tests on O2 data as of November 2014.

The manual describing the management of oxygen data has been updated (Thierry et al., 2014) to take into account the evolution in oxygen sensors and calibration equations. This manual will continue to be updated when needed. A new format for Argo data was defined and implemented. It splits into different files the core parameters (P, T, S), which can be found in the so-called c-file and biogeochemical data that can be found in the so-called b-file (see http://www.argodatamgt.org/Documentation).

1.5 State of Knowledge with Respect to Other Biogeochemical Sensors

Chemical sensors for nitrate (Johnson et al., 2013) and pH (Johnson, K.S., in prep.) are now available and in use on increasing numbers of floats. In the United States, the SOCCOM (Southern Ocean Carbon and Climate Observations and Modeling) program has begun deployment of 20 to 40 profiling floats per year in the Southern Ocean with nitrate, pH, oxygen and bio-optical sensors. In France, regional programs in the Mediterranean (D'Ortenzio et al., 2014), North Atlantic, and Southern Ocean are underway, with dozens of nitrate and oxygen sensors deployed. Integration of the data with the Argo system is underway.

With respect to bio-optical measurements (chl a, b_{bp} and radiometry) the QC procedures for real-time data are progressively implemented as part of the Argo data stream. From first in situ comparisons between HPLC chl a measurements and float chl a (Wetlabs fluorometers), it appears that (1) the standard calibration of fluorometers might be off by a factor of ~2 (overestimation) and (2) regional variations in this calibration are observed, likely related to phytoplankton community composition. This potential variability will be addressed in the

coming months. Additionally, procedures for delayed-mode data delivery are developed for all bio-optical variables.

2. Proposal for 3rd Working Group Meeting

We propose to hold the 3rd WG meeting in conjunction with the 2016 Ocean Sciences Meeting New Orleans (21-26 Feb. 2016). A major focus of this meeting will be the implementation of the proposed oxygen QC procedures in standard Argo routines. Also the state of the art of other biogeochemical sensors will be critically reviewed and possibilities of best practices and QC recommendations will be discussed. Another discussion item is the final product to be delivered by SCOR WG 142 at the end of it life, which is expected after four years, i.e. in spring 2017.

Relevant Publications from Working Group Members (2013-2015)

Bittig, H.C., B. Fiedler, R. Scholz, G. Krahmann, and **A. Körtzinger** (2014). Time response of oxygen optodes on profiling platforms: Dependence on flow speed and temperature and recommendations for field applications. *Limnol. Oceanogr.: Methods* **12**, 617-636, doi: 10.4319/lom.2014.12.617.

Bittig, H.C. and **A. Körtzinger** (2015a). Tackling oxygen optode drift: Near-surface and in-air oxygen optode measurements on a float provide an accurate in-situ reference. *J. Atm. Ocean. Techn.* **32**, 1536-1543, doi: 10.1175/JTECH-D-14-00162.1.

Bittig, H.C. and **A. Körtzinger** (2015b). Pressure response of Aanderaa and Sea-Bird oxygen optodes. *J. Atm. Ocean. Techn.*, re-submitted.

Bushinsky, S.M., and **S. Emerson** (2013), A method for in-situ calibration of Aanderaa oxygen sensors on surface moorings. *Mar. Chem.* **155**, 22–28, doi:10.1016/j.marchem.2013.05.001.

D'Ortenzio, F. H. Lavigne, F. Besson, **H. Claustre**, L. Coppola, N. Garcia, A. Laës-Huon, S. Le Reste, D. Malardé, C. Migon, P. Morin, L. Mortier, A. Poteau, L. Prieur, P-Raimbault, and P. Testor (2014). Observing mixed layer depth, nitrate and chlorophyll concentrations in the northwestern Mediterranean: A combined satellite and NO_3 profiling floats experiment. *Geophys. Res. Lett.* **41**, 6443-6451, doi: 10.1002/2014GL061020.

Fiedler, B., P. Fietzek, N. Vieira, P. Silva, H.C. Bittig, and **A. Körtzinger** (2013). In situ CO_2 and O_2 measurements on a profiling float. *J. Atm. Ocean. Techn.* **30**, 112-126, doi: 10.1175/JTECH-D-12- 00043.1.

Johnson, K.S., L.J. Coletti, H.W. Jannasch, C.M. Sakamoto, D.D. Swift, and **S.C. Riser** (2013).Long-Term Nitrate Measurements in the Ocean Using the in situ Ultraviolet Spectrophotometer: Sensor Integration into the APEX Profiling Float. *J. Atm. Ocean. Techn.* **30**, 1854-1866, doi: 10.1175/JTECH-D-12-00221.1

Johnson, K.S., J.N. Plant, **S.C. Riser**, and **D. Gilbert** (2015). Air oxygen calibration of oxygen optodes on a profiling float array. *J. Atm. Ocean. Technol.*, subm.

Ohde, T., B. Fiedler, and **A. Körtzinger** (2015). Spatio-temporal distribution and transport of particulate matter in the eastern tropical North Atlantic observed by Argo floats. *Deep-Sea Res. I* **102**, 26-42, doi: 10.1016/j.dsr.2015.04.007.

Takeshita, Y., T.R. Martz, **K.S. Johnson**, J.N. Plant, **D. Gilbert**, **S.C. Riser**, C. Neill, and **B. Tilbrook** (2013), A climatology-based quality control procedure for profiling float oxygen data. *J. Geophys. Res.* **118**, 5640-5650, doi: 10.1002/jgrc.20399.

Takeshita, Y., T.R. Martz, **K.S. Johnson**, and A.G. Dickson (2014). Characterization of an Ion Sensitive Field Effect Transistor and Chloride Ion Selective Electrodes for pH Measurements in Seawater. *Anal. Chem.* **86**, 11189–11195, doi: 10.1021/ac502631z.

Group photo from the 2nd meeting of SCOR WG 142 in Brest/France
(from left: Hiroshi Ushida, Satya Prakash, Henry Bittig, Ken Johnson, Arne Körtzinger, Antoine Poteau, Virginie Thierry, Catherine Schmechtig, Orens de Fommervault, Denis Gilbert, Hervé Claustre

.

2.1.8 WG 143 on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4 *Bange, Turner* (2013)

Terms of Reference:

1. Establish the analytical reporting procedures to be used for N_2O and CH_4
2. Adopt an appropriate standard to be used by the scientific community
3. Conduct an intercalibration exercise between the time series programs
4. Host at least two international meetings
5. Establish framework for an N_2O/CH_4 ocean time series network
6. Write a global oceanic N_2O/CH_4 summary paper for publication in *Annual Review of Marine Science* or an equivalent journal.

Co-chairs: Herman Bange (Germany) and Sam Wilson (USA)

Other Full Members

Mercedes de la Paz Arándiga	Spain
Laura Farias	Chile
Cliff Law	New Zealand
Wajih Naqvi	India
Gregor Rehder	Germany
Philippe Tortell	Canada
Rob Upstill-Goddard	UK
Guiling Zhang	China-Beijing

Associate Members

John Bullister	USA
Jan Kaiser	UK
Annette Kock	Germany
Sunyoung Park	Korea
Andy Rees	UK
Alyson Santoro	USA

Executive Committee Reporter: John Turner

2015 Annual Report for SCOR WG #143 "Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4", 1 January 2014 – 31 December 2017

Sam T. Wilson (C-MORE/U Hawaii, USA) and Hermann W. Bange (GEOMAR, Kiel, Germany)
Email: stwilson@hawaii.edu; hbange@geomar.de

1. N_2O and CH_4 standards. At the February 2014 meeting in Honolulu, it was evident that the production of precise, common N_2O and CH_4 standards was vital for the comparison of dissolved concentrations across the global oceans. Production of the gas standards became a top priority and by May 2014, we had raised $30,000 (from NSF via C-MORE, InGOS, and SCOR). By September 2014, we had the contractual agreement established between NOAA PMEL and UH for the production of the standards. John Bullister has coordinated the production of these standards and we are incredibly grateful for his leadership on this matter. All standards have been produced and will be shipped to the SCOR WG member labs by end of 2015, at the latest. The delay in production is due to complications with the purchase and delivery of empty gas cylinders from Air Liquide. Once the lab groups have received the standards, we will conduct a calibration comparison, and then conduct a second comparison of seawater samples. This second sample intercomparison will also include some elevated CH_4 samples, due to the low concentrations in the open ocean.

2. SCOR Working Group meeting on 4 September 2015. We had two SCOR WG#143 meetings scheduled in our proposal, the Honolulu meeting in Feb 2014 and a follow-up meeting in Kiel, Germany in September 2015, in conjunction with the SOLAS conference (7-11 Sept. 2015). The 2nd annual meeting was held on Friday, 4 September, at GEOMAR in Kiel. Please find attached the meeting agenda and participant list. Major discussion points were:

- 2nd Intercomparison exercise: It was agreed that additional samples should be taken from Boknis Eck (BE, as coastal reference site: surface/1m, and deep layer/25m). It was suggested that sampling at BE should be coordinated with the sampling from ALOHA.
- Intercomparison cruise, 12-20 Oct. 2016: It was decided that we should go for it and have an intercomparison exercise for both discrete and underway measurements. A total of 12 berths are available: There will be a max. of 8-10 berths available for WG members and we reserved 2-4 berths for CTD and nutrient/O_2 measurements during the cruise. Gregor Rehder (IOW) will submit the application (ship time is already allocated, but it needs an official application). In order to proceed with the cruise preparation a questionnaire will be distributed to the members of WG mailing list in order to collect information about who would like to participate. It turned out already that some WG members cannot participate, but will send sample vials or instruments (-> Cliff Law, NIWA). There is a Chinese group from U Xiamen which is now operating an underway system for N_2O/CH_4. This group may be invited to join.
- Dave Capelle (U. British Columbia) is using self-made N_2O/CH_4 water standards (=

equilibrating N_2O/CH_4-free water with ambient air). He suggested that for the 2nd Intercomparison, the participating labs should try to prepare and use this kind of water standards as well in order to have a further independent method check. Dave is going to send further information on the standard preparation, which will be distributed to the WG members.

- It was suggested that, prior to the 2nd intercomparison, a method/best practice recommendation/guideline should be distributed. With this we want to make sure that all participating labs are using the same equations, doing the same corrections, apply the same form of calibration curves etc.
- In order to proceed with the framework for the N_2O/CH_4 measurement network it was suggested to set up a list with known time-series measurements (incl. VOS lines) to get a first overview.
- It was suggested to provide (i.e. write) a 'toolbox' for dissolved N_2O/CH_4 concentration computations that can be used as standard routine in Matlab (or other software packages).
- It was suggested to produce a video showing best practice for N_2O/CH_4 sampling.

Additional to the points listed above, there are two new requests to join the upcoming 2nd intercomparison, from Bess Ward (U. Princeton) and Macarena Burgos Martin (U. Cadiz, Spain). This should be not be a problem.

SCOR WG#143 Annual Meeting at GEOMAR, Kiel, 04 Sept. 2015: Andy Rees, Cliff Law, Mingshuang Sun, Jan Kaiser, Annette Kock, Gregor Rehder, Laura Farías, Pacific Ocean, David Capelle, Damian Arévalo Martínez, Mercedes de la Paz, Xiao Ma.

3. SCOR WG#143 in the literature. SCOR WG#143 has been mentioned twice in the literature to our knowledge: In February 2015 Hermann Bange and Annette Kock had a front-page article in Volume 3, no. 3 issue of *Eos* on the MEMENTO database. More recently, David Capelle and Philippe Tortell had a publication in *L&O: Methods* where they include some of the sample intercomparison data.

- Capelle, D.W., Dacey, J.W. and Tortell, P.D., 2015. An automated, high through-put method for accurate and precise measurements of dissolved nitrous-oxide and methane concentrations in natural waters. *Limnology and Oceanography: Methods*, 13(7): 345-355.
- Kock, A. and Bange, H.W., 2015. Counting the ocean's greenhouse gas emissions. *Eos - Earth & Space Science News*, 96(3): 10-13.

4. SCOR WG#143 at conferences. An overview poster about the activities of the WG have been presented at the SOLAS Open Science Conference (Kiel, 7-11 September 2015) and at the InGOS International Conference (Utrecht/The Netherlands, 22-24 September 2015).

SCOR WG #143

"Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4"

Annual Meeting, Kiel, 04 Sept 2015
(venue: GEOMAR, Düsternbrooker Weg 20, 24105 Kiel , Germany)

Hermann W. Bange (hbange@geomar.de) & Sam T. Wilson (stwilson@hawaii.edu)

AGENDA

9:00-9:45	Welcome and Summary of WG activities: Hermann Bange & Sam Wilson (*via GoToMeeting*)
9:45-10:30	Short Reports from WG members (D Capelle/U British Columbia, X Ma/GEOMAR, A Kock/GEOMAR- MEMENTO)
10:30-11:00	Coffee Break
11:00-12:00	Review of the status of Terms of Reference:

1) Conduct an intercalibration exercise between the time series programs
2) Establish the appropriate standards to be used by the scientific community
3) Recommend the analytical reporting procedures to be used for N_2O and CH_4
4) Establish framework for an N_2O/CH_4 ocean time series network

12:30-14:00 Lunch

14:00-14:30 N. Ramaiah (NIO, India): Introduction to SCOR WG#144 "Microbial community responses to ocean deoxygenation"

14:30-15:00 Toste Tanhua (GEOMAR, IOCCP): "Essential Ocean Variables, thinking along the Framework of Ocean Observations"

15:00-15:30 Jamie Shutler (U Exeter, UK): Introduction to ISSI WG "Satellite Earth observation for atmosphere-ocean gas exchange" *(via GoToMeeting)*

15:30-16:00 Coffee Break

16:00 WG Discussion 'The way forward'

- 2nd intercomparison exercise
- A common best practice for the processing/calculation/reporting of underway data: G. Rehder
- Intercomparison cruise, Oct 2016: G. Rehder

18:00 Joint Dinner

List of Participants

1	**D Arévalo-**	**GEOMAR**	**darevalo@geomar.de**
2	**H Bange**	**GEOMAR**	**hbange@geomar.de**
3	**D Capelle**	**U British**	**dcapelle@eos.ubc.ca**
4	**M de la Paz**	**U Cadiz**	**mercedes.delapaz@iim.csic.e**
5	**L Farias**	**U Concepcion**	**lfarias@profc.udec.cl**
6	**N Ramaiah**	**NIO**	**ramaiah@nio.org**
7	**J Kaiser**	**UEA**	**j.kaiser@uea.ac.uk**
8	**A Kock**	**GEOMAR**	**akock@geomar.de**
9	**C Law**	**NIWA**	**c.law@niwa.co.nz**
10	**X Ma**	**GEOMAR**	**mxiao@geomar.de**
11	**A Rees**	**PML**	**apre@pml.ac.uk**
12	**G Rehder**	**IOW**	**gregor.rehder@io-**
13	*J Shutler**	*U Exeter*	*j.d.shutler@exeter.ac.uk*
14	**M Sun**	**GEOMAR**	**misun@geomar.de**
15	**T Tanhua**	**GEOMAR**	**ttanhua@geomar.de**
16	*S Wilson**	*U Hawaii*	*stwilson@hawaii.edu*

*via GoToMeeting

2.1.9 WG 144 on Microbial Community Responses to Ocean Deoxygenation *Ramaiah* (2013)

Terms of Reference:

1. Convene a practical workshop in Saanich Inlet, a seasonally anoxic fjord off the coast of Vancouver Island, British Columbia, Canada, to ground truth common standards for process rate and molecular measurements and identify model ecosystems for future cross-scale comparative analyses.
2. Convene a meeting at the Leibniz Institute for Baltic Sea Research in Warnemünde, Germany to codify standards of best practice, and compose a white paper describing said standards and opportunities.
3. Sponsor a workshop at the marine lab of the University of Concepcion, Chile, to disseminate the best practices described in the white paper, and to provide hands-on experience to international participants, and local students and scientists, with those practices.
4. Convene a meeting at the National Institute of Oceanography in Goa, India, engaging local students and scientists in the project. The goal of this meeting is to compile a peer-reviewed monograph, which will be published as an electronic book in an open-access journal such as Frontiers or PLoS to ensure both visibility and long-term access.

Leadership Coordinator: Bess Ward (USA)

Other Full Members

Sean Crowe	Canada	Elsabe Julies	Namibia
Virginia Edgcomb	USA	Phyllis Lam	UK
Veronique Garcon	France	Nagappa Ramaiah	India
Steven Hallam	Canada	Osvaldo Ulloa	Chile
Klaus Juergens	Germany		

Associate Members

Mark Altabet	USA		
Annie Bourbonnais	Canada	John Kaye	USA
Karen Casciotti	USA	SWA Naqvi	India
Francis Chan	USA	Nancy Rabalais	USA
David Conley	Sweden	Mak Saito	USA
Robinson (Wally) Fulweiler	USA	Frank Stewart	USA
Jung-Ho Hyun	Korea	Matt Sullivan	USA
David Karl	USA	Jody Wright	Canada

Executive Committee Reporter: Mark Costello

SCOR WARNEMÜNDE WORKSHOP (AUG 30-SEPT 3, 2015)

Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany

Workshop as part of the activities of the **SCOR Working Group 144: "Microbial Community Responses to Ocean Deoxygenation"**

More detailed information on the core objectives of this SCOR working group are found here: http://scor-int.org/Working_Groups/WG144.htm

Workshop Objective:

Cross-scale comparison of microbial community structure and function in O_2-deficient marine waters is occluded by a lack of standards for integrating physico-chemical measurements, process rates and multi-molecular (DNA, RNA and protein) analyses. This impedes scientific synthesis using datasets collected by different research teams in a variety of oxygen-deficient marine waters. The Saanich Inlet workshop in 2014 started the process of establishing a minimal core of technologies, techniques and standard operating procedures (SOPs) to enable compatible process rate and multi-molecular data collection. These recommended techniques and SOPs should facilitate future cross-scale comparisons and time-series efforts that more accurately reflect *in situ* microbial community structure and functions, an important consideration for future numerical model development incorporating multi-molecular data.

Whereas the workshop in 2014 included practical exercises in sampling and analyses in Saanich Inlet, the 2015 workshop in Warnemünde aims to summarize existing knowledge and to elaborate recommendations for best practices for assessing microbial communities and biogeochemical processes in oxygen minimum zones (OMZs). For this purpose, additional experts from surrounding institutes in Northern Germany and Denmark were invited to join the SCOR meeting.

Confirmed Attendees:

SCOR members

Jennifer Brum (for Matthew Sullivan), University of Arizona, Ecology and Evolutionary Biology Department, Tucson, AZ, USA. E-mail: jbrum@email.arizona.edu
Sean Crowe, University of British Columbia, Depts. of Microbiology & Immunology, and Earth, Ocean, & Atmospheric Sci., Vancouver, BC, Canada. E-mail: sacrowe1@gmail.com
Virginia Edgcomb, Woods Hole Oceanographic Institution, Geology and Geophysics Department, Woods Hole, MA, USA. E-mail: vedgcomb@whoi.edu
Steven Hallam, University of British Columbia, Department of Microbiology & Immunology, Vancouver, BC, Canada. E-Mail: shallam@mail.ubc.ca
Klaus Jürgens, Leibniz Institute for Baltic Sea Research (IOW), Department of Biological Oceanography, Rostock-Warnemünde, Germany. E-mail: klaus.juergens@io-warnemuende.de
Phyllis Lam, National Oceanography Centre Southampton, Ocean and Earth Science and University of Southampton, Southampton, UK. E-mail: P.Lam@soton.ac.uk

Nagappa Ramaiah, CSIR-National Institute of Oceanography, Biological Oceanography Division, Dona Paula, Goa, India. E-mail: ramaiah@nio.org
Bess Ward, Department of Geosciences, Princeton University, NJ, USA. E-mail: bbw@princeton.edu

Invited guests
Hermann Bange, GEOMAR Helmholtz-Zentrum für Ozeanforschung, Marine Biogeochemie, Kiel, Germany. E-mail:
Carlo Berg, SciLifeLab Stockholm, Dept. of Ecology, Environment and Plant Sciences, Stockholm, Sweden. E-mail: carlo.berg@scilifelab.se
Gaute Lavik, Max Planck Institute for Marine Microbiology, Bremen, Germany. E-mail: glavik@mpi-bremen.de
Carolin Löscher, Kiel University, Department of Microbiology, Kiel, Germany. E-mail: cloescher@ifam.uni-kiel.de
Andreas Oschlies, GEOMAR Helmholtz-Zentrum für Ozeanforschung, Marine Biogeochemie, Kiel, Germany. E-mail: aoschlies@geomar.de
Niels Peter Revsbech, Aarhus University, Department of Bioscience, Aarhus, Denmark. E-mail: revsbech@bios.au.dk
Bo Thamdrup, University of Southern Denmark, Department of Biology, Odense, Denmark. E-mail: bot@biology.sdu.dk
Heide Schulz-Vogt, Leibniz Institute for Baltic Sea Research (IOW), Department of Biological Oceanography, Rostock-Warnemünde, Germany. E-mail: heide.schulz-vogt@io-warnemuende.de

Logistics Support:
Solveig Kühl, Leibniz Institute for Baltic Sea Research (IOW), Department of Biological Oceanography, Rostock-Warnemünde, Germany. E-mail: solveig.kuehl@io-warnemuende.de

General Schedule:
Aug. 30: Arrival in Warnemünde
Aug. 31: Review of 2014 Saanich workshop; SCOR group general issues, future meetings and tasks; discussing plan for white paper
Sept. 1 Presentations and discussion Sept 2nd: Presentations and discussion Sept 3rd: Working groups, writing
Sept. 4: Departure from Warnemünde

Venues

Workshop location
Leibniz Institute for Baltic Sea Research Warnemünde (IOW) Seestraße 15, D-18119 Rostock-Warnemünde, Germany

SCOR WORKSHOP WARNEMÜNDE (AUG 30 – SEPT 3, 2015)

Leibniz Institute for Baltic Sea Research Warnemünde (IOW) Seestraße 15, D-18119 Rostock-Warnemünde, Germany

Monday, Aug 31 (IOW, room 227)

9:00 a.m.	Welcome and Workshop Overview (Klaus Jürgens)
9:30 a.m.	Review of Saanich Inlet Workshop 2014 (**Steven Hallam, Sean Crowe**)
11:00 a.m.	Goals and future activities of SCOR group (all)
12:30 a.m.	**Lunch at IOW**
1:30 p.m.	Introduction to white paper "Recommendations for best practices for investigations in oxygen-deficient marine systems"; discussion of concept and structure
3:30 p.m.	Presentation: Rates of sulfur oxidation in OMZs (**Sean Crowe**)
4:00 p.m.	Discussion white paper
After 7:00 p.m.	Meeting at Restaurant/Pub "Casablanca" (near Hotel Alter Strom)

Tuesday, Sept 1

9:00 a.m.	Wrap up of last days discussions; concept white paper; program overview
9:30 a.m.	**Topic section 1: Adequate Sampling of OMZs**
9:30 a.m.	Impact of spatial and temporal variability in redoxcline structures for microbial communities and biogeochemical processes (**Klaus Jürgens**)
10:00 a.m.	High resolution measurements in the water column with a combination of pump CTD, autoanalyzer and flow through microelectrodes" (**Heide Schulz-Vogt**)
10:30 a.m.	High resolution oxygen measurement in situ and in laboratory incubations (**Niels Peter Revsbech**)
11: 00 a.m.	The case for in situ sample processing and preservation for studies of microbial activities central to our understanding of OMZs (**Virginia Edgcomb**)

11:30 a.m. Sample collection time is a relevant parameter for unraveling microbiomes of OMZ waters (**Carolin Löscher**)

12:00 a.m. General discussion section 1

12:30 p.m. **Lunch at IOW**

1:30 p.m. Modeling OMZ biogeochemistry (**Andreas Oschlies**)

2:00 p.m. Topic section 2: Assessing microbial communities in OMZs

2:30 p.m. Sampling and analysis of viruses in marine oxygen minimum zones (**Jennifer Brum**)

3:00 p.m. Co-occurrence of microaerobic and anaerobic activity in OMZs (**Gaute Lavik**)

3:30 p.m. Assessing biogeochemical functions of microorganisms in OMZs (**Phyllis Lam**)

4:00 p.m. Microbial processes and communities in Arabian Sea oxygen deficient regions (**Nagappa Ramaiah**)

4:30 p.m. General discussion section 2

7:00 p.m. **Diner –** Teepot Restaurant

Wednesday, Sept 2

9:00 a.m. Wrap up of last days discussions; concept white paper; program overview

9.30 a.m. Topic section 3: Biogeochemical process rates

9:30 a.m. Nitrogen transformations using ^{15}N tracer incubation experiments (**Bess Ward**)

10.00 a.m. Experimental assessment of nitrogen transformation rates - water sampling, incubations, and data interpretation (**Bo Thamdrup**)

10.30 a.m. Trace gases in oxygen minimum zones (**Hermann Bange**)

11.00 a.m. General discussion section 3

12:00 a.m. Lunch at IOW

1:00 p.m.	**Topic section 4: Genomic tools**
1:00 p.m.	"Multi-Omics" methods and downstream analyses in OMZ research (**Steven Hallam**)
1:30 p.m.	The OMZ water-column microcosm: A view from single-cell genomics (Osvaldo Ulloa)
2:00 p.m.	General discussion section 4, overall discussion white paper and how to proceed; determining working groups for writing up different section topics
4:00 p.m.	**Excursion**: Departure from IOW to Minster of Bad Doberan
5:00 p.m.	Guided tour Minster of Bad Doberan

Thursday, Sept 3

9:00 a.m.	Wrap up of last days discussions; planning of the day
9:30 a.m.	Elaborate topic sections 1-4 for white paper in small groups
12:30 a.m.	**Lunch at IOW**
1:30 p.m.	Elaborate topic sections 1-4 for white paper in small groups
3:00 a.m.	Coffee Break and General Discussion
3:30 p.m.	Finalize writing on topic sections 1-4 in small groups
5:00 p.m.	Final Discussion and Outlook
7:00	**Farewell diner** at Neptun Hotel

Friday, Sept. 4

Departure from Warnemünde

2.1.10 WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC) (2014) *Urban*

Terms of Reference:

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

Chair
David Turner (Sweden)

Vice-Chairs
Simon Clegg (UK) and Sylvia Sander (New Zealand)

Full Members

Heather Benway	USA	Maite Maldonado	Canada
Arthur Chen	China-Taipei	Alessandro Tagliabue	UK
Andrew Dickson	USA	Rodrigo Torres	Chile
Vanessa Hatje	Brazil		

Associate Members

Eric Achterberg	Germany	Ivanka Pizeta	Croatia
Yuri Artioli	UK	Darren Rowland	Australia
Martha Gledhill	Germany	Stan van den Berg	UK
Giles Marion	USA	Wolfgang Voigt	Germany
Peter May	Australia	Christoph Völker	Germany
Frank Millero	USA	Mona Wells	China-Beijing

Executive Committee Reporter:

The first meeting of WG145 was held in Šibenik, Croatia, on 12-13 April 2015, immediately following the closing symposium of WG139. The achievements of that meeting, and planned further work, are described in Appendices 1 to 3, which were written directly after the meeting as an internal WG report.

The progress towards the Terms of Reference can be summarised 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, Cd, Co, Mn, and Zn). Current capabilities and limitations for oceanographic and biogeochemical calculations will be defined, and future needs established. Important gaps in knowledge, which should have high priority for new measurements, will be identified. The components to be covered will include the seawater electrolytes, the selected trace metals, and buffer solutions and key organic ligands such as those used in CLE-CSV titrations.**

A draft scope of the waters and components to be included was developed at the first meeting. WG members have contributed text on each of these waters and components, and this is now being edited for publication as set out in the Meeting Report. A poster describing the WG and the draft scope has been prepared, and will be shown at the SOLAS Open Scientific Meeting in Kiel, Germany (7-11 September).

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.**

At the first meeting, it was decided to bring forward the public presentation of the WG and its work, in order to inform the community at an early stage in order to maximise acceptance of the results, and to obtain feedback. The WG applied for a Special Session at the 2016 Ocean Sciences meeting in New Orleans, which was combined with a proposal from the WG139 community at the request of the Programme Committee. An application has been made for a Town Hall meeting at Ocean Sciences 2016 to present the draft scope: the outcome will be known later in the autumn. Communication with interested researchers is being developed through a mailing list, and at a website hosted by the University of Otago (http://neon.otago.ac.nz/research/scor145/).

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.**

WG members have submitted 10 reviews of existing speciation calculation programmes using a common questionnaire format focusing on the user interface. This material will be used to

develop a first draft of desirable features in a "best practice" model, which will be discussed and refined at the second meeting.

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.

The question of external funding was addressed at the first meeting, where individual WG members were tasked with investigating potential funding sources. This is a continuing process, which will be reviewed at the second meeting.

A second meeting is planned to be held in New Orleans in February 2016 in conjunction with the Ocean Sciences Meeting.

Appendix 1. Report from Meeting #1, 12-13 April 2015, Šibenik, Croatia

1. Scope of the planned speciation model

The first task for this WG is to define the scope of the planned speciation model, in terms both of environmental conditions and chemical components. A draft was generated on the afternoon of 12 April, and reviewed on 13 April. It was agreed that each item in the planned scope would be accompanied by a short justification explaining which global questions can be addressed with the help of this particular speciation modelling. These texts will form an important component of the various activities aimed at maximising the visibility of the WG (see § 3 below), and will also be important in justifying new work to fill gaps in the availability of the necessary thermodynamic information. The Tables give the allocation of responsibilities. These texts should be accompanied by key references, and submitted via the WG Dropbox by 31 May at the latest.

	Table 1: Conditions	
Priority		**Writer**
1	Oceans	-
1	Temperature -2 to 40°C	-
1	Pressure up to 1100 atm	-
1	Estuaries, including groundwater discharges and river end members)	**Arthur Chen**
2	Polar brines, temperatures below 2°C	**Eric Achterberg**
2	Pore waters	**Vanessa Hatje**
2	Sulphidic conditions	**Maite Maldonado**
2	Temperature up to 100°C for diffuse hydrothermal discharges	**Sylvia Sander**

3	Inorganic contaminant inputs	**Eric Achterberg**
3	Temperature up to 300°C for mixing of hot hydrothermal discharges	**Sylvia Sander**
4	Salt lakes and brines	**Simon Clegg**

	Table 2. Major and minor components	
Priority		**Writer**
1	Major ions of seawater, carbonate species	-
1	Weak acids and bases: bisulphate, borate, fluoride, phosphate, ammonia	**David Turner**
2	Silicic acid	**David Turner**

	Table 3. Trace metals (* = redox active)	
Priority		**Writer**
1	Fe*, Cu*, Zn, Cd	**David Turner**
2	Mn*, Co, Ni,	**David Turner**
2	Pb, Hg (and MeHg)	**Mona Wells**
3	Cr*, As*, Ag, Al, Ln(*)	**Mona Wells**

	Table 4. Buffers and indicators (laboratory conditions only)	**Writer**
Priority		
1	pH buffers: tris, aminopyridine	**David Turner**
1	CLE-CSV buffers: EPPS, HEPES	**Stan van den Berg**
1	Indicators: m-cresol purple, thymol blue, bromocresol green	**David Turner**

	Table 5. Complexants* (laboratory conditions only)	
Priority		**Writer**
1	CLE-CSV competing ligands: SA, NN, APDC, DHN	**Stan van den Berg**
1	”Standard” ligands: EDTA, DTPA, DFB	**Sylvia Sander**
1	S ligands: glutathione, cysteine, thiourea	**Sylvia Sander**
2	Cyclam, cyclen	**Maite Maldonado**

3	”Standard” ligands: NTA, DFE, more siderophores	**Maite Maldonado**
3	CLE-CSV competing ligands: DMG, TAC	**Sylvia Sander**

* Humic materials have also been discussed as Complexants. These will not be included in the Pitzer model, but coded separately e.g. according to the WHAM or NICA-Donnan formulations.

2. Planning the review of available thermodynamic data

This was a subgroup meeting held on the afternoon of 13 April. The participants were Simon Clegg, Darren Rowland, David Turner and Mona Wells. It was agreed that the first priority would be the major, minor and trace components of seawater. The following order of actions was agreed:

- **Simon Clegg** will document the data sources used by the Miami and Clegg & Whitfield models.
- **David Turner** will document the data sources used by the Miami model for trace elements.
- This documentation will be passed to **Darren Rowland**, who will check whether the JESS database contains later information on the interactions documented.
- The results will form the basis of a review of data availability for the relevant elements in seawater. This review will be presented at the planned 2016 Town Hall meeting, and submitted for publication during early 2016. Potential journals identified were *ES&T* and *Environment International.*
- The data review for buffers, indicators and ligands will be carried out and published separately to the review of the elements.

3. Activities to maximise the WG visibility in the marine science and chemical communities

Based on experience from previous SCOR WGs, Arthur Chen and Sylvia Sander emphasised the need to act on this point as soon as possible so as to ensure the that final product is well known and thus has a good chance of being accepted and used by the marine science community. Using the speciation model scope as the basis of this initial dissemination will allow interested scientists to comment on this scope, and thus ensure a broad acceptance.

- An article presenting the WG and scope in *Eos* (**David Turner** to make contact and coordinate writing)
- An article presenting the WG and scope in *Chemistry International* (**David Turner** to make contact and coordinate writing)
- An article presenting the WG and scope in *Elements* (**Sylvia Sander** to make contact and coordinate writing)

- An article presenting the WG and scope in *Frontiers in Marine Biogeochemistry*, in the WG139 special issue (Editor **Eric Achterberg**; **David Turner** to coordinate writing)
- A WG website, to be hosted at Otago University, following a similar structure to the WG139 website (responsibility: **Sylvia Sander**)
- A Special Session on speciation modelling at Ocean Sciences 2016 (application deadline 29 April, responsibility: **David Turner** and **Sylvia Sander**)
- A Town Hall meeting at Ocean Sciences 2016 (applications open in July, responsibility: **David Turner** and **Sylvia Sander**)
- Establishment of a mailing list of interested scientists. **Sylvia Sander** will ask scientists on the WG139 mailing list if they also wish to be on the WG145 mailing list.

The articles listed above should be submitted, and preferably published, before the end of 2015.

4. External funding opportunities

Additional funding for both senior scientist and postdoc time would be valuable in developing the optimal Pitzer database for marine applications. Additional funding will be essential for developing the user-friendly Web-based calculation programme described in the terms of reference. Based on the WG discussion, **Simon Clegg** will circulate a list of potential funding opportunities, identifying the individual WG member tasked with investigating each opportunity in further detail.

5. Additional expertise

The need for additional expertise, complementing the WG membership was discussed. A shortlist of names was identified. The WG Chair and Vice-chairs will sound out these individuals' interest in attending the 2016 meeting as guests.

6. Review of existing speciation modelling programmes

A task for the WG is to develop specifications for a Web-based speciation modelling tool. As a first step, the WG will review the user interfaces of existing programmes in order to identify capabilities that are well appreciated by users. 15(?) potentially interesting programmes were identified. It was agreed that these would first be reviewed by WG members experienced in their use, in order to identify a smaller number of programmes to be reviewed in more detail at the next meeting. **Simon Clegg** will circulate the list of programmes with a nominated reviewer for each programme, and a questionnaire to be completed by the reviewers.

7. Plan for the next meeting

The next meeting will be held in conjunction with the 2016 Ocean Sciences Meeting in New Orleans, USA. The provisional date is 21 February, the day before the Ocean Sciences Meeting opens. The following agenda items will be covered:

- Adjustments to the modelling scope, following comments received

- Status of the data availability review
- External funding opportunities
- Workshop on the user interface of existing modelling programmes
-

8. Thanks to the local host

The WG expressed their sincere appreciation to Ivanka Pižeta for her tireless and efficient support.

Appendix 2. Meeting programme

12 April

9:00	Introduction: background to the WG and project plan	David Turner
9:30	WG members present themselves (1-2 minutes each)	
9:45	Project scope: Summary of questionnaire replies and draft project scope	Sylvia Sander
10:30	Coffee	
11:00	Talk: overview of chemical speciation modelling	Simon Clegg
11:45	Talk: modelling natural organic matter chemistry	David Turner
12:30	Lunch	
13:30	Talk: The TEOS standard for seawater	Arthur Chen
14:15	Discussion: scope of the project	
15:00	Coffee	
15:30	Discussion: scope of the project	
17:30	End of Day 1	

13 April

9:00	Scope of the project: discussion of the revised draft
10:30	Coffee
11:00	Discussion: additional contacts and potential external funding (questions 9 and 10 in the questionnaire)
11:45	Assignment of tasks in preparation for Meeting no. 2
12:15	Next meeting: time, place and meeting plan
12:30	Lunch

Afternoon session for speciation modellers only:

13:30	Discussion on the scope of the review paper (Deliverable 1 of the WG)
14:00	Discussion on the work to be done to meet Objectives 1 and 2. This includes collection and review of relevant physico-chemical information for the seawater electrolyte; analyses of current Pitzer parameter databases for data sources and coverage of agreed systems and environmental conditions; uncertainty analysis.
15:00	Coffee
15:30	Discussion continues
16:30	Discussion on potential external funding for the above and later work of the WG.
17:00	Assignment of tasks.
17:30	Meeting ends

Appendix 3. Participants

David Turner, chair
Simon Clegg, vice-chair
Sylvia Sander, vice-chair
Eric Achterberg
Arthur Chen
Vanessa Hatje
Maite Maldonado
Ivanka Pižeta
Darren Rowland
Rodrigo Torres
Stan van den Berg
Christoph Völker (12 April only)
Mona Wells

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

Terms of Reference

1. Combine and build upon existing global and individual databases of natural and artificial radionuclide distributions to make an user friendly and easily accessible on line product.
2. Summarize and publish review papers on these global radionuclide datasets and provide examples of how these can help improve our understanding of ocean processes and contaminant fate and transport.
3. Identify gaps in scientific knowledge in relation to radioactivity in the marine environment.
4. Bring together academic, nuclear industry and national laboratory expertise for an international symposium on radionuclides in the ocean.
5. Provide a warehouse of education materials to assist in the education and training of the next generation of marine radiochemists and radioecologists.
6. Develop tools to enhance public understanding of radioactivity, in particular in the ocean.
7.

Co-chairs:
Ken Buesseler (USA) and Minhan Dai (China-Beijing)

Other Full Members:

Michio Aoyama	Japan	Pere Masqué	Spain
Claudia Benitez□Nelson	USA	Paul Morris	Monaco
Sabine Charmasson	France	Deborah Oughton	Norway
Roberta Delfanti	Italy	John Smith	Canada

Associate Members:

Andy Johnson	USA	Nuria Casacuberta	Switzerland
Reiner Schlitzer	Germany	Jordi Vives i Batlle	Belgium
Gary Hancock	Australia	Vladimer Maderich	Ukraine
José Godoy	Brazil	Sandor Muslow	Chile

Executive Committee Reporter: Wajih Naqvi

First report of SCOR Working Group #146, September 2015.
Radioactivity in the Ocean, 5 decades later (RiO5)

Group photo taken on July 17, 2015 at WHOI

I. Major Activities:

SCOR WG 146 held three teleconferences on 3 June and 1 July 2015 to discuss WG activities and the plan of the first meeting. The first WG meeting was held on 15-17 July 2015 in Woods Hole Oceanographic Institution. Eight Full Members, and two Associate Members participated throughout the meeting. The meeting went extremely well with very fruitful discussion.

II. Progress

The proposed action items of WG # 146 are well underway and/or being planned. Along the lines of the Terms of Reference, we summarize as below some of the actions being taken and/or being planned:

ToR #1: Combine and build upon existing global and individual databases of natural and artificial radionuclide distributions to make an user friendly and easily accessible on line product which will be useful to both the scientific community and the public.

The WG has updated the databases via the IAEA's MARiS portal, including data collected, and is working on the compilation of other data sets via the GEOTRACES and HAM databases and individual studies. MARiS is a publicly accessible database in the same spirit embraced by GEOTRACES (http://www.egeotraces.org/) and various time-series programs (HOT (http://hahana.soest.hawaii.edu/hot/hotdogs/interface.html), PAPA (http://oceanobservatories.org/infrastructure/ooi-stationmap/station-papa/), etc.).

ToRs #2 & 3: Summarize and publish review papers in peer-reviewed journals on these global radionuclide datasets and provide examples of how these can help improve our understanding of ocean processes and contaminant fate and transport. Identify gaps in

scientific knowledge in relation to radioactivity in the marine environment and publish the results in a perspectives paper in Eos or elsewhere.

During the first WG meeting, we came up with an outline for a paper to be submitted to *Annual Reviews in Marine Science* in March 2016. Other possible review papers are being discussed and developed.

ToR #4: Bring together academic, nuclear industry and national laboratory expertise for an international symposium on radionuclides in the ocean.

We were initially hoping that IAEA would be a major sponsor for such an international symposium, but it turned out that major support from IAEA is not possible. The WG is exploring and considering alternative ways to promote marine radioactivity science and to foster exchanges between academic, industrial and governmental sectors.

ToR #5: Provide a warehouse of education materials to assist in the education and training of the next generation of marine radiochemists and radioecologists.

The WG has been working towards the development of a series of e-lectures on: 1) Radioactivity Basics, 2) Introduction to Radionuclides in Marine Systems, 3) Radionuclides as Tracers of Marine Processes, 4) Impacts and Radioecology. These lectures will be in Benitez-Nelson radiochemistry course in Spring 2016 and further tested in Xiamen Marine Radiochemistry Course in June 2016. Eventually, these lectures will be submitted for publication to eLectures: http://aslo.org/lectures/.

The brochure "How radioactive is our ocean?" (www.OurRadioactiveOcean.org) will be made available at least into Chinese by 2016, perhaps into Portuguese and other languages. We also discussed about improving the survey used to see what students know about radioactivity.

The WG will also take the advantage of having its next WG 2016 meeting in Xiamen to give public lectures on ocean radioactivity topics on World Ocean Day (June 8). Also, the WG will be holding a short training course following the WG meeting in Xiamen on June 9-11, 2016 for Asian students and young scientists. SCOR has been requested to provide travel support for developing country scientists to attend this course.

ToR #6: Develop Web−based tools to enhance public understanding of radioactivity, in particular in the ocean.

A new data visualization tool is being developed at WHOI via the OurRadioactiveOcean website.

III. Future plan

The second meeting of the WG#146 has been scheduled to be held in Xiamen on 5-7 June 2016. The third WG meeting will be held in Aug. 2017 in France.

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

Naik, Naqvi

Terms of Reference

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

Co-chairs:

Michio Aoyama (Japan) and E. Malcolm S. Woodward (UK)

Other Full Members:

Susan Becker	USA	Hema Naik	India
Karin Bjorkman	USA	Raymond Roman	South Africa
Anne Daniel	France	Bernadette Sloyan	Australia
Claire Mahaffey	UK	Toste Tanhua	Germany

Associate Members:

Karel Bakker	Netherlands	TaeKeun Rho	Korea
Minhan Dai	China-Beijing	Sophie Seeyave	UK
Andrew Dickson	USA	Jonathan Sharp	USA
Akiharu Hioki	Japan	Winnie van Vark	Netherlands
Alex Kozyr	USA	Takeshi Yoshimura	Japan
Akihiko Murata	Japan		

Executive Committee Reporter: Wajih Naqvi

First report of SCOR Working Group #147, September 2015. Towards comparability of global oceanic nutrient data (COMPONUT)

SCOR WG 147 held its first meeting on 14-15 April 2015 in Vienna, Austria. The first day was held as a workshop of the 2015 EGU General Assembly, with the second day held outside of the main conference venue. Eight Full Members, 3 Associate Members and 2 observers participated throughout the meeting, and a further two Full Members participated via Skype in the morning session of Day 2. Following useful and active discussions during the meeting, all of the Terms of Reference and proposed actions were discussed at length, and action timelines were agreed to be worked towards in the coming months and years. A number of the actions are well underway, and a summary of the year so far with regard to the Terms of Reference, is highlighted below:

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

ToR #2: To assess the homogeneity and stability of currently available RMs/CRMs: The group needs to determine whether the current producers are achieving a level of precision within and between laboratories which is comparable to or better than 1%.

To assess the homogeneity and stability of currently available RMs/CRMs, reported values that were a result of the JAMSTEC-IOCCP 2014/2015 International Nutrient inter-comparison study (58 participating laboratories in 28 countries) are now being analyzed as the results are now all being correlated and prepared for publication. In this inter-comparison study, 4 CRMs jointly certified by KANSO/JAMSTEC, Japan; 3 CRMs certified by NMIJ, Japan; and 4 RMs produced by KIOST, Korea were used. The homogeneity of 7 CRMs at higher nutrient concentration levels has been judged by uncertainty of certificated values at better than 1% (k=1) and those measured by consensus median and standard deviation of reported values were between 1 and

2%. A further set of CRMs from Canada, called MOOS-3, were found to be contaminated, and hence their values compromised, and so were not used in the intercalibration exercise.

ToR #3: To develop standardized data-handling procedures with common data vocabularies and formats, across producers and users, and will include the future linking of national and international data archives. The group will seek to involve international data center representatives to contribute to and lead this task.

We discussed the idea that reported format should contain uncorrected RMNS data for the Reference used. In the future, the updated GO-SHIP manual should specify that reported seawater nutrient values will be the 'unadjusted' ones, that is, with no corrections to RMNS applied on initially reported data. Reported values will be in μmol/kg, with conversion from μmol/l performed to be the responsibility of the chief scientist or nutrient PI. Ideally, reported values should be accompanied by a summary of RMNS analysis results. However, this is still in discussion, as there are other views from other data centres. Progress is being made, but dialog will continue with various data centres. A final way forward will be concluded for the GO-SHIP manual in 2016.

ToR #4: To promote the wider global use of RMs by arranging workshops to actively encourage their use, and to provide training in analytical protocols and best practices, including sample preservation protocols, particularly targeted towards developing countries.

One major criticism of the early work was that the CRMs recommended were profiting one commercial manufacturer. To address this and to promote the wider global use of RMs (ToR 4 of WG#147), JAMSTEC stated that they would seek to provide CRMs to the global community at a more reasonable price than currently available commercially: (expected price per bottle is between ¥6,000 and ¥7,000) (US$50-US$58, £32-£38 or 45-52 Euros). Essentially, JAMSTEC would purchase a number of batches of CRMs for the global community and sell them at no profit. The range of nutrient concentrations will be probably at 5 levels, ranging from Atlantic surface water to North Pacific high levels; the probable levels are as follows:

No.	Level and seawater	Nitrate	Phosphate	Silicate
1	Low in Atlantic	1.0	0.4	~2
2	Middle in Atlantic	~12	~0.5	~12
3	Middle in Pacific	~25	~1.5	~60
4	High in Pacific	>35	>3	>110
5	High in Atlantic	~30	~1.5	~30

NIOZ have this summer provided 400 liter of Low Nutrient Seawater (LNSW) to JAMSTEC to begin preparation of a low-concentration nutrient CRM. This is now in Japan and CRM production will be carried out in October 2015.

To produce the Pacific deep water level CRM, JAMSTEC will collect 1,000 liters of seawater in October 2015, and discussions are underway to obtain Atlantic deep water, from a UK cruise vessel.
These are the first 2 of the new series of CRMs being produced as a result of the WG #147 group. In order to estimate and confirm the requirements of the global community and the full required range of CRMs wanted by the community over the next few years, WG#147 will distribute a questionnaire in September 2015 to the global community, by various mailing lists and websites, attempting to gain a true consensus of the CRMs required.

A further part of this ToR is to provide training in analytical protocols and best practices, and we will aim to provide places for scientists from developing countries to be trained in nutrient analysis, with possible support from POGO, and other financial support initiatives within the WG. This training course is provisionally programmed for November 2017, to be held at NIOZ (The Netherlands) with a number of analyzers available for use, where some scientists from developing countries will be able to work and learn alongside experienced nutrient analysts.

As part of making the global community more aware of the work of the WG, it is important to get the message to the community. There have been two specific talks/presentations made this year. Dr. Claire Mahaffey presented a talk to the UK Marine Management Forum in August about the work of the Group, and Malcolm Woodward presented a talk at the International GAIC 2015 conference in Galway, Ireland, entitled ‘Towards comparability of global nutrient data’. One very important issue affecting the global community is the varying quality of various commercially available silicate standards (sodium hexafluorosilicate). Discussions have begun to investigate the possibility of having one central silicate material used by all labs from one supplier from the same high-quality batch, and so gaining more consistency among laboratories. Investigations and discussions with manufacturers has commenced.

Novel ways were discussed on how to arrange funding for activities of this WG, and it was hoped that through selling small batches of CRMs at reduced rates, the money generated would go to supporting scientists from developing countries to attend the training workshop at NIOZ, for example. Funding sources to enable these developing countries to send scientists also were discussed through support from POGO grants that are available.

ToR #5: To continue regular global inter-comparison studies, following on from the previous exercises in 2003, 2006, 2008 and 2012, with collaboration of IOCCP-SSG and RCGC-JAMSTEC.

The JAMSTEC-IOCCP 2015 International Intercomparison study of CRMs was conducted and completed this year. This I/C study had 58 participating laboratories from 28 countries. In this I/C study 4 CRMs jointly certified by KANSO/JAMSTEC, Japan, 3 CRMs certified by NMIJ, Japan and 4 RMs produced by KIOST, Korea were available to the global community for analysis. JAMSTEC and IOCCP have a plan to conduct the next I/C study of CRMs in 2016/2017.

ToR #6: To update the GO-SHIP nutrient measurement manual, which was originally a product of the IOC-ICES SGONS, (Study Group on Nutrient Standards).

To update the GO-SHIP nutrient measurement manual, which was originally a product of the IOC-ICES SGONS (Study Group on Nutrient Standards) (Hydes et al., 2010), WG#147 will start to update this GO-SHIP manual later this year. Susan Becker, the Head of the Scripps Nutrient Facility, has agreed to lead this update, with input from all the members.

ToR #7: To publish reports on this WG's activities and workshops.

A report of the workshop focused on phosphate analysis that was held at NIOZ in 2012, which was originally a product of the IOC-ICES SGONS, will be officially published in October 2015, with an ISBN number.

Second meeting of the WG#147, 2016.
Various meeting venues for the second workshop for 2016, were discussed in Vienna, and although the 2016 Ocean Sciences Meeting (21-26 February 2016, New Orleans, Louisiana, USA), was an obvious venue, it was decided that it was too early and many people would not be able to attend for various reasons. Other options are being investigated and discussed, and it is hoped to decide the venue in the autumn of this year.

2.2 Working Group Proposals

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

Abstract
Knowledge of zooplankton production rates is key to our understanding how physical forcing such as climate change will impact the material and energy flux pathways which characterize the structure and function of marine ecosystems. Unfortunately, our understanding of the processes driving variation in zooplankton production is limited due to difficulties in identifying the most practical and relevant methodologies for measuring the production rates of natural zooplankton populations and communities across a wide range of phyla and trophic levels. A quantitative comparison, reevaluation and inter-comparison of methodologies are urgently needed.

The proposed Working Group (WG) will focus its attention on assessing the applicability of existing methodologies (i.e., traditional and biochemical methodologies) for measuring *in situ* rates of zooplankton production, and for developing new methodologies. The work will be conducted over a period of four years, culminating in a final report that will:

1. Review and summarize assumptions (in peer-reviewed articles), recent progress and limitations of traditional and biochemical methodologies for measuring the production of natural zooplankton populations and communities.
2. Develop recommendations for standardized protocols for both the traditional and biochemical methodologies available for measuring zooplankton production. These standardized protocols will be made available globally to users via a website.
3. Build a global network of the scientists and laboratories measuring zooplankton production rates.
4. Develop a rigorous inter-comparison/calibration methodology for production rates measured with different approaches.
5. Compile published rates of zooplankton production measured with both traditional and biochemical methodologies.
6. Promote international cooperation of zooplankton production researchers through international organizations such as ICES, PICES and IMBER.

Scientific Background
Zooplankton communities occupy a central position in the flow of matter and energy passing from primary producers to animals at higher trophic levels in marine ecosystems (e.g., Lalli and Parsons 1993). Over the past two decades, the need for quantitative evaluations of marine ecosystem function has been emphasized as necessary toward improving our understanding of how marine ecosystems respond to global climate change (e.g., Walther et al. 2002; Edwards and Richardson 2004; Boyce et al. 2010). Zooplankton production represents a quantitative proxy for the functional response of marine ecosystems since it corresponds to the zooplankton biomass accrued through consumption of lower food web levels.

Zooplankton production has long been estimated using a variety of methods which either: 1) follow the development of zooplankton populations or communities over the course of several weeks or months (e.g., Hirche et al. 2001; Ohman and Hirche 2001); or 2) employ *ex situ* fixed-period incubations (e.g., Burkill and Kendall 1982, Kimmerer and McKinnon 1987; Berggreen et al. 1988; Peterson et al. 1991). Incubation-based techniques with simultaneous sampling of natural communities are the most widely used methods in the field. In 2000, Runge and Roff (2000) reviewed the field application of these traditional methods in a chapter of the ICES Zooplankton Methodology Manual (Harris et al. 2000). However, shortly after its publication, some studies documented limitations of the incubation-based methods, which required revision of the application and interpretation of these approaches and their derived production estimates (Hirst and McKinnon 2001; Hirst et al. 2005; Kimmerer et al. 2007). Meanwhile, advances in biochemical tools for measuring zooplankton growth and production, which were not covered by Runge and Roff (2000), were also developed (Wagner et al. 2001; Sastri and Roff 2000; Oosterhuis et al. 2000; Yebra and Hernández-León, 2004) and have been applied to a wide range of organisms and habitats (e.g., Yebra et al. 2004, 2009; Sastri et al. 2012).

Over the past half century, phytoplankton production rates have been measured using radio-isotope (Steeman-Nielsen 1952) and stable isotope-based approaches (Hama et al. 1983). In the early 1980's, similar measurement approaches were also developed for bacterial production rates (Fuhrman and Azam 1982). A major consequence of the long-term use of routinely applicable *in situ* methods for phytoplankton and bacterial productivities is that we can now generate their spatio-temporal patterns at relatively high resolution using satellite imagery. SCOR has sponsored several working groups covering related topics such as standardization for zooplankton sampling (WG3 and WG13), biomass measurements (WG23), and global comparisons of zooplankton time series (WG125). Despite support by SCOR and the availability of many measurement methods zooplankton production, the routine and universal application of these methodologies is limited because they can only be used under specified conditions and are not necessarily comparable. Moreover, the existing production estimates include some uncertainty because zooplankton communities span a wide range of phyla and trophic levels.

In October 2012, a workshop was convened to discuss the issues surrounding the most commonly applied zooplankton production measurement methodologies. The motivation for this workshop was the recognition that there is still little knowledge of, or confidence in, the existing zooplankton production methodologies relative to those used for estimating primary and bacterial productivity. The two major conclusions which emerged from the workshop are as follows:

1) We need to summarize assumptions, limitations and recent progress of existing methodologies which purport to measure zooplankton production.
2) We need methods which are routinely applicable to natural zooplankton populations and communities across a wide range of phyla and trophic levels.

In order to resolve these significant issues, an international WG on zooplankton production methodologies was proposed during the workshop.

Rationale

It is particularly timely to focus on zooplankton production because assumptions and limitations underlying the most commonly applied methods have now been reconsidered and other approaches have also been developed since the publication of the *ICES Zooplankton Methodology Manual* in 2000. A major consequence of these recent developments has been a general confusion about how these methods should be applied for natural zooplankton populations and communities, and how the various estimates can be compared. The latest IPCC report (IPCC 2013) has reaffirmed that global warming exerts widespread impacts on natural systems; a quantitative evaluation of secondary productivity is therefore both timely and critical for understanding how marine ecosystems adapt to continued global climate change. However, there is still little information on zooplankton production as a proxy for the integrated biological response of lower trophic levels in marine food webs. Indeed, the generation of global maps of primary productivity is now routine, but the ability to make similar spatial comparisons is lacking for zooplankton productivity. At this stage, a comprehensive review of zooplankton production methodologies (in the context of recent advances) would allow us to:

1) Elaborate on recommendations for the standardized application of traditional and biochemical zooplankton production measurement methodologies for worldwide users
2) Develop protocols for inter-comparison/calibration between different approaches
3) Compile existing zooplankton production estimates.

Since the WG objectives are global and fundamental to ocean science, it is reasonable that the WG activities are sponsored by an international scientific organization such as SCOR. The WG objectives can also be shared by the global scientific efforts and the science topics of marine ecosystems emphasized by the International Council for the Exploration of the Sea (ICES), the North Pacific Marine Science Organization (PICES) and the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project. If this WG is sponsored by SCOR and endorsed by PICES, ICES and IMBER, information exchanges and discussion on ocean science would be enhanced among members of these organizations, and would provide the basis for training in both developed and developing countries. For this purpose, the proposed WG has assembled scientific expertise from PICES/ICES and from several developing nations in order to fully represent the worldwide community of zooplankton researchers as well as to foster a global exchange of scientific information and discussion.

Terms of Reference

This WG will:

1. Summarize and review assumptions (in peer-reviewed articles) and recent progress and limitations of traditional and biochemical methodologies for measuring zooplankton production of natural populations and communities.
2. Develop recommendations for standardized protocols for both traditional and biochemical zooplankton production rate measurement methodologies and make these available worldwide for users on a website.

3. Build a global network of scientists and laboratories measuring zooplankton production.
4. Develop protocols for inter-comparison/calibration between different approaches.
5. Compile existing zooplankton production rates estimated by traditional and biochemical approaches.
6. Promote international cooperation between zooplankton production researchers through international organizations such as ICES, PICES and IMBER.

Working plan

Year 1 (2016)

- WG meetings will be held for discussing details of the working plan just before or after the Ocean Science Meeting and the ICES Working Group on Zooplankton Ecology (WGZE) annual meeting.
- The WG will host a workshop at the PICES/ICES 6th Zooplankton Production Symposium (ZPS) to discuss traditional and biochemical methodologies for measuring zooplankton production across a wide range of phyla and trophic levels, including gelatinous groups and other less studied taxa in addition to major crustacean groups. After this workshop, a WG meeting will be held for drafting review articles on traditional and biochemical methodologies for measuring zooplankton production.
- The WG will work on the review articles summarizing the assumptions, advantages and limitations of both traditional and biochemical methodologies for measuring zooplankton production of natural populations or communities.

Year 2 (2017)

- The WG will submit the articles to peer-reviewed journals.
- A WG meeting will be held to discuss standardized procedures and to develop recommendations for the traditional and biochemical zooplankton production measurement methodologies just before or after the Aquatic Sciences Meeting.
- The WG will produce and publish guidelines for standardized procedures with recommendations for worldwide users on the proposed website.
- The WG will build a global network of scientists and laboratories measuring zooplankton production in collaboration with former members of the SCOR WG on Global Zooplankton Time-series (WG125).
- The WG will compile existing zooplankton production rate estimates measured by traditional and biochemical methodologies in order to make comparisons and to quantify driving forces.
- The WG will post the lists of the network partners and the zooplankton production estimates on a website.

Year 3 (2018)

- A WG meeting will be held to discuss suitable protocols for inter-comparison/calibration between different approaches and the WG outreach activities (e.g., summer schools and promotion to international organizations).
- The WG will develop methodological protocols for inter-comparison/calibration of

different approaches for measuring zooplankton production.

- The WG will disseminate the results produced (i.e., guidelines report, list of partners, compilation of production estimates) through workshops and sessions at international conferences such as Aquatic Sciences Meeting, Ocean Sciences Meeting, as well as at ICES WGZE and PICES annual meetings.

Year 4 (2019)

- The WG will promote global cooperation and collaboration on zooplankton production measurements in international programs endorsed by ICES, PICES and IMBER.
- The WG will submit a final report to SCOR.

Deliverables

1. The WG will publish peer-reviewed review articles summarizing the assumptions, recent advances and limitations of both traditional and biochemical methods to estimate production of zooplankton populations and communities.
2. The WG will post a guideline report with recommendations on standardized procedures for both traditional and biochemical methods on a website of an international organization such as PICES and/or ICES.
3. The WG will host summer schools teaching traditional and biochemical methodologies for measuring zooplankton production for students and early-career scientists.

Capacity Building

1. The WG will work to create a global network of collaborating zooplankton production researchers from ICES and PICES nations as well as developing countries.
2. The WG will post a list of the scientists and laboratories (and their contact information) forming the global network on a website.
3. The WG will convene an international and/or regional summer school on zooplankton production measurements for students and early-career scientists.
4. The WG will provide guidelines and assistance on the application of standardized experimental procedures of traditional methodologies and biochemical approaches to estimate zooplankton production for worldwide users on a website.
5. The WG will promote integrating zooplankton production rate measurements into ecological modelling and satellite imaging efforts.

Working Group composition

Full Members (*: Chairs, TM: Traditional method, BM: Biochemical method)

	Name	Gender	Place of	Expertise/ Area	Roles
1	Toru Kobari*	Male	Japan	TM/BM expertise, Western North Pacific	Coordinating to PICES
2	Lidia Yebra*	Female	Spain	BM developer, BM/TM expertise Mediterranean Sea and North Atlantic	Coordinating to ICES
3	Akash Sastri	Male	Canada	BM developer, Freshwaters, Eastern North Pacific and Arctic Seas	Coordinating to PICES
4	Andrew G. Hirst	Male	UK	TM developer, Global oceans	Compiling zooplankton production data
5	Wim J. Kimmerer	Male	USA	TM developer, Coastal regions	Compiling zooplankton
6	Sigrún Jónasdóttir	Female	Denmark	TM/BM expertise, North Atlantic and North Sea	Coordinating to ICES
7	Felipe Gusmão	Male	Brazil	TM/BM expertise, South Atlantic	Networking with developing countries
8	Jenny Huggett	Female	South Africa	TM/BM expertise, Upwelling regions and Indian Ocean	Networking with developing countries
9	Rubao Ji	Male	USA	TM expertise, Production modeler, North Atlantic and Polar Regions	Coordinating to ICES, Incorporating WG products to ecological modelling
10	Takafumi Hirata	Male	Japan	Satellite imagery analysis, Global oceans	Incorporating WG products to satellite imagery

Associate Members (TM: traditional method, BM: biochemical method)

	Name	Gender	Place of	Expertise/ Area	Roles
1	Ruben Escriba	Male	Chile	TM expertise,	Coordinating to IMBER
2	Hyung-Ku	Male	Korea	TM expertise, Continental	Coordinating to PICES
3	Marina	Female	Argentina	TM expertise,	Networking with developing
4	William T. Peterson	Male	USA	TM expertise, Upwelling regions	Coordinating to PICES
5	Sanae Chiba	Female	Japan	Long-term change, Western North	Coordinating to WG125
6	Elena Gorokhova	Female	Sweden	BM expertise, Freshwaters and coastal regions	Coordinating to ICES
7	May Gómez	Female	Spain	BM expertise, Upwelling regions, North	Coordinating to ICES

Working Group contributions

Toru Kobari

Develop methodology for comparison/calibration between different approaches.
Produce a review paper and standardized manual on traditional methodologies.
Build global network of researchers measuring zooplankton production.
Produce WG report to SCOR committee.

Lidia Yebra

Develop methodology for comparison/calibration of different approaches.
Produce a review paper and standardized manual on biochemical methodologies.
Build global network of researchers measuring zooplankton production.
Produce WG report to SCOR committee.

Akash Sastri

Promote WG activities and results to PICES.
Contribute to review paper and standardized manual on biochemical methodologies.
Build network of researchers measuring zooplankton production in North Pacific and freshwaters.

Andrew G. Hirst

Compile existing zooplankton production estimates by traditional and biochemical methodologies.
Contribute to review paper and standardized manual on traditional methodologies.
Build network of researchers measuring zooplankton production in Southern Ocean.

Wim J. Kimmerer

Contribute to review paper and standardized manual on traditional methodologies.
Develop methods of estimating biomass per animal using image analysis.
Build network of researchers measuring zooplankton production in upwelling regions.

Sigrún Jónasdóttir

Promote WG activities and results to ICES.
Convene international workshops, sessions and/or summer schools.
Build network of researchers measuring zooplankton production in North Atlantic.

Felipe Gusmão

Build network of researchers measuring zooplankton production in South Atlantic.
Convene international and/or regional workshops, sessions and/or summer schools.
Contribute to review paper and standardized manual on biochemical methodologies.

Jenny Huggett

Build network of researchers measuring zooplankton production in South Atlantic and Indian Ocean.
Convene international and/or regional workshops, sessions and/or summer schools.
Contribute to review paper and standardized manual on traditional methodologies.

Rubao Ji

Compile existing zooplankton production models.
Promote incorporation of WG products to ecological modelling.
Build network of researchers modeling zooplankton production.

Takafumi Hirata

Produce global and/or regional map of zooplankton production estimates using satellite imagery.
romote incorporation of WG products to satellite imaging technology.

Relationship to other international programs and SCOR Working groups

1. Contribute to the update of the Zooplankton Methodology Manual (2000) produced by the ICES Working Group on Zooplankton Ecology (WGZE) by publishing review papers.
2. Promote zooplankton production measurements to science plans in international organizations such as PICES, ICES and IMBER.
3. Propose sessions and workshops at international meetings and conferences co-sponsored by ASLO, PICES and ICES.
4. Creation of a global network for zooplankton production researchers based on the products of SCOR WG125.
5. Promote zooplankton production measurements and networking within the 2nd International Indian Ocean Expedition (IIOE-2), an IOC/SCOR/IOGOOS initiative from 2016 to 2020.

Appendix

Key references for each full member (up to 5 papers)

Toru Kobari

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Lidia Yebra

Yebra, L., Hernández-León, S. (2004). Aminoacyl-tRNA synthetases activity as a growth index in zooplankton. J. Plankton Res., 26, 351–356.

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2.2.2 SEAmount Faunal vulnerabilty to impacts of Ocean Acidification and Mining (SEAFOAM) *Burkill*

Summary/Abstract
We propose a new SCOR Working Group (2016 to 2018) that seeks to assess new impacts on seamount ecosystems from ocean acidification (OA) and deep-sea mining for cobalt crusts.

The WG seeks to re-evaluate and augment the science priorities defined in 2012 by the Census of the Marine Life, but taking into account the new threats. The WG would initiate the first conference session focussed on OA impacts and deep-sea ecosystems as part of The Fourth Symposium on Oceans in a High CO2 World, in Hobart, 2016 and plans to work with Dr. Richard A. Feeley with whom Dr. George conducted an international OA Workshop in Florida in 2008) The WG plans to develop a follow-on capacity building workshop in Fiji to address commercial deep-sea mining on seamounts, which will start in the region in 2016. In 2017, the WG will meet for three days at North Carolina State University to generate two open-access publications; 1) the first global assessment of OA on deep-sea fauna, and 2) a blueprint for monitoring mining impacts on seamount ecosystems. In 2018, the WG will meet for 3 days at Oxford University, UK, hosted by Prof. Alex Rogers (SEAFOAM WG) to produce a peer-reviewed publication on conservation objectives for seamounts in the face of multiple human impacts. As a follow-up, WG members will go to Ghent University, Belgium, to work with Prof. Ann Vanreusel (SEAFOAM WG) on 'Capacity Building' in developing nations on deep ocean ecosystem management. The culmination of the WG will be the long-time archiving of information on selected seamounts as "Seamount Data Pool" (SDP) to complement Data Banks on Seamounts at Scripps and University of British Columbia.

Scientific Background and Rationale

Deep-Sea Overview:

It is essential to recognize that there are fundamental links between the deep ocean and the rest of the Earth System. It has been demonstrated that deep-sea ecosystems, their biodiversity and ecosystem functioning, can change quickly and significantly because of direct (e.g. bottom trawling, deep-water oil spills) and indirect (e.g. climate variation) human impacts (Smith et al., 2009). In addition to these known impacts, two new pressures have been recognized in recent years; 1) ocean acidification, including the effects of changing pH on shell-bearing planktonic and benthic organisms, and 2) the rapid development of deep-sea mining with its potential to disturb exceptionally large areas of the seabed. There is an urgent need to consider how deep-sea ecosystems will respond to these new pressures and whether there will be significant feedbacks to other parts of the Earth System. In particular, deep-sea seamounts are considered to be especially vulnerable (Consalvey et al, 2010).

This proposal is timely owing to: (1) the increasing interest of "Oceans in the High Carbon World" and (2) the new licenses (2013 –2015) issued by International Seabed Authority (ISA) for the exploration of cobalt-rich crusts on seamounts. The proposed work is truly global in scale encompassing Exclusive Economic Zones (EEZs), Extended Continental Shelves and the High Seas (Areas Beyond National Jurisdiction). Owing to the cross jurisdictional nature of seamount

research, and the need for generic strategies for seamount management, a SCOR WG is probably the only way to approach the growing problem facing seamounts and generate good science to guide management decisions. Seamounts are underwater mountains and occur throughout the world's oceans. There are as many as 100,000 seamounts at least one kilometer in height.

However, of these, less than 200 have been studied in any detail and their biodiversity is still poorly known. Depending on the height of the summit they may have particularly high productivity and may serve as migratory stopovers for whales and other pelagic species.

Seamounts are heterogeneous habitats, often spanning a great depth range (Pitcher et al., 2007; Consalvey et al., 2010; Clark et al., 2010).. Their topography interacts with a wide variety of physical processes including internal waves and tides. As a result seamounts may support highly varied and patchy benthic communities. As for all deep-sea species the seamount fauna generally has long generation times and therefore seamount communities are particularly sensitive to physical impacts, such as bottom trawling and mining. As sampling of seamounts increases, previously held views of seamounts as having a high proportion of endemic species on individual seamounts are challenged (Rowden et al., 2010; Clark et al. 2012). It is now known that many species are shared with other deep-sea habitats, such as continental slopes and banks, although seamounts may have communities with a different structure (Rowden et al., 2010). Historically, seamounts have been poorly sampled owing to their complex topography.

It is only now with the greater availability of Remotely Operated Vehicles (ROVs) and the rapid development of genetic techniques that many issues relating to seamount ecosystems can be resolved. The lack of comprehensive data has led to generalizations about seamounts as a whole. Very often, however, the generalisations apply only to a subset of seamounts, depending also on the biogeographical province and depth band in which they occur (McCain, 2007; Kvile et al., 2013). A concerted effort on studying seamounts is needed, and possible.

Apart from global warming threats on coral reefs in shallow seas through coral bleaching and the increasing spread of deoxygenation by creating hypoxic or anoxic zones in ocean areas off river deltas, ocean acidification (OA) threatens ocean health through effects on plankton (e.g. pteropods) and benthic shell-bearing animals (corals and molluscs) which in some cases are deep-water habitat engineers.. Increasing CO_2 input is expected to decrease ocean pH by 0.3 to 1.5 by 2100, thus lowering the carbon ion concentration of surface waters. This rapid and dramatic scenario of ocean acidification has the potential to have serious effect on calcification of marine organisms. Since industrialization, there has been a substantial increase in CO2 flux into the oceans from atmosphere. It is cautioned that by 2100, if this flux is not reduced by shifting gear to renewable energy, irreversible damage may occur to our ecosystems and may diminish ecological services.

There has been an exponential increase in the number of publications on biological effects of OA and several recent reviews have covered this topic. However, few studies cover the benthic realm. The importance of the combined, and frequently interactive, impacts of multiple stressors (such as temperature, low oxygen and pollutants) is now recognized, as well as the potential for multi-generational adaptation. Experimental research confirms that survival, calcification, growth, development and abundance can all be negatively affected by acidification, but the scale of

response can vary greatly for different life stages, between taxonomic groups and according to other environmental conditions, including food availability. Volcanic CO_2 vents can provide useful proxies of future OA conditions allowing studies of species responses and ecosystem interactions across CO_2 gradients. Studies at suitable vents in the Mediterranean Sea and elsewhere show that benthic marine systems respond in consistent ways to locally-increased CO_2. At the shelf-edge, the ongoing shoaling of carbonate-corrosive waters (with high CO_2 and low pH) threatens cold-water corals, in particular *Lophelia pertusa,* in the North East Atlantic Ocean.

In upwelling areas of the Northeast Pacific Ocean, shoaling of the Aragonite Saturation Horizon (ASH) has reduced hard-coral ecosystems dominated by scleractinian corals. The ASH is located much deeper in the other regions of the deep sea. This led, in part, to Tittensor et al. (2010) postulating that OA threat is really confined to continental margins (continental slopes and plateaus) and that mid-ocean seamounts may not be impacted adversely by OA. However, this thesis needs urgent clarification particularly in polar seas and in areas affected by cold water out-flows. A concerted study of seamounts is required in relation to OA threats and other human impacts, such as trawling, mining and OA threats.

Cobalt-rich ferro-manganese crusts are formed by the precipitation of manganese and iron from cold seawater coating the rocky slopes and summits of seamounts in a layer up to 25 cm thick at ocean depths typically between 800 and 2500 m (Baker and Beudoin, 2013). The crusts form very slowly (e.g. only a few mm every one million years). There are about 1,200 seamounts and guyots which may be of commercial interest in the western Pacific Ocean alone, some of which have been licensed in the last 3 years by the UN International Seabed Authority (ISA) for cobalt crust exploration. In addition, the ISA is in the process of agreeing to an extensive exploration license for cobalt crusts on the Rio Grande Rise in the SW Atlantic Ocean.

Mining crusts involves removing the relatively thin layer of ore from the underlying rocky surface. Removing the crust will destroy all the sessile organisms. It is not known how long it will take to recolonize impacted areas, but there is evidence that corals on seamounts at depths where mining may occur may be as old as 2300 years (Carreiro-Silva et al., 2013). Recovery may take a long time. A number of biological issues arise, for instance: 1) How connected are seamounts with other deep-sea habitats such as continental slopes and banks? 2) What population sizes are required in areas of biodiversity conservation to ensure connected and long-lasting reproductive populations? 3) What are the possible cumulative impacts of mining? (Baker and Beaudoin, 2013).

Terms of Reference (ToRs)

1. Ocean acidification impacts of pH change on deep-water coral reefs on continental margin and seamount communities above and below the Aragonite Saturation Horizon (ASH) and Calcite Saturation Horizon (CSH).
2. Influence of physical disturbance and mine tailing releases from deep-sea mining for cobalt crusts on seamounts).
3. Connecting ongoing global deep-sea conservation activities to assess the influences of cumulative human impact on seamount ecosystems and biodiversity of seamount ecosystems.

Work Plan – details of the Terms of Reference

ToR 1. Ocean Acidification

The working group will build upon previous initiatives by organizing a follow-up workshop at the 'Ocean in a High CO2 World' conference in Hobart in April 2016, hosted by Dr. Ron Thresher of CSIRO of Australia (WG member and the nominal chair of the international planning committee. The research presented will be used to produce a peer-reviewed publication detailing a 10-years research plan for studying the OA impacts on seamounts in the world oceans (Deliverable #1). This document will be finalized at the second SEAFOAM WG meeting in North Carolina in 2017.

Background for SCOR WG: The Hobart session on deep-sea ecosystems and ocean acidification builds on two previous "Ocean Acidification workshops" led by Dr. Bob George (SEAFOAM Chair), one held at Ft. Lauderdale, Florida during the 11th International Coral Reef Symposium (July 7 –11, 2008) and another held at Wellington, New Zealand during the 4th International Deep-Sea Coral Symposium (Dec. 1-5, 2008). The recommendations from the Florida workshop were submitted through Dr. Shirley Pomponi of the NAS 'Ocean Studies Board' to US National Academy of Sciences (NAS) to increase budget allocation for OA research for both NSF sand NOAA through Congressional appropriations.

ToR 2. Mining Impacts

SEAFOAM will seek to stimulate coordinated international research on seamount ecosystems and mining issues, building on the scientific community created through the Census of Marine Life (CoML, 2000-2010) (Consalvey et al. 2010).

A workshop will be organized at North Carolina State University in 2017 to produce: (1) a peer-reviewed publication detailing a 10 year research plan for studying OA impacts on seamounts in the world oceans (Deliverable ToR # 1) and (2) a publication detailing the science behind the first regional environmental management plan for a cluster of seamounts, balancing the needs of resource exploitation with the conservation of regional biodiversity (no species loss). The workshop will focus on the western equatorial Pacific Ocean where a large number of seamounts within a region have been licensed for the exploration of cobalt crusts (Deliverable ToR #2). The workshop will set the proposed management plans within the context of long- term climate change scenarios (e.g. Gehlen et al., 2014).

Capacity building funding will be sought from the ISA (drawn from direct funding of contractors to the ISA, and from the ISA Endowment Fund) for Master's level students to attend and participate in the workshop, especially those from south west Pacific Ocean island states.

Additional funding for capacity building will be sought from the South Pacific Commission (SPC) which is coordinating deep-sea mining issues within Exclusive Economic Zones in all island states within the region.

ToR 3. Conservation of Seamount Ecosystems

In 2014 the UN Convention on Biological Diversity (CBD), in collaboration with UNEP, updated the impacts of OA in a report on "A Updated Synthesis on the Impacts of Ocean Acidification Impacts on Marine Biodiversity" (Hennige, Roberts and Williamson (2014). Dr. Braulio Dias, Executive Director CBD, gave a succinct summary of this report with recommendations for future OA research and monitoring. In this proposal to SCOR for creating a WG, we have taken the advice from these recommendations. We also realize that thus far we have focused more in the Atlantic and Pacific Oceans and have not included the Indian Ocean. Therefore, we have included an expert from National Institute of Oceanography in Goa, India (Dr. V. K. Banakar). To bring together these many disparate strands a workshop will be organized in Oxford, UK, (2018), building on the results of the two previous workshops, to produce an open access publication on the conservation and management of deep-sea seamounts, including a forward-looking 10-year international research plan (Deliverable ToR#3).

Deliverables:

In addition to the 3 deliverables related to the ToR detailed above, SEAFOAM will prepare a multi-authored comprehensive science paper on potential impact of ocean acidification with emphasis on shell-bearing fauna in the seamounts such as scleractinian coral species. This paper will include the following research questions:

(1) How will ASH and CSH will behave in different geographic regions, upwelling zones on the eastern parts of world oceans vs non-upwelling zones on western parts of the world oceans?
(2) Which deep-sea coral species have inherent genetic adaptability to be resilient in low pH conditions (and what shore-based OA study facilities are called for in order to conduct long-term experiments on chosen deep-sea corals?
(3) What recommendations should be developed to International Seabed Authority for esignation Marine Protected Areas (MPAs) in the seamounts that are targets of seafloor industries in the cobalt mining in the coming decade?

Capacity Building Plan

Much of capacity building and training in marine science, conservation and management is focused on coastal systems. The marine training portal www.marinetraining.eu, as a measure of international opportunities, shows only a very limited number of courses targeting human impacts and deep-water systems. Searching the keywords "ocean acidification" and "deep-sea mining" provides only a negligible number of records. The importance and scale by which OA and mining may impact biodiversity and ecosystem functioning in deep-water have not been reflected in training programs that have been organized to date. This is of concern as developing countries start to utilize offshore resources within their Exclusive Economic Zones (EEZs). The cross boundary causes and consequences of OA, the international framework in which mining operations occur, and the global distribution of seamounts within and beyond EEZs, requires international awareness and action. Therefore, building knowledge and training capacity on OA

and deep-sea mining in developed and developing countries, including fast growing nations such as India, and Brazil is a major objective for SEAFOAM.

We aim to inform and educate young scientists on the threats, research needs and management tools for the conservation of biodiversity and resource exploitation on seamounts. We aim to conduct three new capacity building activities related to SEAFOAM.

First, we will contribute expert knowledge to a workshop for developing countries planned for Namibia in 2016 (http://www.indeep-project.org/wg/population-connectivity) by WG 3 of the INDEEP Project. The topic is "Biodiversity and connectivity of deep-sea ecosystems in areas targeted by deep-sea mining" in relation to management and decision making. The plan is to have a 10 day workshop with 18-20 participants.

Second, we will time the third SEAFOAM workshop in Oxford in 2018 to allow a follow up course on seamount ecology and human impacts at Ghent University as part of their international Masters of Oceans and Lakes (www.oceansandlakes.be). This course educates 30 students each year, in a two-year course, complete with project work on a topic of direct importance to the student's country of origin. Students from 30 developing countries have attended at the Master's level todate. Many students have gone on to Ph.D. studies or to environmental management roles in their home country. A special course will be offered with a certificate awarded for attendance.

Third, over the next 4 years new contractors to the International Seabed Authority for exploration of cobalt crusts on seamounts are required to provide at sea training opportunities and fellowships (http://www.isa.org.jm/training). SEAFOAM will work with the students selected to act as role models for future capacity building.

In addition to these initiatives SEAFOAM will search for funding from agencies (e.g. UNESCO) and foundations (e.g. Packard, Sloan, Total) to provide scholarships for people from developing countries to attend targeted workshops. In particular, SEAFOAM will work with the South Pacific Commission (SPC) to provide a training program in Polynesia on seamounts and environmental management to follow on from the WG's meeting in Hobart in 2016.

Funding support, especially in relation to capacity building in developing nations will be sought from private philanthropic foundations concerned about biodiversity loss in the oceans such as the Sloan Foundation and the Packard Foundation.

Relationship to other SCOR WGs and International Programs:

SEAFOAM seeks to interact with the following ongoing efforts that emphasize the need to resolve OA threats to marine ecosystems and biodiversity. Apart from work on seafloormapping and ocean observatories, SCOR has had little focus on benthic ecosystems in the world's oceans in the past. SEAFOAM builds on interests in SCOR on oceans in a high CO2 world and ocean acidification to fill a important gap in SCOR's past and present work.

International programs that will benefit directly from SEAFOAM and which have produced reports calling for research produced by SEAFOAM are:

1. 2014 Recommendations from Convention for Biological Diversity (CBD) Report

2. SCOR WG will interact with Prof. Alex Rogers, Professor of Zoology at Oxford, UK and will use his consultant service on seamount ecosystem research..

3. Dr. Maria Baker of National Oceanography Centre and the University of Southampton UK has consented help as liaison between the SCOR WG and INDEEP and DOSI (Deep-Ocean Stewardship Initiatives) that have made significant progress under the leadership of Prof. Lisa Levin of Scripps Institution of Oceanography and Prof. Elva Escobar of UNAM, Mexico to assemble concerned deep-ocean scientists to address issues such as:

   (A) Deep-Sea Mining (Prof. Craig Smith, University of Hawaii)
   (B) Global Ocean Assessment (Dr. Tony Koslow, Scripps Institution of Oceanography)
   (C) Ocean Conservation (Dr. Jeff Ardron, Commonwealth Secretariat, London)
   (D) Collaborations with Developing Nations (Dr. Christian Neumann)
   (E) High Sea and Sargasso Sea Commission (Dr. Kristina, Gjerde, IUCN)
   (F) Networking (Dr. Maria Baker, NOC, University of Southampton, UK)
   (G) Deep-Sea Fisheries (Dr. Les Watling, University of Hawaii)
   (H) Legal Issues and Mining Tailings (Dr. Eva Ramirez, NIVA, Norway)
   (I) Oil and Gas Explorations and Drilling (Dr. Eric Cordes, Temple University, Philadelphia, USA)).

4. The SCOR WG will also interact with Dr. Tim Shank who will host the 2016 Deep-Sea Coral Symposium. Note: the first International deep-sea coral symposium in USA was coordinated by Prof.. Robert Y. George (GIBS) and Dr. Robert Brock (NOAA) at the University of Miami in 2005). Dr. George co-edited this symposium proceedings with Dr. Stephen Cairns of Smithsonian Institution in two volumes, one entitled: "Conservation and Adaptive Management of Deep-Sea coral and seamount ecosystems."

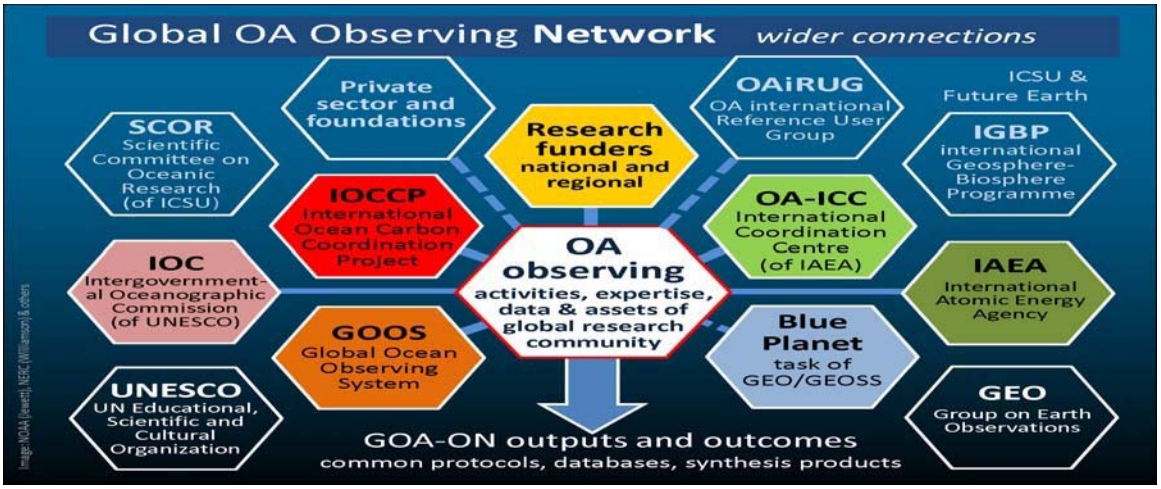
5. The results of the SCOR WG will find ready application in the environmental management of cobalt-rich crusts on seamounts, through the International Seabed Authority, Kingston, Jamaica, which is seeking to expand work on regional Strategic Environmental Assessments (SEA) in relation to deep-sea mining (International Seabed Authority, 2014). SCOR results will be provided through links of the SCOR WG to the ISA Secretariat and ISA Legal and Technical Commission (LTC), an expert group that advises the ISA Council in its decision making (www.isa.org.jm). Dr Billett (SEAFOAM WG) is a member of the current ISA LTC.

6. To bring together these many disparate strands a workshop will be organized in Oxford, UK, (2018), building on the results of the two previous workshops to produce an open access publication on the conservation and management of deep-sea seamounts,

including a forward-looking 10-year international research plan

7. Global Ocean Acidification Network (GOAN)

We are also aware of the existing “Global Ocean Acidification Network” , with a vast number of scientists and managers from many nations, actively involved in OA research and monitoring efforts in the world ocean with Dr. Libby Jewett of NOAA as a coordinator of this activity, as illustrated below. The Scientific Committee for Oceanic Research (SCOR) is one of many participants in this ongoing network



8. The Brazilian Ocean Acidification Research Group (BrOA; www.broa.furg.br) was created in December 2012, as an action arising out of the workshop "Studying Ocean Acidification and its Effects on Marine Ecosystems" (Dec. 4-6, 2012, Cananéia, Brazil), which was organized by the International Geosphere-Biosphere Program, University of São Paulo, Brazilian Council of Scientific Research and Development and Brazil's National Institute for Space Research. In March 2015, BrOA identified: (A) National ocean acidification projects and learning how they have integrated field and laboratory experimentations (B) Scientific collaboration between Brazil and other countries in the context of ocean acidification research.

COLLABORATION WITH GOA-ON, NOAA AND OA EXPERTS

Dr. Sam Dupont at the Department of Biological and Environmental Sciences of Gothenburg University and Sven Loven Center for Marine Sciences, Kristineberg, Sweden, has offered to help SEA FOAM and will participate in the first meeting of SEASFOAM WG for SCOR on May 7, 2016 in Hobart, soon after the 4th High Carbon Ocean Symposium. Dr. Dupont is a member of Executive Council of Global Observatory Network for Ocean Acidification (GOA-ON) and he is leader of the Biology WG of GOA-ON). Dr. Dupont is also a member of the International Coordination Center for Ocean Acidification. We will also invite Dr. Sam Dupont (Sweden), Dr. Richard A, Feely (NOAA) Dr. Libby Jewett (NOAA) and also Dr. Jean-Pierre Gattuso

(University of Pierre-et-Marie Curie) who chairs the 'Ocean in the High Carbon World' symposium in Hobart (May 3-6, 2016) to participate in the SEAFOAMWG meeting on May 7, 2016.

SCOR WG SEAFOAM (Seamounts Ocean Acidification and Mining)

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

Name	Gender	Place of work	Expertise relevant to proposal
1 Prof.Robert Y. George (CHAIR)	Male	Raleigh, North Carolina	Deep-Sea Ecology. Ocean Acidification
2 Dr. David Billett (VICE_CHAIR)	Male	Southampton, UK	Deep-Sea Mining and Benthic communities
3 Prof. Billie J. Swalla	Female	Univ. of Washington, Washington State	Ocean Acidification Research Facility
4 Prof. Alex Rogers	Male	Oxford University, UK	Seamounts Ecology
5 Dr. Anna Metaxas	Female	Dalhousie University, Canada	Deep-Sea Ecosystems
6 Dr. Ron Thresher	Male	CSIRO, Hobart, Tasmania, Australia	High Carbon Oceans
7 Prof. Marco Taviani	Male	Marine Geology Institute, Italy	Deep-Sea Geology and deep- sea Corals
8 Dr. Marcelo Kitahara	Male	Sao Paola, Brazil	Deep-Sea Hard Corals
9 Prof. Ann Vanreusel	Female	University of Ghent Belgium	Deep-Sea seeps and nematode biodiversity
10 Dr. V. K. Banakar	Male	NIO, Goa, India	Deep Sea Minerals

Associate Members (no more than 10)

Name	Gender	Place of work	Expertise relevant to proposal
1 Dr. Jason Hall-Spencer	Male	Univ. of Plymouth, UK	Deep-sea conservation and Ocean Acidification
2 Dr. Thomas Hourigan	Male	NOAA, USA	Deep-Sea Corals
3 Prof. Robert S. Carney	Male	LSU, USA	Deep-Sea Ecology
4 Dr. David Eggleston	Male	CMST, North Carolina State University, NC	Marine Ecosystem Services/Conservation
5 Dr. Myriam Sibuet	Female	Institut Oceanographique, Paris, France	Deep-Sea Ecology
6 Dr. Alison Swaddling	Female	Suva, Fiji	Deep-Sea Mining and Ecology
7 Dr. Eva Ramirez	Female	NIVA, Oslo, Norway	Marine Ecology
8 Dr. Ashley Rowden	Male	NIWA, Wellington, New Zealand	Seamount Ecology/Fisheries
9 Dr. Robert H. Byrne	Male	University of South Florida,	High Carbon Ocean/ pHMonitoring
10 Dr. Telmo Morato	Male	University of Azores	Seamount Ecology

Brief CVs of each Full Member

1. Dr. Robert Y. George (GIBS) – Chair

Dr. Robert Y. George was Professor of Biological Oceanography for 30 years (1972-2002) at UNC-Wilmington, North Carolina, USA and he taught a graduate course on deep-sea biology. Dr. George conducted original deep-sea research for 40 years off North Carolina Coast, Puerto Rico Trench, Blake Plateau Coral Ecosystems, Sargasso Sea (Beaufort – Bermuda Transect), Arctic and Antarctic deep-sea. Since 2002, Dr. George has been the President and CEO of the George Institute for Biodiversity and Sustainability, a Non-Profit 501-C-3 organization in North Carolina. Dr. George now serves as NOAA delegate to ICES (International Council for Exploration of Seas) Deep-Sea Working Group, since 2005, and organized with NOAA the 3rd international deep-sea coral symposium at the University of Miami.

2. Dr. David Billett, (NOC, Southampton, Visiting Research Fellow, UK) Vice-Chair/Rapporteur

David Billett is a Visiting Research Fellow at the National Oceanography Centre, Southampton and a deep-sea biologist with over 38 years of experience of mid-ocean ridges, abyssal sediments, seamounts, coral mounds, submarine canyons, continental slopes. Dr Billett has a particular interest in 1) the effects of climate change on deep-sea ecosystems, 2) distinguishing between natural and man-made change, and 3) the environmental management of offshore deep- water fisheries, oil and gas production and mineral mining, working on the expert advice group, the Legal and Technical Commission, for the UN International Seabed Authority.

3. Dr. Billie J. Swalla, Director, Friday Harbor Laboratories, UW

Dr. Swalla is an expert on sessile tunicates with several papers on molecular taxonomy. She is also involved in the operation of 'Ocean Acidification Research Facilty", funded by US National Science Foundation. Dr. Swalla holds summer courses to train graduate students both American and from abroad to offer research skills in the areas of marine biodiversity conservation and ocean acidification impact on shell-bearing invertebrates in the sea.

4. Dr. Anna Metaxas (Dalhousie University, Canada)

Dr. Anna Metaxas is professor at the Department of Oceanography in Dalhousie University, Nova Scotia, Canada. Dr. Metaxas teaches 'Deep Sea Biology' and she also participates in the International Ocean Institute Training Program in Dalhousie University. She is the chair of the INDEEP working group on "Population Connectivity" and is spearheading the capacity-building workshop in Namibia. She is also chair of the INTERRidge working group on "Ecological Connectivity and Resilience. Her research expertise encompasses a wide variety of interests that include octocoral larval ecology, hydrothermal vent system associated with seamounts and deep water gorgonian corals. Dr. Metaxas does field-oriented research on cruises, laboratory research experiments on both larval and adult deepwater corals and prediction models.

5. Dr. Ronald Thresher (CSIRO, Australia)

Dr Ron Thresher is a senior scientist at the Australian Commonwealth Scientific and Industrial Research Organization with a focus on deep-sea oceanography/communities, in particular deep-sea corals, studying long-term oceanic records for the Southern Ocean to complement modern instrumental records, threats posed by climate change and ocean acidification on deep-sea reefs. He has examined options for mitigating the impacts of climate change on seamount communities and investigated the potential application of pH and other environmental proxies in the ecology of deep-sea corals, including links to regional oceanographic features at intermediate depths. Ron is also the Chair of the international scientific steering committee for the planned 2016 "Oceans in the High CO2 World", to be held in Australia, which directly dovetails with the proposed WG work plan.

6. Prof. Ann Vanreusel (University of Gent) –Coordinator for Capacity Building

Prof Ann Vanreusel is head of the research group Marine Biology of Ghent University (Belgium) with extensive expertise in structural and functional biodiversity research in shallow-water and deep-sea benthic ecosystems. Prof. Vanreusel has focused her research on the ecology of extreme marine environments including the canyons, cold water corals, polar seas and cold seeps. Recently

much of her research has focused on CO2 seeps to understand impact of long term extreme acidification on biota.

7. Dr. Marco Taviani (Italian Marine Institute)
Dr Marco Taviani is Research Director at the Insititute of Marine Sciences (ISMAR)-CNR, Bologna, Italy, with an interest in bio-sedimentology (biogenic carbonate factories, hydrocarbon-imprinted carbonates, deep water coral ecosystems), Cenozoic-Recent marine extreme environments (polar, cold seeps), carbonate geochemistry, paleoclimatology and paleoceanography (Antarctica, Mediterranean, Red Sea, Western Indian Ocean). He has carried out over 40 oceanographic missions (Mediterranean, Red Sea, Atlantic Ocean and Antarctica) often as chief-scientist, onboard Italian, German, French and US research vessels, including ROV operations, manned submersibles, rotary drilling, scientific SCUBA diving for the study of cold-water corals to assess their biodiversity and unravel their paleoclimatic potential.

8. Dr. V. K. Banakar (National Institute of Oceanography, Goa, India)
Dr. Banakar has three decades of research experience in the field of deep-sea mineral exploration and paleoceanography/palaeoclimate working on marine mineral deposits particularly manganese nodules, seamount crusts and hydrothermal sulfides.

9. Dr. Marcelo Kitahara (University of Sao Paulo, Brazil)
Dr Kitahara is a deep-sea coral molecular biologist at the University of Sao Paulo, Brazil, using molecular approaches in addition to morphology (microarchitecture, and macro and microstructure of the skeleton), fossil data, and bioinformatics to study the evolutionary history of scleractinian corals and related groups, such Corallimorpharia. This research is showing how scleractinians have survived climate change and OA events in the past and shedding light on how corals of ecological and economic importance will cope with increasing modern anthropogenic pressures.

10. Dr. Alex Rogers (Oxford University)
Dr. Rogers is an expert on seamount ecosystems with focus on cold-water coral. He employs molecular tools and traditional taxonomy to study seamount ecosystems in spatial and temporal scales. Dr. Rogers has worked with International Seabed Authrities (ISA), IUCN and UN Division of Laws of the Seas. He has guided Ph.D research pf more than 2 dozen doctoral scholars

Five key references for each Full Member

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2. Dr. Alex Rogers (Oxford University)

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8. Dr. Marco Taviani (Italian Marine Institute)

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ASSOCIATE MEMBERS

The Associate members play a key roles in two relevant areas (1) Teaching training courses for students from developing nations concerning deep sea biodiversity and resources as well as (2) advising the SCOR-SEAFOAM WG.on areas of their expertise. For example, (A) Dr.Telmo Morato (Azores) will advise on seamount fisheries, (B) Dr.Myriam Subuet (France) will be an asset as Associate Member wit vast experience in deep-sea ecosystem service, (C) Dr. Alison Swaddlng in Fiji will provide guidelines on deep sea mineral explorations, based on her experience in in Fiji. Papa New Guinea and Tonga. (D) Dr. Ashley Rowden (New Zealand) will help SEAFOAM with his knowledge on biodiversity, habitat heterogeneity and seamount fisheries.(E) Dr. Tom Hourigan (NOAA, USA) has authored a comprehensive report on the status of cold water corals of the world in 2008 and is now heading the habitat conservation program focusing on deep-sea corals. Dr. Hourigan, in collaboration with Dr. Peter Etnoyer of NOAA, is currently preparing a summary report on status of the deep-sea coral ecosystems in continental margins and seamounts within US EEZ and this report will be published online in 2016 and will become a valuable resource for the proposed SCOR WG – SEAFOAM.(F) Dr. Bob Byrne of University of South Florida is well-known for his research on climate change on carbon chemistry of the ocean and (G) Dr. Bob Carney was director of NSF Biological oceanography program is renowned scholar on deep-sea zonation and biodiversity.

PROPOSED BUDGET

1. 2016 SCOR WG Delegates for participation High Carbon Ocean conference and workshop in Tasmania

$ 12,000

2. 2017 SCOR WG Annual meeting workshop at NC State University
(Cost for travel plus hotel/per diem for 9 members of WG, George as host)

$ 15,000

3. 2018 SCOR WG Final Conference at Oxford, UK
(Travel/hotel cost at flat rate of $ 2,000 for five WG members)

$ 14,000

4. Travel cost for chair and vice-chair (Final Report Preparation)

$ 4,000

TOTAL FUNDS REQUESTED FROM SCOR

$ 45,000

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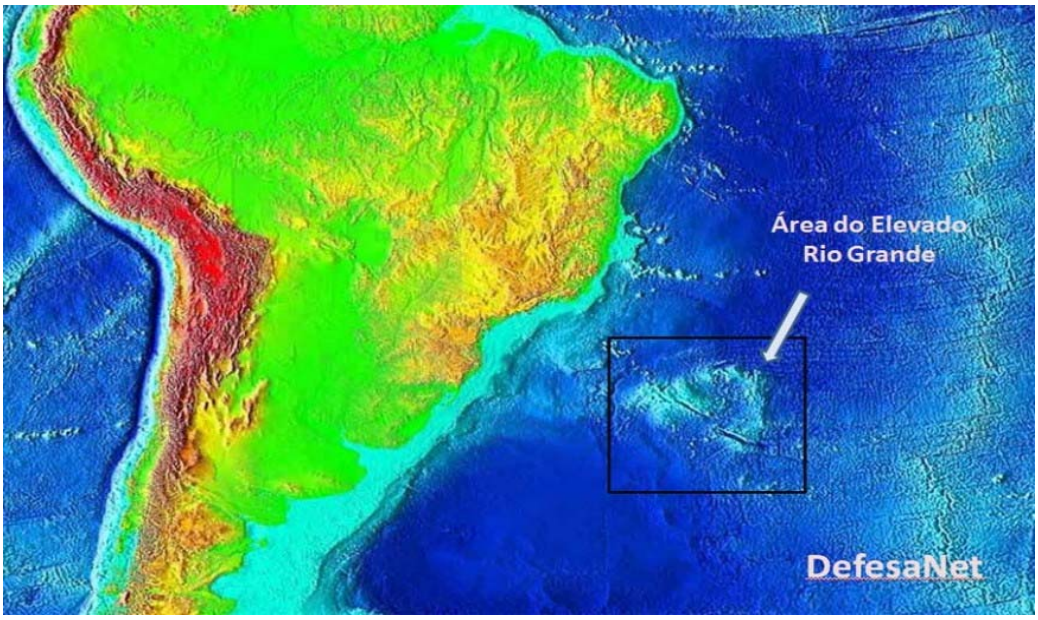
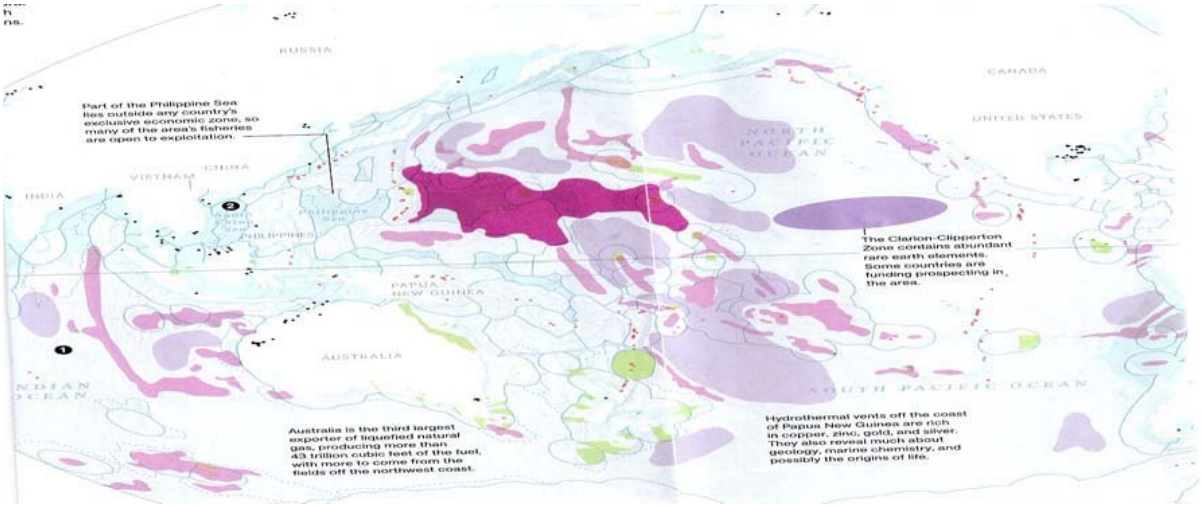
Figure 1. RIO GRANDE RISE: COBALT MINING ZONE



Location of RIOGRANDE RISE

FIGURE 2. MINERAL RESOURCES ON DEEP-SEA FLOOR IN PACIFIC



Mineral deposits in Deep-Sea (Source: National Geographic). Dark Pink-reddish is Cobalt; Violet is Copper and Nickel and Black Dots are Oil and Gas Explorations.

2.2.3 BIOgeochemistry of COral REef systems (BIOCORE) *Brussaard*

Summary/Abstract
Coral reefs are home to more than 25% of all marine species, making them the most diverse marine ecosystem. However, globally coral reefs are threatened by human activities at both large- (ocean warming and acidification) and local-scales (e.g. pollution, overfishing).The impact and extent of these disturbances vary between ocean regions, due to factors such as proximity to land and local human activity. While some anthropogenic activities have been clearly demonstrated to cause decline of dominant reef taxa, it is currently unclear how such changes impact the overall biogeochemistry and function of these ecosystems. This is caused by the fragmented knowledge of impacts, derived from observations from relatively few locations. Because many anthropogenic impacts are fundamentally chemical in nature, understanding the biogeochemical context of coral reefs in a changing world is critical to improve preservation efforts and enhance the health quality of these endangered ecosystems. Therefore, a coordinated international effort is needed to obtain a global understanding of biogeochemical processes in coral reef systems.

The **BIOCORE** working group would take a major step towards understanding the global variability in coral reef system biogeochemistry by 1) creating an accessible internet-enabled data platform, 2) summarizing the latest scientific insights by publishing a series of open access manuscripts, 3) hosting international workshops geared toward identifying gaps in our understanding of coral reef biogeochemistry, and 4) pursue capacity building in the research field for scientist from developing countries. The **BIOCORE** working group would thereby not only advance our understanding of coral reefs, but also provide knowledge of crucial importance for predicting how future changes will impact these unique ecosystems.

Scientific Background and Rationale
Coral reefs are vibrant, living assemblies which are amongst the most impressive and varied ecosystems on the planet. They are primarily found in tropical and semitropical waters (between 30°N and 30° S), where they provide food and income and a variety of services to hundreds of millions of people, mainly from tourism and fisheries (Moberg and Folke 1999), and are home to a myriad of marine species that are dependent on coral reefs to feed, reproduce, and obtain shelter. Globally, coral reefs are threatened by a combination of local (e.g. pollution, overfishing, growing coastal populations) and global stressors (ocean warming, acidification)(e.g. Cyronak et al. 2013), which, across large parts of the ocean have caused the steady decline of dominant coral communities (Burke et al. 2011; Fabricius 2011; Hughes et al. 2010). Corals are ecosystem engineers and thus play a crucial role in physically shaping the ecosystems they live in, mainly by their ability to produce large calcium carbonate structures. In order for corals to calcify and grow, they need stable environmental conditions, temperatures typically around 25□C, and oligotrophic, sunlit, and alkaline waters (Atkinson & Falter 2003; Uthicke et al. 2014). Understanding the interactions of biological, chemical, and geochemical fluxes and processes, that is the biogeochemistry, that control environmental conditions and the response of coral ecosystems to change is therefore crucial. However, much of the research on coral reefs to-date has been biological, with some geological and geochemical work.

We propose to form a SCOR Working Group which would focus on the biogeochemistry of coral reef systems (**BIOCORE**) across global and local scales to determine how coral reef systems have been and are being altered by environmental change. As coral reefs are globally spread over large geographical areas, the work we propose, naturally includes a strong international element, providing a unique framework to link existing information. Human pressures on coral reefs are increasing globally in both developed and developing countries. But the impact and extent of these disturbances varies between regions due to factors such as proximity to land, coral reef community composition, local human activities and the extent to which strategies for coral reef management are followed. The **BIOCORE** working group would provide the first step towards a more complete understanding of global variability in the biogeochemistry of coral reef systems. Many relevant data sets have been collected by independent researchers, agencies and nations, but comparing and synthesising this data from different reef systems, is a huge task, which requires sustained activity of a co-ordinated group of researchers. One example of such an analysis would be to summarize and understand why the daily and seasonal patterns in the partial pressure of carbon dioxide (pCO_2) are different between coral reef systems globally. It can easily be visualized using the NOAA Coral Reef Moorings data (http://www.pmel.noaa.gov/co2/story/Coral+Reef+Moorings), that the amplitude and patterns in the pCO_2 varies between systems, but understanding why this is the case would be one of the questions addressed by the **BIOCORE** working group. Another example of a detailed analysis would be to review and comprehend why the limiting nutrients for primary production varies between systems. While primary productivity in some coral reef systems is suggested to be limited by phosphorus (e.g. Florida Keys) others are limited by nitrogen (e.g. Great Barrier Reef) when assuming a Redfield Nitrogen: Phosphorus ratio of 16:1 (Redfield et al. 1963). This points to the nutrient biogeochemistry of these systems being different. Understanding the causes of these fundamental differences would be another valuable endeavour for the **BIOCORE** working group. As international efforts requiring prolonged activities are rarely funded by national research agencies a SCOR Working group would be an ideal platform to gather experts from key coral reef areas from around the world.

The "**BIOCORE**" working group would be comprised of an international consortium of coral reef researchers. Our major focus would be on increasing knowledge of coral reef biogeochemical processes that can be utilised for scientific, management and public outreach activities. This would be accomplished through; 1) providing a synthesis and review of coral biogeochemical processes by publishing a special issue in an open-access journal, 2) developing a strategic plan to fill in gaps in our knowledge, 3) pursuing capacity building for developing country scientists and 4) improving access to information by creating online databases and use other available communication tools.

Terms of Reference

The working group on "BIOgeochemistry of COral REef systems (**BIOCORE**)" would:

1. **Identify and combine datasets** of key biogeochemical measurements in coral reefs to centralize the information and improve accessibility;
2. Write a **short perspectives paper** after the first meeting, to be submitted to an open-access journal (PeerJ or Frontiers in Marine Science), highlighting the importance and knowledge gaps in coral reef biogeochemistry;

3. Identify gaps in scientific knowledge and **develop priorities and recommendations** for future efforts within coral reef biogeochemistry studies;
4. Organize a **series of invited, peer-reviewed manuscripts** as a special issue in an open-access journal to enhance our understanding of coral reef processes;
5. **Conduct active outreach to coral reef researchers in developing countries** to build capacity through participation in the working group activities;
6. **Engage with the wider scientific and management coral reef community** by inviting them to the regular working group meetings.

These actions would be achieved during the working group meetings (annually for three years), building web-based resources and publishing of scientific manuscripts. This would establish the platform for the coral reef science community to build an international programme on coral reef biogeochemistry similar to existing international oceanic programs such as "GEOTRACES".

Working plan/Timeline

Year 1 In order to provide high international visibility the first working group meeting would piggyback on the 13th International Coral Reef Symposium (ICRS: Hawaii, USA, June 19-24, 2016). The meeting would consist of an organized presentation session and subsequent 2-day workshop after the symposium so that participants from the symposium would be able to attend. Local coral reef authorities (e.g. NOAA-CRED and OAP) would also be invited to attend the workshop in order to provide end-user inputs and perspectives on the working program. This would ensure that the coral reef community is well informed of the working group objectives and targets. Other goals for the first working group meeting would specifically include the following:

- Inform the coral reef community of working group goals and targets;
- Obtain input from the coral reef research community and authorities on priorities and targets for future studies;
- Identify and distribute specific tasks to working group participants and set targets for deliverables, to ensure that all of the terms of reference would be covered during the 3-year period;
- Present the outline of the working group database and facilitate discussion for improvement;
- Launch social media platforms (e.g. Facebook, Twitter) which would be updated during the meeting and over the following 3 years;
- Draft a brief perspectives paper to be submitted to open-access journal highlighting the importance and research needs;
- Coordinate a special issue of an open-access journal (e.g. PeerJ or Frontiers in Marine Science) using papers presented in the special session at ICRS to report the current state of reef biogeochemistry and future research goals.

Year 2 Working group meeting 2. We would apply for a topical session at the aquatic science Meeting 2017 (Hawaii, USA; February 26 – March 3) and furthermore organize a 2-day workshop following the meeting. This would ensure participation and input from the wider oceanographic community. Goals of the meeting would include the following:

Focus progress on database synthesis and get the data webpage operational;

- Publish special issue in open-access research (PeerJ or Frontiers);
- Inform oceanographic community of working group goals and targets and discuss with the ASLO community the major goals and knowledge gaps;
- Develop final list of future challenges and research needs.

Year 3 Working group meeting 3 would be a 4 days meeting hosted by the Australian Institute of Marine Science, Townsville (AIMS) in 2018, with venue and accommodation costs covered as an in-kind contribution from AIMS. Representatives from the Great Barrier Reef Marine park authority would also be invited to this meeting to provide end-user inputs. Goals for the meeting would include the following:

- Finalize data access portal;
- Produce working group outcome document as open-access perspectives article in the journal "Coral Reefs";
- Discuss future plans for continuing working group efforts to build a robust platform for an international programme similar to the "GEOTRACES" program.

Capacity Building

Understanding coral reef biogeochemistry is essential for our understanding and capability to predict how coral reefs will respond to environmental changes and to develop and test strategies for coral reef management. Currently, this knowledge is often restricted to single locations and individual research groups. Many coral reef systems are located in developing nations with growing, but limited, research capacity. **The BIOCORE working group would therefore link key geographical areas and experts to enhance our understanding and develop new capability in coral reef biogeochemistry.** To ensure that these links are created, we would have full participation from Full Members in the meetings to be held in 2016, 2017 and 2018. We would also identify important knowledge gaps which would encourage new research efforts in this area. All working group members would furthermore participate individually and collectively in efforts to increase public and scientific understanding of coral reef biogeochemistry. Specifically we would develop capacity on several levels by:

- Creating a Facebook page and a Twitter account to promote public interaction. Activities of outreach are also anticipated through national and regional user groups and media.
- Including experts from around the globe to increase interactions, knowledge transfer, student exchanges and mentoring. The inclusion of scientists from developing nations provide links to ecosystems and research institutions in their respective regions and this ensure capacity building for developing country scientists through participation in the working group meetings and sessions hosted at international conferences, otherwise difficult to archive.
- Publishing of the working group outcomes in an open-access journal to provide a new resource to help expand the field and provide information to policy makers and managers. To build new capacity and sustain young researcher we would encourage all working group members to involve early career scientist in the writing of these open-

access publications.
- Invite end-user groups to attend and contribute to working group meetings (e.g. Great Barrier Reef Park Authority, NOAA).

Start and End Date
July 2016 to September 2018

Deliverables
If approved, this working group would:

1. Establish a database, hosted at AIMS, to connect available data of reef biogeochemical measurements.
2. Publish a scientific perspectives manuscript in an open-access journal, highlighting the importance and knowledge gaps in coral reef biogeochemistry.
3. Produce a series of publications to be included in a special issue of an open-access journal to enhance our understanding of coral reef processes. The papers would summarize current knowledge and identify gaps in our scientific knowledge and help us prioritise and make recommendations for future efforts within the research area.
4. Build and maintain at AIMS a support network for coral reef researchers in developing countries, including resources for grants, supplies, data repositories, and management guidelines.

Working Group Members
Full members of this Working Group were selected to assemble the appropriate scientific expertise and to span over the different geographical areas where coral reefs exist, including developing countries where a large fraction of the world's coral reefs are found.

Associate Members were chosen to expand the scientific and geographical working area, and they would assist with specific working group deliverables. As costs of attending the 3 working group meetings won't be covered for these members, we have mainly chosen associate members from countries where funding is likely to be available to cover such expenses in order to maximize meeting attendance.

The researchers included represent a broad geographical spread, from Asia, Australia, Europe, Middle East, North and South America. The working group members also span from early to mid-career international researchers to international leading experts in coral reef biogeochemistry.

Full members			
Name	**Gender**	**Place of work**	**Expertise**
Nicholas Bates	M	BIOS, Bermuda	Coral biogeochemistry
Beatriz Casareto	F	Shizuoka University, Japan	Microbial ecology and
Ruy Kenji Kikuchi	M	Universidade Federal da Bahia, Brazil	Coral biogeochemistry
Christian Lønborg*	M	AIMS, Australia	Microbial ecology and biogeochemistry
Craig E. Nelson*	M	CMORE, USA	Microbial ecology and biogeochemistry
Xosé Anxelu G. Morán	M	KAUST, Saudi Arabia	Microbial ecology and biogeochemistry
Aazani Mujahid	F	University Malaysia Sarawak, Malaysia	Physical oceanography
Anond Snidvongs	M	Phuket Marine Biological Center, Thailand	Coral biogeochemistry
Adrienne J. Sutton	F	NOAA, USA	Ocean acidification
Aline Tribollet	F	IRD, France	Coral ecology and biogeochemistry
* = co-chairs			
Associate members			
Name	**Gender**	**Place of work**	**Expertise**
Eric De Carlo	M	University of Hawaii, USA	Coral biogeochemistry and acidification
Henrieta Dulaiova	F	University of Hawaii, USA	Coral geochemistry
Bradley D. Eyre	M	Southern Cross University, Australia	Coral biogeochemistry
Andréa G. Grottoli	F	Ohio State University, USA	Coral and isotope biogeochemistry
Joanie Kleypas	F	CGD/NCAR, USA	Ocean acidification
Nichole Price	F	Bigelow, USA	Ocean acidification
Jing Zhang	M	State Key Laboratory, China	Coral biogeochemistry

Funding

In order to reduce overall costs and ensure sufficient funding is available for all full members to attend all meetings we have 1) arranged that the Australian Institute of Marine Science, Townsville would cover the venue and accommodation costs for the third meeting in 2018 and 2) agreed that full members from developed countries, where possible, would cover parts of the cost of their own travel and accommodation from other sources.

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Uthicke S., Furnas M., Lønborg C. 2014. Coral reefs on the edge? Carbon Chemistry on inshore GBR Reefs. PloS One 9, doi:10.1371/journal.pone.0109092

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

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

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

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

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

Background and Rationale

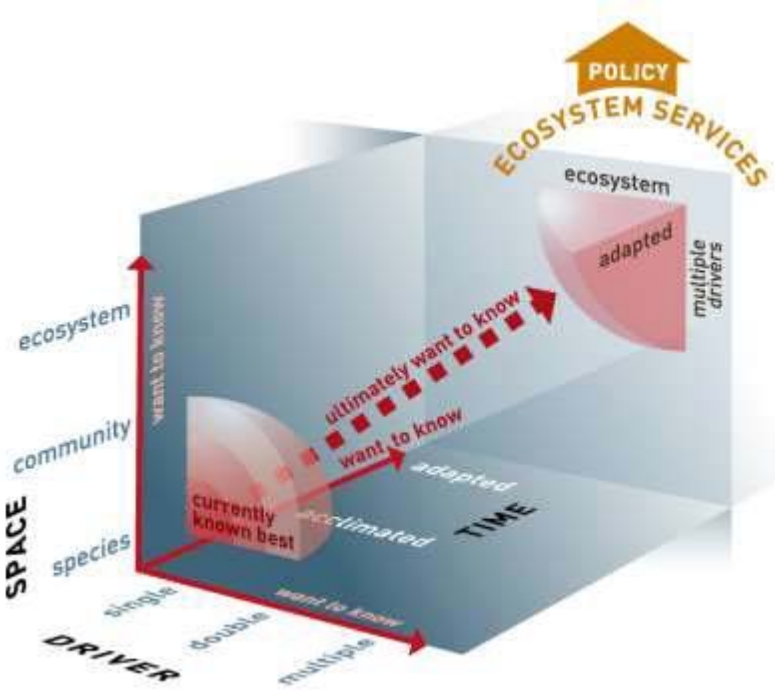

Figure 1 Present state of knowledge on Changing Ocean Biological Systems: most information on the impacts of ocean change presently available is on acclimated single species/strains under the influence of a single driver (lower left corner). Red arrows indicate the direction where we must expand our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

Theme 1: From single to multiple drivers

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

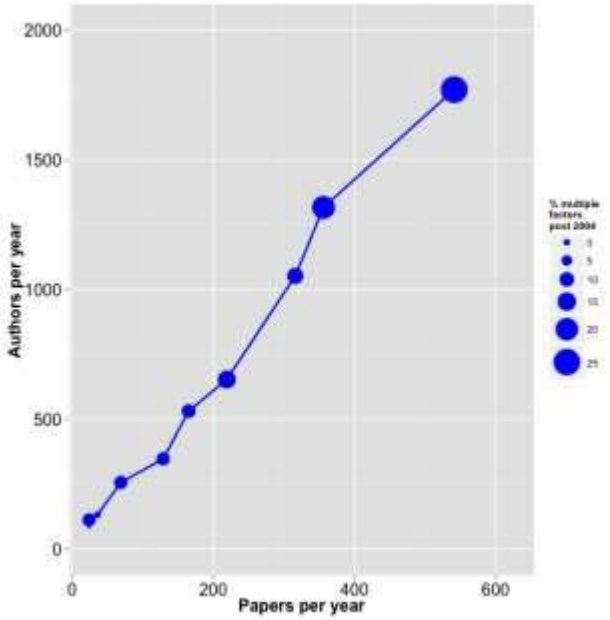

Figure 2 Increase in the number of papers focusing on both ocean acidification and other environmental drivers. Data courtesy of Jean-Pierre Gattuso, from a bibliographic database arranged with the Ocean Acidification International Co-ordination Centre (OA-ICC).

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

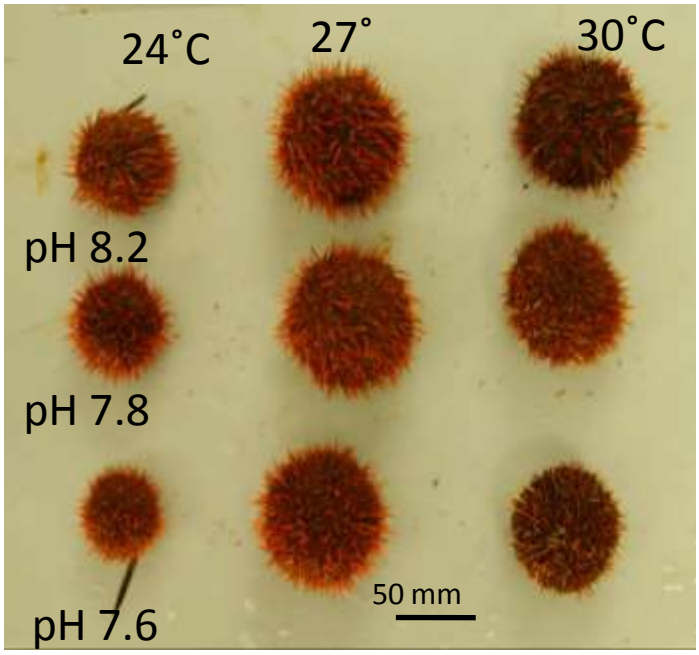

Figure 3 An example of the complex interplay of multiple environmental drivers on marine life. Temperature and pH both had a significant effect on growth of this sea urchin.

Acidification reduced body size and warming mitigated this effect. Image - courtesy of Maria Byrne (University of Sydney, Australia).

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

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

Theme 2: From organisms to ecosystems

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

There has been increased use of mesocosms (large volume, 1000 L or more, enclosures, Figure 4) to examine marine pelagic ecosystems in coastal and most recently oceanic waters, which has provided valuable information on the responses of the organisms that occupy trophic levels across foodwebs (Calbet et al., 2014). These mesocosm studies provide unprecedented detail on how ecological and biogeochemical processes will be altered by ocean change. This approach has also opened the door for implementing experimental evolutionary biology approaches in natural systems (Scheinin et al. 2015). Other ecosystems, such as those in benthic nearshore waters (from the tropics to the polar oceans) have also been examined via mid-term (months) deployments of innovative large volume (1000 L) experimental chambers such as Free Ocean CO_2 Enrichments (FOCE) (Gattuso et al., 2014). Both mesocosms and FOCE enable multiple large-scale multi-disciplinary marine manipulation experiments that detail both ecological and biogeochemical responses to environmental change (Figure 1).

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

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

Theme 3: From Acclimation to Adaptation

Virtually all manipulation experiments, whether based on single- or multiple-driver experiments with organisms, communities, or ecosystems, have not considered the potential for adaptation to influence the outcome of the study (Schaum et al., 2014). In order to detect a measurable response to environmental manipulation, such experiments are primarily conducted using climate change projections for the year 2100, and thus represent a quasi- instantaneous alteration of environmental conditions, for example, increasing pCO_2 from present day (400 µatm) to 750 µatm (projected in some climate change IPCC scenarios for year 2100) on a timescale of hours to days. Such an experimental design cannot take into account the abilities of the study organisms to acclimate (days to weeks) or adapt (longer timescales) to alterations of oceanic conditions that occur incrementally over years or decades. Adaptation via micro-evolution for rapidly reproducing organisms such as microbes has been shown to occur on shorter timescales (<1000 generations, years) than previously thought (Lohbeck et al., 2013, Hutchins et al. in press), revealing the ability and indeed the need to consider evolutionary responses in global change experimental design (see Figure 1).

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

Terms of Reference (TOR)

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

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

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

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

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

6) Build an interactive website on 'multiple drivers and marine biota' to ensure the long-term future and inter-connectedness of this international research community, and to provide educational information at a variety of levels.

7) Publish a series of short articles in both the scientific media and with scientific journalists to disseminate the challenges and opportunities surrounding multiple drivers and ecosystems.

8) Engage with policy-makers and science communication experts to produce a glossary of terms and an implementation guide for policy-makers to better understand the role of multiple drivers in altering marine living resources and ecosystem services.

Working plan

The TOR will each be fulfilled as action items between and/or during WG meetings. We will run each meeting alongside conferences that will be well attended by WG members including Oceans in a High CO_2 World (May 2016), the Ocean Global Change Biology Gordon Research Conference (GRC, July 2016, 2018), and other venues – AGU/EGU meetings to minimise travel costs.

Year 1

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

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

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

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

Year 2

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

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

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

Year 3

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

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

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

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

Year 4 and looking beyond the lifetime of the COBS WG

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

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

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

Deliverables

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

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

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

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

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

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

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

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

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

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

a) A new generation of scientists, from an wide range of countries, with comprehensive skillsets to further evolve the field of COB, and to meet the challenges that lie ahead in better understanding how ocean biota will respond to changing ocean conditions.

b) A series of interactive guidelines (wiki books on a multiple drivers BPG) that can be readily updated and accessed on line by the emerging international community of both established and emerging early career researchers.
c) An interactive website that will continue to act as a repository for new information and emerging initiatives that the international community can focus on.

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

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

Working Group composition

Full Members

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

9 Jorge Navarro	Male	Marine Science Institute, Austral University of Chile, Chile	Climate change and marine bivalves
10 Kunshan Gao	Male	Xiamen University, China	Multiple drivers and their interactive effects on ocean biota

Associate Members

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

Working Group contributions

Together, the full members bring a wide range of expertise that ranges from multiple driver lab and field manipulation studies, evidence of biological responses to a changing ocean (from

satellites), environmental sensor design, experimental evolutionary biology, and mathematical modelling.

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

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

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

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

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

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

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

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

Jorge Navarro (Chile). Professor Navarro is a leading researcher on the impact of ocean changes on commercial bivalves such as mussels. His multi-driver research has targeted larval to adult bivalves to assess which part of the life cycle is most susceptible to changing ocean conditions.
Kunshan Gao (China). Prof. Gao is recognized as the leading authority in China on ocean acidification and primary producers, including both microplankton and macrophytes. His

recent work has focused on understanding the responses of phytoplankton to multi-variate climate change processes.

Relationship to other international programs and SCOR Working groups

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

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

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

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

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

Abstract: Species diversity measures based on taxonomy, and more recently on molecular data, dominate our view of global biodiversity patterns. However, consideration of species functional traits, such as size, feeding ecology and habitat use, can provide insights into biodiversity patterns by representing how communities contribute to ecosystem processes. Moreover response traits, characteristics linked to how species respond to environmental change, have been linked to the processes underpinning community recovery following disturbance. We propose identifying functional traits for the global vent species pool to provide the first quantification of spatial and temporal patterns in functional diversity in this unique ecosystem. We will use expert knowledge and a literature review to identify both effect and response functional traits, and retrieve data for diverse macrofaunal and meiofaunal taxa. Our aim, given that trait-based measures provide a means to directly compare communities with species arising from different evolutionary trajectories, is to test whether vent communities from different biogeographic provinces display functional convergence while accounting for the geological and chemical settings. We will further test for change in functional diversity following the formation of new vents and disturbance events. This knowledge is critical for environmental management, given that hydrothermal vents are presently targeted for mineral resource exploitation by 2017. Our proposed working group will build an open-access traits database and offer a novel perspective on global biodiversity and succession patterns in vent communities. We will advance our understanding of the potential for functional diversity metrics to inform effective management and risk assessment guidelines at vents.

Scientific Background and Rationale

Why Functional Diversity? Most studies of biodiversity patterns and assemblage change focus on species. Even so, while some species may be very similar, others may differ markedly in their morphology, behavior, and ecology, and play different roles in a community and, ultimately, ecosystem function. Therefore functional trait approaches offer a means to distinguish differences in how species interact with their environment and other species (Lefcheck et al. 2015). Functional diversity (FD) metrics integrate the total variation in functional traits across all species within a community, providing an important perspective to diversity that complements patterns gained from taxonomic diversity measures (Faith 1996, Stuart-Smith et al. 2013).

Changes in community processes that are linked to functional traits are, in some cases, more important than changes in the species present, such as when understanding the implications of community responses to disturbance is of interest. Community processes may also be more predictable in comparison to traditional taxonomic approaches (Suding et al. 2008), as well as being a more sensitive measure of community change (Coleman et al. 2015). Therefore, using trait-based methods to characterize community dynamics provides a means to examine functioning-related consequences to community processes following both natural and human-related disturbances.

Functional trait ecology and statistical tools are also rapidly evolving to consider changes in community function driven by local diversity (alpha diversity) and variation of community composition through space (beta diversity). Thus a functional trait perspective will allow us to identify those species that play an important role in maintaining local functional diversity, sites that contribute in exceptional ways to beta diversity, and drivers of significant temporal trends at different spatial scales.

Why Hydrothermal Vent Communities? Functional trait methods have largely been developed using plant assemblages (although functional trait approaches are presently being widely applied) where characteristics that define species in terms of their ecological roles and interactions are direct indicators of ecological process and function. For instance, there is a strong link between leaf traits (e.g., size), plant growth and primary production through photosynthesis. In a similar way, symbiont-hosting invertebrates are dependent on access to hydrothermal vent fluids, which deliver reduced compounds such as hydrogen sulfide or methane, used by microorganisms as an energy source for the synthesis of organic molecules. Animals that host bacterial symbionts have specialized morphological traits including enlarged tissues where bacteria are located, and thus there is a direct relationship between the size and shape of chemosynthetic animals and ecosystem processes, such as primary productivity. Hydrothermal vent ecosystems are therefore particularly compelling conceptually for analysing functional diversity patterns in both time and space. However, a functional trait approach has not yet been attempted in these communities.

The timing and geometry of ancient plate boundaries have shaped the distribution of hydrothermal vent communities which group into distinct biogeographic provinces (e.g., Tunnicliffe & Fowler 1996, Bachraty et al. 2009, Moalic et al. 2011). Vent species therefore differ among vent fields and plates and cannot be compared at a global scale using taxonomic differentiation measures. However, trait-based approaches provide a means to compare communities comprised of different species. Although functionally equivalent species may be present in different vent provinces, it remains an open question whether vent communities have a similar functional composition and structure, although their phylogenetic origins differ. By quantifying global patterns in vent functional diversity we will answer this question and further test whether large-scale differences in physical factors (such as depth) relate to functional diversity patterns (Ramirez-Llodra et al. 2007).

Conservation of hydrothermal vent ecosystems is a growing concern as exploitation of massive sulfide deposits is planned for 2017 in Papua New Guinea and exploration licenses have been issued in both state and high seas vent systems. The strong association of vent ecosystems with the target high-grade ores has focused attention on the risks and the lack of management frameworks to assess potential impacts and devise mitigation (Van Dover 2010, Boschen et al. 2013, Collins et al. 2013). As the International Seabed Authority considers management frameworks for high seas extraction (ISA 2015), our proposed SCOR Working Group (WG) will make considerable progress with a focus on ecosystem function using functional diversity measures to complement taxonomic and molecular approaches.

Functional traits have the potential to offer new insights into how we prioritize, assess risk, and develop conservation and management strategies for these unique ecosystems at local, regional and global scales. We will identify functional traits that are expected to respond to habitat

disruption, and test for change in these metrics following formation of new vents, replicated at different sites (e.g., Mid-Atlantic Ridge, East Pacific Rise and Juan de Fuca Ridge) where time-series community data have been collected (e.g., Marcus et al. 2009,Mullineaux et al. 2012, Cuvelier et al. 2014). What we propose is, therefore, a direct analogue of the classical ecological experiment with replication, but one that has been conducted at an appropriate scale for improved global management understanding.

The potential for new ecological understanding gained from analysis of functional diversity at vents to inform global conservation and management policy is great, however a rigorous traits database has yet to be collated for the global vent fauna. We will bridge this gap to build an open-access functional trait database that can be updated as new species and areas of hydrothermal activity are discovered, and can also be extended to include additional chemosynthetic systems such as cold seeps and whale falls.

Terms of Reference

We have assembled an international and interdisciplinary team to:

1. Synthesize species lists for each hydrothermal vent ridge and volcanic arc system by updating and error checking previously collated databases (e.g., Chemosynthetic Ecosystem Science, ChEss: http://chess.myspecies.info) so that we have the most up-to-date species database incorporating newly discovered areas of hydrothermal activity (e.g., Rogers et al. 2012).
2. Identify key functional traits including i) effect traits: traits related to how species influence ecosystem processes, and ii) response traits: traits that we would expect to influence the magnitude, direction and how quickly species respond to environmental change or a disturbance event (Díaz et al. 2013). Given that one of the main and unresolved challenges in the field of functional ecology is the selection of traits that relate to ecological processes and ecosystem functioning (Lefcheck et al. 2015), we will formulate a conceptual framework describing our rationale for inclusion of each functional trait.
3. Use expert knowledge and the literature to parameterize a functional traits database for hydrothermal vent fauna.
4. Apply macroecological analyses to map functional diversity in vent systems and test hypotheses regarding the mechanisms underpinning spatio-temporal patterns in functional diversity, using the best numerical methods to analyze trait-based alpha and beta diversity.
5. Identify functional traits that may have relevance for conservation and management objectives given possible exploitation of deep-sea sulfide deposits and provide guidelines for incorporating functional trait approaches into risk assessment procedures.

Working Plan

Our team includes experts in geochemistry, oceanography, biology, ecology, biogeography, statistical ecological and network modeling, and spans highly experienced senior researchers through to early career researchers. We are thus building international capacity to develop a

comprehensive functional traits database and ask ecological questions that are fundamental to building ecological and applied theory. We will achieve our terms of reference though three workshops.

The first workshop "*FDvent: A functional traits database for hydrothermal vent fauna*" will be hosted [early 2016] at the National Oceanography Centre, Southampton, UK. Prior to the workshop, WG members will have produced an updated global species list for vents. We will use the first days of the workshop to identify traits for inclusion in the global database, with the aim of contributing to ongoing efforts to collate functional trait data in a standardized and accessible format (to both humans and computers) and integration with trait information from other taxa (e.g., EMODnet: http://www.emodnet-biology.eu/, Encyclopedia of Life, Traitbank: http://eol.org/info/516, FishBase: www.fishbase.org, Polytraits: (Faulwetter et al. 2014), TRY: http://www.try-db.org).

We will focus on a mixture of effect and response traits that shape ecosystem structure and function, as well as mediating how species respond to environmental changes, such as physiological niche, body mass, generation length, trophic level and reproductive strategy. We will also consider whether species are endemic to vents and their relative dispersal abilities – traits likely to influence species responses to disturbance.

In the second and third days of the workshop we will fill in our traits matrix using the taxonomic literature, to be supplemented as required from museum collections, and the collections of the workshop team. Bringing experts together to represent hydrothermal vent fauna from each ridge system and different taxa will lead to efficient collection of these traits from the literature and allow gaps of knowledge to be filled using expert opinion. Moreover, approaches to missing data have been developed that we can apply, such as the use of imputation methods for ranking of communities on the basis of their functional diversity indices (Taugourdeau et al. 2014). We will further use hierarchical Bayesian analysis to infer values based on those of closely related species, which allows (1) quantitative data-driven assessment of the lowest level in the taxonomic hierarchy at which a significant proportion of the variation in species-level values is explained and (2) quantification of uncertainty so that values in derived analyses can be weighted to reflect confidence (e.g., Fazayeli et al. 2014) which can be compared to expert estimates.

As a group we will also explicitly consider the sources of error and bias in cross-ecosystem and cross-taxa estimates of traits that can be incorporated in our modeling frameworks (e.g., greater inaccuracy for some taxa or between sampling methods). Defining these issues will then allow us to present solutions, such as modeling sampling variability independently between regions or using machine learning approaches which are not constrained by probabilistic assumptions about the distribution of the response.

The second workshop will be hosted [early 2017] at the University of Victoria, Canada: "*Global patterns in the functional diversity of hydrothermal vent communities*". We will take the functional traits matrix developed in the first workshop to link functional diversity patterns among biogeographic provinces with physical data (e.g., ridge spreading rate, ocean depth, fluid chemistry) to identify patterns, possible drivers and potential processes underpinning the functional diversity of vent communities at large spatial scales. Functional diversity reflects the

value and range of traits that influence ecosystem function and thus is not captured in a single measure. We will therefore use community-weighted mean trait values, as well as functional richness, dispersion and redundancy (Mouchet et al. 2010, Laliberté et al. 2014). We will use a variety of approaches including methods to test for trait-environment relationships, e.g., fourth-corner method (Dray and Legendre 2008), generalized and linear mixed effects modeling, and network theory (Moalic et al. 2011, Lindo 2015). We will also extend recently developed tools in community ecology such as local contributions to beta diversity (LCBD indices) to the study of functional trait ecology (Legendre & Gauthier 2014). Our aim is to provide a creative opportunity for our team to explore and model the data using different methods at a range of spatial scales, as well as to brainstorm ways of conceptualizing the data.

The third workshop entitled "*Using community responses to natural disasters and disturbance to guide conservation of hydrothermal vent communities*" will be hosted [early 2018, location to be announced pending the success of co-funding applications to assist associate members with travel costs]. Prior to the workshop our WG will synthesize time- series data from vents (e.g., Marcus et al. 2009, Mullineaux et al. 2012) and analyze trends in the functional diversity of the community. Our aim will be to identify functional traits that are expected to respond to habitat disruption, and test for sensitivity in these functional traits following formation of new vents or disturbance events, replicated at different locations. The workshop will therefore be a venue for our WG to discuss the application of functional traits to inform impact assessments of large-scale exploitation of sulfides and to explore the use of approaches such as temporal beta diversity indices (P. Legendre) and network modeling (S. Kininmonth). We will thus aim to develop a framework to explore how functional traits can inform the management and conservation guidelines for hydrothermal vents and publish our findings (open-access) in an international journal.

Deliverables

Database

- Deliverable 1: Our WG will release our functional traits database at the end of the project including up-to-date and accuracy checked species lists representing the world's vent systems, to be hosted on the InterRidge website (http://vents-data.interridge.org/), and distributed to the Oceanographic Biodiversity Information System (OBIS) database repository and the World Register of Marine Species (WoRMS, T. Horton, proposed associate member, is on the WoRMS steering committee).

Open-access peer-reviewed publications

- Deliverable 2: Our WG will describe the database, our rationale for inclusion or exclusion of particular traits, and a reproducible example for our methods to estimate missing trait data. We will publish these details and the database in a scientific data journal (e.g., Scientific Data) so that the database will be associated with a DOI.
- Deliverable 3: We will accomplish the first macroecological analyses of functional diversity patterns in hydrothermal vent systems, and target our findings for a high-impact, open- access journal.
- Deliverable 4: We will conduct an analysis of functional time-series following catastrophic events and disturbance at hydrothermal vents, and target our findings for a high-impact, open-access journal.
- Deliverable 5: We will publish management and risk assessment guidelines for hydrothermal vent communities based on functional traits for publication and dissemination to policy makers.

Capacity Building

A downloadable, searchable, and freely accessible functional traits database product (FDvent) that will also be published in a static, open-access format (target journal: Scientific Data) will be an important resource. We will ensure compatibility with other database schemas and metadata (e.g., EMODnet, Encyclopedia of Life, and Traitbank). FDvent will provide a basis upon which we can expand in future proposals to include other chemosynthetic communities, such as hydrocarbon seeps and organic falls (e.g., large mammal carcasses, wood). The FDvent database will also be a resource that will allow these unique ecosystems to be included in global analyses comparing different ecosystems to develop ecological theory.

Building FDvent will further allow us to develop proposals to produce more accessible data that is fit for purpose. For instance, Microsoft Research (http://research.microsoft.com/en-us/labs/Cambridge/) offers funding to make biodiversity and functional trait data available in different formats, tailored to a variety of purposes including education, outreach, policy and science.

We will also actively involve early career researchers (full member: Alejandro Estradas, UNAM, Mexico) and invite PhD students to contribute to the working group meetings and to run analyses with the FDvent traits database (Abbie Chapman, NOCS, UK, presently undertaking a PhD co-supervised by A.E. Bates and V. Tunnicliffe, and Rachel Boschen, NIWA, NZ, presently undertaking a PhD co-supervised by WG full member A.A. Rowden). Involving early career researchers will provide important training opportunities and spearhead functional trait ecology in chemosynthetic systems, as well as engaging early career talent in the SCOR process.

Working Group Composition

Full Members (in alphabetical order after the proposed SCOR WG chairs)

Name	Gender	Place of work	Expertise relevant to proposal
1. Amanda Bates (Co-Chair)	Female	University of Southampton, UK	Functional trait ecology, global biodiversity and conservation, hydrothermal vent gastropod biology
2. Verena Tunnicliffe (Co-Chair)	Female	University of Victoria, Canada	Deep-sea biodiversity and conservation, functional traits, Northeastern and western Pacific vent fauna
3. Alejandro Estradas-Romero	Male	Instituto de Geofísica, UNAM, Mexico	Mexican vent fauna, biological oceanography, diatom biology, chemosynthetic microorganisms
4. Andrey Gebruk	Male	P.P. Shirshov Institute of Oceanology, Russia	Deep sea bottom communities, Mid-Atlantic Ridge vents, trophic ecology of hot vent shrimps, functional traits
5. Ana Hilário	Female	University of Aveiro, Portugal	Reproductive ecology and biogeography of deep-sea ecosystems
6. Baban Ingole	Male	CSIR-National Institute of Oceanography, Dona Paula, Goa, India	Environmental impact assessment, conservation and management, Indian Ridge vent fauna
7. Pierre Legendre	Male	Université de Montréal, Canada	Functional diversity statistics, beta diversity indices, numerical ecology
8. Eva Ramirez-Llodra	Female	NIVS, Norway	Census of Marine Life project ChEss coordinator, reproductive ecology
9. Ashley Rowden	Male	NIWA, New Zealand	Biodiversity and conservation, Kermadec Ridge vent fauna
10. Hirome Watanabe	Female	JAMSTEC, Japan	Biogeography and biodiversity, western Pacific and Indian Ocean hydrothermal vents

Associate Members

Name	Gender	Place of work	Expertise relevant to proposal
1. Stace Beaulieu	Female	WHOI, USA	Biodiversity, biogeography
2. Peter Girguis	Male	Harvard University, USA	Physiology and biochemistry of deep sea microorganisms, relationships between microbes
3. Tammy Horton	Female	NOC, UK	Amphipod taxonomy, functional traits, biogeography
4. Stéphane Hourdez	Male	Station Biologique Roscoff, France	Polychaete taxonomy, biology and ecology
5. Stuart Kininmonth	Male	Stockholm Resilience Centre, Sweden	Bayesian network modeling, global ecology
6. Jozée Sarrazin	Female	IFREMER, France	Biodiversity, impact assessment, Mid- Atlantic and Northeast Pacific Ridge vent fauna
7. Hans Tore Rapp	Male	University of Bergen, Norway	Taxonomy and systematics of marine invertebrates, Arctic Ridge
8. Ann Vanreusel	Female	University of Ghent, Belgium	Meiofauna, biodiversity and functioning

Working Group Contributions

- **Amanda Bates** will co-chair the WG meetings. Amanda did her PhD on the functional traits of gastropod species from the Juan de Fuca Ridge hydrothermal vents. She is a lecturer in macroecology where she works on developing functional trait metrics for conservation applications and global ecology.
- **Verena Tunnicliffe** will co-chair the WG meetings. Verena has been developing understanding of the biogeography of vent systems, community ecology, and species functional traits since their discovery.
- **Alejandro Estradas-Romero** will contribute knowledge of the shallow water vents in the Pacific. He has an interest in the ecology and functioning of microorganisms, phytoplankton ecology and biological oceanography.
- **Andrey Gebruk** will contribute to WG activities as an expert on hydrothermal vent fauna of the Mid-Atlantic Ridge, trophic ecology of hydrothermal vent shrimps and relationships between shallow and deep-water hot vent communities.
- **Ana Hilário** did her PhD on the reproductive ecology of siboglinid tubeworms from hydrothermal vents and cold seeps. Her research is focused in the reproductive ecology and larval dispersal of deep-sea invertebrates, and population connectivity and its implications for biogeography, and spatial planning and management.
- **Baban Ingole** is an expert on Indian Ridge vent fauna, seamount fauna, as well as Environmental Impact Assessment of Deep Sea mineral mining. He further has an interest in the diversity of meio- and macrobenthic species and functional traits for conservation applications.
- **Pierre Legendre** is an expert in numerical ecology, with special emphasis on the

variation of communities through space and time (beta diversity). An important component of his research is the development of quantitative methods to analyze multivariate ecological data. He has published papers on functional diversity indices.

- **Eva Ramirez-Llodra** was the Project Manager of the ChEss- Census of Marine Life project (2002-2010) investigating the biogeography of deep-water chemosynthetic ecosystems. She developed ChEssBase, is co-PI of the international INDEEP network for deep-sea research, and has expertise in biodiversity and reproductive studies of deep-sea ecosystems, including hydrothermal vents.
- **Ashley Rowden** has been developing an understanding of the vent biogeography of the New Zealand region, and its relationship to the vent biogeography of the western Pacific Ocean, through sampling of vent communities on the Kermadec volcanic arc. Ashley is also currently involved in a functional traits-based ecological risk assessment of deep-sea habitats, which includes an assessment of both vent and seep habitats.
- **Hiromi Watanabe** researches biodiversity, biogeography and population connectivity using genetic analyses as well as rearing experiments of embryos and larvae of deep-sea hydrothermal vent faunas in western Pacific and Indian Oceans. She will contribute expertise in reproductive and larval traits of vent species.

Relationship to Other International Programs and SCOR Working Groups

We will build upon the ChEss database (http://chess.myspecies.info) by collating species lists produced since 2010 and error-check the database (proposed full member, E. Ramirez- Llodra designed ChEssBase and co-coordinated ChEss). We will further take advantage of databases that are under development by our WG team (e.g., InterRidge, http://www.interridge.org, by S. Beaulieu).

Our WG will also embrace an open-data philosophy. For instance, WG associate member P. Girguis is presently the chair of DeSSC (Deep Submergence Science Committee, https://www.unols.org/committee/deep-submergence-science-committee-dessc) and he has been working to facilitate international collaborations and "open access" to data and metadata generated during US expeditions. Moreover, Girguis is on the advisory board for the Ocean Genome Legacy (http://www.northeastern.edu/cos/marinescience/ogl/), a non- profit marine research institute and genome bank dedicated to exploring and preserving the threatened biological diversity of the sea. The purpose of OGL's collection of DNA blueprints (genomes) is to provide secure storage and broad public access to genomic materials, to create a forum for sharing samples, data and ideas, and to serve as a catalyst for research that can help to protect marine ecosystems and improve the human condition. OGL is willing to serve as an open access repository for new samples, and will provide any and all samples for SCOR WG members.
We will contribute understanding on the importance of ecosystem function with respect to deep-sea mining, and thus link to projects such as DOSI, Deep-Ocean Stewardship Initiative (WG members E. Ramirez-Llodra, A.A. Rowden, and V. Tunnicliffe sit on the DOSI advisory board). DOSI seeks to integrate science, technology, policy, law and economics to advise on ecosystem-based management of resource use in the deep ocean and strategies to maintain the integrity of deep-ocean ecosystems (http://www.indeep-project.org/deep-ocean-stewardship-initiative).

We will further take advantage of any opportunties to develop cross-overs between the SCOR Working group on “Seafloor Ecosystem Functions and their Role in Global Process" through Prof. Ingole, who has been invited to attend the group’s first meeting in Naples, Italy (September 2015).

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

Summary

Ocean water is a biofluid, thickened by exopolymeric substances (EPS) produced mainly by algae and bacteria. Locally, particularly at scales <~1 cm, this EPS has been shown to increase viscosity many-fold, and gives elasticity to the water. Some of this EPS occurs as sheaths and glycocalyxes around algae and bacteria, and are thought to be part of their ecological engineering strategy.

In the last ~15 years, superhydrophobicity (SH) has been discovered at hydrophobic, sculptured surfaces. SH is manifest by superhydrophic drag reduction (SDR) in surface layers up to several, μm thick. It also can promote strong repulsion of materials such as dirt and fouling organisms. Commercially available SH self-cleaning materials are now widely available, and are being developed for non-toxic ("green") antifouling coatings for ships, etc.

There is little awareness of these developments amongst the ocean-environment research community, and little understanding of the sciences underlying their development: namely rheology; nano/microfluidics (NMF), and the electrochemical bases of non-toxic antifouling mechanisms.

Swarming of protists and bacteria occurs, where concentration is much increased and synchronised swimming occurs, in which viscosity can be changed many-fold. *RheFFO* WG shall investigate such effects occurring locally in the oceans.

A principal object of this WG is to form a nucleus of scientists all literate in: (i) ocean sciences of pelagic ecology and biogeochemistry; (ii) rheology; (iii) surface science, including NMF and biofouling/antifouling mechanisms. The WG will thus have strong activities in capacity development (CD), from an interdisciplinary team of experts mainly to young scientists.

2. Scientific Background and Rationale (1237/1250)

2.1 Rheology

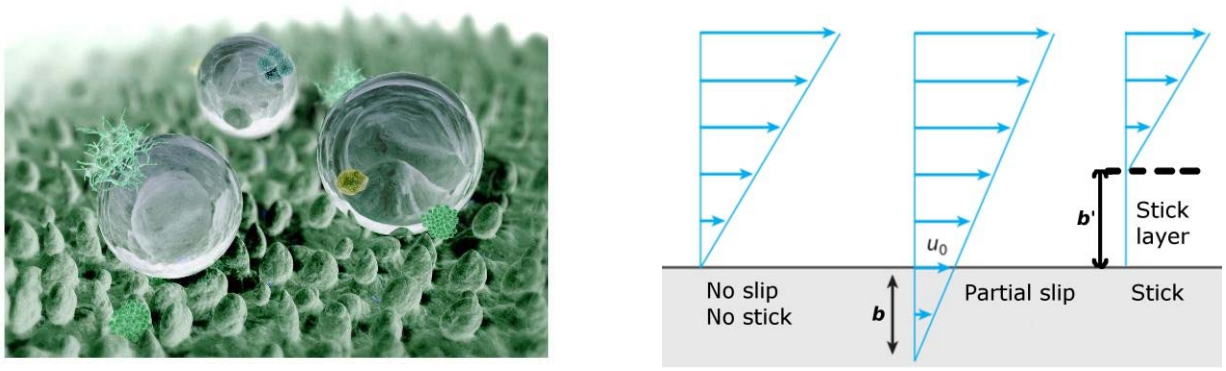
Left: Foam on the beach at Yamba, north of Sydney, Australia, produced from EPS, believed to be primarily secreted by Phaeocystis *sp. (c) Icon Images.*

Right: Marine organic mega-aggregate during a mucus event in the northern Adriatic. Its form reflects deformation by a large turbulent eddy. From Stachowitsch et al. (1984, P.S.Z.N.I., Mar. Ecol., 5: 243-264).

The sea is a non-Newtonian biofluid, and its rheological properties have been made in relation to its biological content. Yet most oceanographers are still unaware of this, or if they are aware, they do not have the training to apply these findings to their own research and models.

2.2 Superhydrobicity (SH), antifouling and self-cleaning

Have you ever wondered how many algae keep so clean? Lotus leaves do it by having SH self-cleaning surfaces. Encounter and fouling of surfaces by plankton, including their larvae, take place largely in near-surface layers. Recent developments in "green" (i.e. non-toxic) methods of antifouling on ships (Wang et al., 2014), other marine structures and desalination membranes (Balzano et al., 2014) can be applied to investigate adhesion, recognition, and repulsion by plankton.



Left: Computer-enhanced image of SH leaf surface in air ((c) Julia Lauren Vasic on March 30 2008). Right: A fluid flowing over a surface. Left - standard model; middle SH tends to produce slipping; right - adsorption of ions or mucus tends to produce a "sticky" layer. b is slip length; b' is sticking length; u0 is slip velocity. b can range from nanometres to micrometres, or occasionally millimetres.

2.3 Nano/microfluidics

Recent developments in nano- and microfluidics, including "lab-on-a-chip", have shown that surfaces in fluids exert influence from nanometre to millimetre scale into the fluid. This concerns pico- to micro- plankton, including the sculptured surfaces of diatoms, the microfibrils around pro- and eukaryotes and the micrometre-scale feeding appendages of copepods and other zooplankton (Rothstein, 2010; Wong et al., 2011; Jenkinson, 2014). Most oceanographers are unaware of this.

2.4 Incorporation rheological measurements into models of ocean fluidics

GEOHAB (2011) posed the question, "How can we quantify modifications in turbulence by phytoplankton through changes in the viscosity of its physical environment?" At that time, the state-of-the-art (Jenkinson & Sun, 2010) was that viscosity η of seawater and freshwaters was

composed of an aquatic component ηW due to water (and salts) plus an excess organic component ηE due mainly to EPS.

Total viscosity,

$$\eta = \eta_W + \eta_E \quad \text{[Pa s]} \quad (1)$$

Broadly, η_E shows a negative relationship power-law relationship with shear rate $\dot{\gamma}$, so that

$$\eta_E = k.\dot{\gamma}^P \quad \text{[Pa s]} \quad (2)$$

where k is a coefficient and P is an exponent, both related to phytoplankton-produced EPS concentration and type. P can vary from 0 to ~-1.4 (shear thinning), and has exceptionally been found positive (shear thickening). Using chlorophyll *a* concentration *chl* as a proxy for phytoplankton, then

$$\eta_E = k.chl^Q.\dot{\gamma}^P \quad \text{[Pa s]} \quad (3)$$

where Q is the phytoplankton concentration exponent, found to be about 1.3 generally. Further research, however, has shown that Q can vary locally with the growth phase of the bloom (Seuront & Vincent, 2008).

EPS thickening, moreover, is generally lumpy, probably associated with polymer spontaneous assembly (Chin et al., 1998; Ding et al., 2008, 2009). This produces length-scale dependent viscosity, which can be modelled using a lumpiness exponent.

Eq. 3 can now be "corrected" for length scale by a third exponent:

$$\eta_E = k.chl^Q.\dot{\gamma}^P.(L/M)^d \quad \text{[Pa s]} \quad (4)$$

where L is the length-scale of interest, M is the length scale of measurement, and d is the length-scale exponent. A model of whether lumpy EPS could thicken the water enough to stabilize a pycnocline (Jenkinson & Sun, 2011a) found that the value of d in Eq. 4 was very critical. To investigate d, η of phytoplankton and bacteria (PB) cultures was measured in capillaries of different radii. While η was increased in some combinations of shear rate, capillary radius, 0.35 to 1.5 mm, and PB species, presumably by EPS, η was surprisingly decreased in other combinations (Jenkinson & Sun, 2014). This may be associated by superhydrophobic conditions, sometimes called the *Lotus Leaf Effect*, at the surfaces of PB and EPS (scales nm to possibly 100s μm).

2.4.1 Some effects of increased viscosity (with suggested primary length scales) include:

1. Damping of turbulence and of sub-Kolmogorov-scale water movement: 1 nm – 1 m (Jenkinson, 1986);
2. Due to elasticity and lumpiness, complex changes to patterns of water movement, and de-coupling of shear rate from dispersion: 1 nm – 1 m (Jenkinson, 1986);

3. Partial and/or total clogging of the gills of fish (Jenkinson, 1989; Jenkinson et al., 2007), molluscs, tunicates, sponges, polychaetes, etc.: 1 nm – 1 mm;
4. Due to rising organic matter and adsorption to the air-sea surface, reduction of air-sea gas h exchange (Calleja et al., 2009), wave and ripple damping (Carlson, 1987): 10 μm – 10 m;
5. Complex situations, illustrated by *Phaeocystis*, which produces closely associated stiff mucus holding cells together in colonies (~50-2000 μm), while also producing looser diffuse mucus that increases viscosity at larger scales (Seuront et al., 2006), as studied in sludge organic aggregates (Liu et al., 2010): 50 μm – 1 m;
6. Flocculation into mucous aggregates, thus increasing sinking or rising speed and hence vertical organic flux (Mari et al., 2012): 100 μm – 1 mm.
7. Possible reinforcing of pycnoclines by PB EPS (Jenkinson & Sun, 2011, 2014): 10 cm–10 m;
8. Trapping of toxins close to metabolically active surfaces, such as cell membranes and gills (Jenkinson, 1989): 10 nm – 1 mm.

2.5 <u>Investigation techniques of seawater and lakewater thickening include:</u>

2.5.1 **Rheology**

1 Rheometry: a) concentric cylinder; b) sliding piston; c) capillary flow; d) ichthyoviscometry;
2 Studies of fluid movement at small scale: a) 3D particle image velocimetry (PIV); b) 3D particle tracking velocimetry (PTV);
3 Studies of small forces at small scale: Atomic Force Microscopy (AFM)
4 Combination of electrochemical techniques with rheometry, microscopy and PIV/PTV, ***in situ*** **if and when possible**;

2.5.2 <u>Nano- and microfluidics of biosurfaces (particularly sticking layers and slip layers at surfaces)</u>

1 High-speed video with PIV and PTV of flow through capillaries coated with organic sculptured layers of hydrophobic (Rothstein, 2010), hydrophilic (Bauer & Federle, 2009) and omniphobic (Wong et al., 2011) surfaces. To be combined with transmission electron microscopy (TEM), scanning electron microscopy (SEM), pressure/flow curves, and possibly standard rheometry of the test materials.
2 Scanning electrochemistry of organic matter film dynamics: Hanging mercury drop.
3 Use of electrochemical techniques developed to study the effects of biological coatings on corrosion dynamics;
4 Studies of attraction-repulsion fields, electrical double layers (EDLs).
5 Immunological type radicle-radicle recognition and adhesion.

2.5.3 <u>Biofouling, with adhesion, recognition and repulsion</u>

1 Fouling organisms need to encounter suitable surfaces, recognise them as suitable, then initiate a series of actions to adhere to the surface, and possibly to use means to penetrate it. Organisms subject to fouling are likely to have evolved antifouling mechanisms to avoid being fouled. Related to fouling and antifouling actions can be

considered:

a. Predation and avoidance of predation;
b. encounter and avoidance of "unwanted" sexual encounter;
c. Parasitism/symbiosis and avoidance of unwanted parasitism/symbiosis;
d. Pathogenic infection (by bacteria, viruses) and its avoidance;
e. Colonisation of different substrates (macrophytes, corals, rocks) by benthic dinoflagellates (*Gambierdiscus*, *Ostreopsis*) involved in harmful and toxic algal blooms (especially in tropical and subtropical regions, but apparently expanding their range associated with global warming);
f. By diffusion reduction and binding of toxins to mucus, protection of cells against nutrient competition and "stealing" by other microbial organisms.

2. The aim will be to use techniques developed largely for "green" biomolecule-modulated industrial antifouling techniques (for ships, cooling intakes, fish-farm cages and nets, etc.) to investigate fouling by organisms of other organisms and of non-living substrates in the sea (plankton, fish and benthic organisms, organic aggregates, sediment, rocks, etc., possibly already covered by biofilms).
3. The techniques to be used require further discussion by the WG members.

3. **Terms of Reference**

3.1 Vision

The ocean science community lacks expertise in (1) Rheology (the study of deformation in non-Newtonian materials); (2) nano- and microfluidics; (3) fouling and antifouling; (4) surface-surface recognition and adhesion. These domains affect trophic, sexual, parasitic, pathogenic and other types of encounter, that take place close to electrically controlled surfaces including glycocalyxes. Only when this knowledge is shared among ocean researchers, modellers and engineers, can there be more fundamental understanding of the processes occurring at the cell-size small scale. Without such knowledge sharing, which requires strong CD, future models of how the oceans will react ecologically and biogeochemically to future global changes will be unnecessarily flawed.

3.2

Objectives

A. Through capacity development (CD) of younger scientists, particularly in emerging countries, the multidisciplinary team of experts create a corps of ocean researchers, modellers and engineers literate in: (1) Rheology; (2) Nano- and microfluidics; (3) Fouling and antifouling at surfaces; (4) Electrochemical investigation tools, that they will teach to their students and graduate students in the decades to come.

B. During the lifetime of the WG, carry out research to carry this expertise to other oceanographic problems, to involve the members' students in theoretical and empirical research, published in scholarly papers, books, multimedia, and incorporated in outreach material across the globe.

4. Work plan

Year 1

Actions

- Before the Workshop, produce the kick-off draft SCOR Core Research Project (CRP) for RheFFO.
- **Workshop 1.** Objective: "Define the implementation plan for the Core Research Project"
  - Interdisciplinary CD by multidisciplinary team of experts of key younger scientists.
  - All experts and younger scientists participate. Each expert gives one or two 1.5-h lecture(s) on his/her expertise.
  - Each younger scientist outlines his/her expertise, and how (s)he believes the WG is needed to help solve bottlenecks in ocean research.
  - Experts give practical demonstrations of their techniques, and give the others hands-on experience.
  - The experts work together to write a keynote paper for a high impact open access scholarly journal, led by designated chair. Younger scientists may be invited to participate.
  - A terminal task of the Workshop will be to go through and refine the Core Research Project, and produce the final version.
  - Back in their home institutes, the experts lecture on these topics, incorporating *RheFFO* expertise. Between meetings, using electronic media, they help younger scientists to seek funding and write ocean-science proposals, incorporating *RheFFO* expertise.
  - They finalise the keynote paper for publication.
  - They shall incorporate *RheFFO* material in other ocean work.
  - The Rheology and micro- and nanofluidics experts raise funds and recruit PGs and PDs in their home labs to work on ocean-related problems using their expertise, as well as helping the trained younger scientists around the world.
  - Progress report 1.
  - Keynote paper 1.

Year 2

- Workshop 2
  - All WG members participate, with their PGs and PDs as suitable.
  - Continued CD –. One lecture course per expert, with major contribution by younger scientists, and contribution by the PGs and PDs.
  - Appropriate reports by Experts' and PDs and PGs report on research done back home.
  - One or two multi-editor books should be initiated with chapters written by members of the WG and others. The authors should take advantage of the meeting

to work together on their books and chapters, as well as on the second keynote annual paper.
    - Experts' reports on progress in achieving WG deliverables.
    - The experts work together to write a paper on a topic different from that in Year 1.
- Social activities will be strongly encouraged liaison between PDs and PGs from different institutes and disciplines, as long-term friendship will be crucially important for maintaining the developed corps of expertise after the end of the WG.
- Back home, each expert shall recruit more PDs and PGs. Experts should invite their colleagues and their PDs and PGs to work together in their home institutes and if possible on sea cruises.
- Progress report 2.
- Keynote paper 2.

Year 3

- Workshop 3
    - As above
    - The books should be nearing completion or in press. Finalising should be done.
    - The workshop also needs to focus on preparing the winding up of the WG at next year's workshop.
- Progress report 3.
- Keynote paper 3.

Year 4

- Before the workshop, the final report should be drafted, for finalisation at the workshop.
- Workshop 4
    - As above. The last annual paper will be prepared.
    - All the books and monographs will be already completed or in press.

- The WG has to be wound up with a final paper for online publication by SCOR, that will be a scientific review of new discoveries made during the WG in relation to other progress made in ocean science, rheology and nano- and microfluidics, pointing out new questions and gaps in knowledge.
- Annual progress report 4.
- Final report for whole period of WG.
- Final report, incorporating progress report for Year 4.
- Keynote paper 4.

5. Deliverables

- One Kick-off Core research project
- One finalised Core Research Project

- Four keynote papers in top learned journals.
- Two multi-editor books (or a book and a monograph).
- 4 annual progress reports
- 1 Final Report, for publication by SCOR.

6. Capacity development

6.1 Production of a corps and a network of interdisciplinary expertise worldwide.

An important aim of this WG is to produce a world-wide nucleus of scientists with expertise in rheology, nano- and microfluidics, and biofouling and antifouling, along with the electrochemistry tools to do some of this research, all in relation to plankton ecology, biogeochemistry and other aspects of oceanography. EECB will continue throughout the WG to progressively deepen interdisciplinary understanding. A principal aim will be to develop a corps and a network of young scientists and engineers trained in all aspects of *RheFFO* knowledge. We will aim so that these young scientists become friends and remain friends for the rest of their careers, publishing together, co-mentoring each other's students, and thus continuing CD into the future.

6.2 Cross-disciplinary knowledge transfer

The experts in different fields, physical oceanography, plankton biology and harmful algal blooms, biogeochemistry, rheology, nano/microfluidics, biofouling, electrochemistry and atomic force microscopy, shall develop interdisciplinary capacity in exceptionally talented young scientists from different backgrounds, specially invited to joint the WG workshops.

7. Working Group composition

7.1 Full Members

Name	Gender	Place of work	Expertise relevant to proposal
Ian R. JENKINSON Chair	M	Institute of Oceanology Chinese Academy of Sciences, Key Laboratory of Marine Ecology and Environmental Sciences, Qingdao, P.R. China	Physical-Chemical-Biological coupling, particularly related to p harmful algal blooms. Rheology and ocean turbulence. Superhydrophobic surfaces. Ecological engineering;

Elisa BERDALET Chair	F	Institut de Ciències del Mar (CSIC). Barcelona, Spain	Physical-biological interactions. - Harmful Algal Blooms. - Biochemical methods. - Microplankton physiology. Vice-chair of the Scientific Steering Committee of the SCOR/IOC-UNESCO program GEOHAB, Global Ecology and Oceanography of Harmful Algal Blooms
Laurent SEURONT Chair	M	Centre National de la Recherche Scientifique and Université de Sciences et de Technologies de Lille, Wimereux, France.	Phytoplankton, zooplankton, coastal oceanography, multiscaling and (multi) fractals in physical, biological and economic systems, and particularly in marine ecology, seawater viscosity in relation to phyto- and bacterioplankton.
Jinju (Vicky) CHEN	F	Lecturer in Nano-Biomechanics, Newcastle University, UK	Modelling and experimental characterisation of rheology of biofilms, biofilm formation, and biofilm attachment. Microfluidics for biofilm characterization
Mariachiara CHIANTORE	F	Associate Professor in Ecology at DiSTAV, Università di Genova, Italy	Modeling and mitigation of benthic harmful algal blooms. Ecology of *Ostreopsis* spp., especially environmental triggers, toxic effects.
Wei-Chun CHIN	M	School of Engineering, University of California, Merced, USA	Experience with marine gels and EPS aggregation mechanism. Applying various techniques from nanotechnology and engineering. Impact of environmental factors (pH, temperature and pollutants) on marine microgels and EPS.
Stephen HERMINGHAUS	M	Max Planck Institute of Dynamics and Self- Organization, Head of Dept. Dynamics of Complex Fluids, Göttingen, Germany	Rheology, nano/microfluidics, rheological effects of swarming cells, rheological effects of marine plankton, rheological effects at surfaces. Experience in organization

Sophie LETERME	F	Plankton Ecology Laboratory, Flinders University.	Senior Lecturer,
Zhuo LI	F	Tongji University, College of Environmental Science & Engineering, Shanghai, P.R. China	Associate professor, rheology, developing micro/nano- fluidic biosensors, and computational fluid dynamics (CFD).
James G. MITCHELL	M	School of Biological Sciences, University of Flinders, Adelaide, Australia	Heads a group focusing on nanometer to micrometer scale processes and marine ecosystems. Lessons learned have been applied to nanotechnology, including microfluidics and nanofabrication.

7.2 Associate Members

Name	Gen	Place of work	Expertise relevant to proposal
Myriam BORMANS	F	National Centre for Scientific Research and Université de Rennes I, Rennes, France	Research director. Role of turbulence in phytoplankton dynamics, colony formation and EPS production, morphological traits based ecology. Provides experimental grid stirred tank, and NanoSIMS (Secondary Ion Mass Spectrometry) expertise
Valentina GIUSSANI	F	Department of Earth and Environmental Science, University of Genoa, Italy	Doctorante, Ecotoxicology and management of benthic harmful algal blooms, especially in relation to their mucilaginous matrix.
Moshe HAREL	M	CEO, Sha'ked Microbial Solutions Ltd., Tel Aviv, Israel	Mutual relationship of a green-alga and the freshwater cyanobacterium *Microcystis* sp., and dynamics of EPS.

Xavier MARI	M	Researcher, Institute of Research for Development, Marseille, France	Characterisation of TEP, measuring sinking and rising, cohesive properties, aggregation dynamics in estuaries
Javeed Shaikh MOHAMMED	M	Head, Faculty of Innovative Design and Technology, Universiti Sultan Zainal Abidin, Kuala Terengganu, Malaysia	Biological microelectromechanical systems (BioMEMS), Nanotechnology, Microfluidics, Hydrogels
Michael ORCHARD	M	Physical Ecology Laboratory, University of Lincoln, UK	Research Assistant. High-speed video- microscopy of predation in marine protists. Adhesion, rheology and surface science
RI QIU	M	State Key Laboratory for Marine Corrosion and Protection, Luoyang Ship Material Research Institute, Qingdao, P.R. China	Assistant professor. Prevention of marine biofouling and corrosion, using "green" organic techniques and surface properties. Superhydrophobic surfaces. Electrochemistry as a tool to measure ion migration and for changing behaviour of fouling organisms.
Massimo VASSALLI	M	CNR – The Biophycs Institute, Genoa, Italy	Using physical tools such as atomic force microscopy and optical tweezers to measure physical properties of biological systems (mainly mechanics and rheology of cells, gels and proteins).
Peng WANG	M	Institute of Oceanology Chinese Academy of Science, Key Laboratory for Marine Corrosion and Biofouling, Qingdao, P.R. China	Associate professor. Prevention of marine corrosion and biofouling, using "green" organic techniques and surface properties. Electrochemistry. Superhydrophobic surfaces.

Tim WYATT	M	CSIC, Institut de Investigaciones marinas, Vigo, Galicia, Spain	Senior Research Fellow, HABs, fisheries, organic matter and ecological engineering, eclecticism and excellent writing skills.

8. Working Group contributions

BERDALET, E.

1. Berdalet shall provide CD in (i) Physical-biological interactions; (ii) Harmful Algal Blooms; (iii) Biochemical methods; (iv) Microplankton physiology. She is Vice-chair of the Scientific Steering Committee of GEOHAB.
2. Berdalet will provide world level expertise on ocean pelagic ecology and biogeochemistry, as well as project leadership and co-ordination.

CHEN, J.

1. Chen's research team shall contribute to Multiscale modelling and characterisation of biofilms, nanobiomechanics of bacteria (DTA award).
2. Chen's group shall also provide infrastructure for research on and characterisation of microfluidic devices.

HERMINGHAUS, S.

1. Herminghaus heads the department 'Dynamics of Complex Fluids' at the Max-Planck-Institut for Dynamics and Self-Organization, Göttingen, that investigates collective behavior and pattern formation in soft matter systems, important for understanding the dynamics of self-propelled entities, such as some plankton.
2. Herminghaus shall provide CD in microfluidics, rheology and structure formation in complex matter, shall provide infrastructure for the study of the interaction of active swimmers with surrounding flow fields.

JENKINSON, I.R.

1. Jenkinson pioneered and give CD in: (i) measurement of viscosity and elasticity in algal cultures and in seawater; (ii) measurement of reduced viscosity in algal cultures in capillary flow, e.g. Lotus leaf effect); (iii) incorporate of such findings into models of ocean fluidics.
2. Jenkinson will provide CD in seawater rheology, and an interface between (i) ocean scientists and (ii) rheologists and fluidicists, and will direct CD in both directions.

LETERME, Sophie

1. Leterme's group of two research associates and a PhD shall provide infrastructure and expertise on transparent exopolymeric polymer (TEP) production by microbes in desalination systems.

2. Biofouling potential of microbes in desalination systems, and expertise in plankton ecology in relation to surface nano/microstructure.

LI, Zhuo

1. ZL's research group consists of ten members focusing on rheology in polymer solutions and activated sludge
2. The group shall provide micro/nano- fluidics infrastructure and CD for fluid dynamics investigation and nano-biosensors for monitoring chemical components, as well as running computational fluid dynamics (CFD) software.

MITCHELL, J.G.

1. Mitchell's research 27-member group focuses on the influences of nanometer to micrometer scale processes on marine ecosystems.
2. Mitchell will provide expertise and CB on nanometre to micrometre surface structure in relation to NMF in plankton and other pelagic particles.

SEURONT, L.

1. Seuront is internationally recognized for his expertise in micro-scale patterns and processes in the ocean.
2. Seuront's shall provide CD on: (i) biologically-driven viscosity and its temporal dynamics and (ii) inferring the potential impact of this excess viscosity on structure and function in pelagic ecosystems, as well as bioproduction of excess viscosity, and its effects on structure and function in pelagic ecosystems.

ZHANG, D.

1. Zhang is head of the Key State Lab of Marine Corrosion and Biofouling. Her laboratory shall provide electrochemical tools to work on marine antifouling based on superhydrophobicity and slippery liquid-infused porous surfaces (SLIPS), related to marine biofouling and corrosion control.
2. Zhang's team shall provide CD, particularly in relation to surface-based and electrochemically-based control by organisms of surface fouling, and defeat of antifouling activity.

9. Relationship to other international programs and SCOR Working groups

9.1 GEOHAB – Global Ecology and Oceanography of Harmful Algal Blooms

There are close links between some *RheFFO* members and GEOHAB. Berdalet is Vice-Chair of GEOHAB. Wyatt and Jenkinson have participated in GEOHAB meetings and scientific activities for many years. GEOHAB (2013) has recommended that measurements of viscosity and rheology be carried out in relation to harmful algal blooms. It is foreseen that strong relations between *RheFFO* WG and GEOHAB (or its successor organization) will continue.

9.2 SCOR WG 141 – Surface Microlayer (SML) Working Group

There are strong cross-cutting subjects between *RheFFO* and SCOR WG 141. These particularly concern the accumulation of dissolved, colloidal and particulate organic matter in the SML, and its modulation of processes including air-sea gas exchange (Calleja et al, 2009), ripple damping (Carlson, 1987), upward flux of salt, water vapour (evaporation and spray) and plankton spores during storms, and downward entrainment of gas as bubbles. In October 2014, Jenkinson accepted a very kind offer by YANG Gui-Peng, to participate in a SCOR WG 141 Workshop at Qingdao, PR. China. This experience will provide input to *RheFFO* in organising SCOR workshops, while the subject matter is also relevant to RheFFO.

9.3 Other organisations

- Other organisations with which *RheFFO* will make contact are
- SOLAS, WOCE,
- Turbulence programmes, GOTM, GETM, FABM
- IMBER
- Programmes in Rheology, Nano/microfluidics, Corrosion, Biofouling and antifouling.

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2.2.7 Translation of Optical Measurements into particle Content, Aggregation & Transfer (TOMCAT) *Smythe-Wright*

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

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

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

Scientific Background and Rationale
The oceans play a critical role in controlling the climate by storing large quantities of carbon dioxide (CO_2) in the interior. The interaction between atmosphere and deep ocean storage is driven in large parts by the biological processes associated with production, sinking and remineralization of organic matter in the ocean. These processes, collectively known as the biological carbon pump, keep atmospheric CO_2 concentrations ~200 ppm lower than if the oceans were abiotic (Parekh et al. 2006). The size of ocean carbon storage is determined by the amount of organic matter exported and the rate at which sinking organic matter is reworked and respired in the mesopelagic zone (region between 100-1000 m depth) (Kwon et al. 2009). Accurate estimates of these two processes (export and remineralization of sinking organic matter) are therefore key to understanding the ocean carbon cycle and how it regulates atmospheric CO_2 concentrations.

One of the big challenges in estimating export and remineralization is the accurate measurement and characterization of sinking particle fluxes. Traditionally, export flux is collected using sediment traps, which collect particles at a certain depth over a period of several days to months. Owing to the limited spatial and temporal coverage of sediment traps, characterization of export flux is restricted. Short-comings include the inability to resolve variations in export flux over

short time periods and across space. Moreover, particles are pooled in the sediment traps, making it hard to characterize the origin and composition of the individual particles. Rather, sediment traps give bulk estimates only and no information on the individual particles making up the bulk flux. Especially particle size is an important parameter determining how and how fast it sinks, how much material an object contains, and who can find and eat it. Knowing the sizes and abundance of the settling particles is the starting point for understanding how they interact with the marine environment.

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

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

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

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

The challenge now is to systematically improve the use of optical devices for understanding particle dynamics and export. This includes the comparison and inter-calibration of the outputs of available optical particle devices, as well as collation and distribution of knowledge on how

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

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

Terms of Reference

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

(1) compare current devices that optically measure particles and document the advantages and disadvantages of each device.
(2) inter-calibrate the outputs of different devices and/or highlight calibration difficulties.
(3) define key parameters to use for interpretation of the optical information and decide which measurements are most important for characterizing particle export.
(4) improve techniques/algorithms for the conversion of optical observation into fluxes.
(5) decide on how to best analyse the increasingly larger data sets.
(6) develop software examples and codes, placed on a public repository.
(7) deposit optical particle data in an internationally-recognised database that can be actively added to as new data is collected (to allow for large scale analysis and future data exchange)
(8) advise on future methods to maximize data collection and interpretation.

Working plan (logical sequence of steps to fulfil terms of reference, with timeline.

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

The first step would be the technology analysis, which will focus on optical instruments that have been deployed in various regions of the world's oceans and have collected an extensive database

on particles. The working group will compare the outputs of these instruments. The main questions will address

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

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

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

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

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

Deliverables

(1) Review paper prioritizing research to fill identified knowledge gaps
(2) Publication on inter-calibration of currently used optical devices
(3) Sensitivity analysis of how good optical measurements translate into real fluxes

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

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

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

Capacity Building

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

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

The database will be supported by the British Oceanographic Data Centre (BODC). BODC is a UK national facility for looking after and distributing data concerning the marine environment.

BODC has 26 years' experience in making high-quality data readily available to UK research scientists in academia, government and industry. They play an active role in the international exchange and management of oceanographic data, sitting on panels such as the International Oceanographic Data and Information Exchange (IODE). BODC will contribute to the working group by

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

Working Group composition

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

Name	Gender	Place of work	Expertise relevant to proposal
1 Sari Giering (chair)	F	United Kingdom	Biological carbon pump, particle export measurements using sediment traps and Marine Snow Catcher, measuring optical properties of particle characteristics
2 Klas Ove Möller	M	Germany	Video Plankton Recorder (VPR), expertise in automatic particle recognition and characterization from photos, large volume data acquisition
3 Sünnje Basedow	F	Norway	Laser Optical Plankton Counter (LOPC), expertise in particle recognition from transparency and size, size spectra, large data acquisition
4 Lionel Guidi	M	France	Underwater Video Profiler (UVP), expertise in automatic particle recognition and characterization from images, large volume data acquisition and analysis
5 Morten Iversen	M	Germany	In situ and ex situ photogrammetry of particles, connecting optical properties of particle characteristics
6 Andrew McDonnell	M	USA	Marine particle dynamics, in situ imaging of particles and zooplankton

7 Adrian Burd	M	USA	Theoretical modelling of particle dynamics
8 Catarina R Marcolin	F	Brazil	Automatic particle recognition LOPC and Zooscan, size spectra, large data acquisition and analysis
9 Sandy Thomalla	F	South Africa	Linking Southern Ocean optical property measurements and biogeochemistry to characterize plankton community and particle export
10 Tom Trull	M	Australia	Southern Ocean particle flux measurements, In situ measurement of particle sinking rates, use of gel traps to collect and characterize sinking particles, deployment and interpretation of optical sensor equipped moorings and Bio-Argo profiling floats.

Associate Member (no more than 10)

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

Working Group contributions

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

Sari Giering (Researcher at the National Oceanography Centre, Southampton, UK):
Sari is a marine biogeochemist with research focus in carbon export, zooplankton ecology and particle dynamics. She has extensive expertise in using a combination of field measurements, models and data synthesis to better constrain the ocean carbon cycle.

Morten Iversen (Head of Helmholtz Young Investigator Group SeaPump at the Alfred Wegner Institute, Germany):
Morten's research focuses on understanding how food web composition influences particle export dynamics, specifically how particle size and composition determine sinking speed and particle remineralization. His group is developing several new camera systems and new in situ methods to collect intact marine particles.

Andrew McDonnell (Associate Professor at the University of Alaska Fairbanks, USA):
Andrew's research focuses on assessing the biogeochemical role of various particle processes such as particle formation, sinking, lateral transport and remineralization. He uses a wide range of laboratory and field methods including sediment traps, in situ photography and particle incubations.

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

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

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

Lionel Guidi (Researcher at Laboratoire d'Océanographie de Villefranche sur Mer, France):
Lionel's expertise is optical sampling measurements (especially the Underwater Vision Profiler, UVP), automatic particle recognition, large data compilation and analysis, and conversion of imaging data into flux estimates. Recent efforts included a global synthesis of particle size distribution and related estimate flux profiles as calculated from the UVP.

Catarina Marcolin (Researcher at University of São Paulo, Brazil):
Catarina uses optical systems such as the LOPC and ZooScan to automatically detect and measure plankton and particles in situ and ex situ. Her expertise includes coding for large data set analysis.

Sandy Thomalla (Senior Scientist at Southern Ocean Carbon and Climate Observatory, South Africa):
Sandy's research focuses on linking optical property measurements (scattering, absorption, attenuation) with the biogeochemistry (species composition, carbon content, size structure, photophysiology) in order to optically characterize the plankton community and predict carbon export potential. She further uses bio-optics floats with upward facing transmissometers to estimates particle flux.

Tom Trull (Professor of Marine Biogeochemistry at the Antarctic Climate and Ecosystems Cooperative Research Centre University of Tasmania, and Senior Principal Research Scientist CSIRO Oceans and Atmosphere Flagship Hobart, Australia)
Tom is an expert in Southern Ocean particle flux measurements, including in situ measurement of particle sinking rates, use of gel traps to collect and characterize sinking particles, deployment and interpretation of optical sensor equipped moorings and Bio-Argo profiling floats. He further aims to expand the global use of biogeochemical and bio-optical sensors on Argo floats to measure ocean ecosystem productivity and export.

Relationship to other international programs and SCOR Working groups

To our knowledge the only SCOR working group that focused on particle export was WG116 'Sediment Trap and ^{234}Th Methods for Carbon Export Flux Determination' (approved 1999). As outlined above, the development of optical sensors would complement sediment-trap-based export estimates and help to understand the biological carbon pump. This working group would further complement WG134 'The Microbial Carbon Pump in the Ocean' (approved 2008) in the effort of understanding the ocean carbon cycle.

Key References

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Appendix

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

Basedow:

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

Summary

We propose to establish a new working group that will initiate and develop a new global model for assessing nutrient and constituent export through submarine groundwater discharge (SGD) to nearshore coastal areas and offshore SGD fluxes from artesian aquifers - **the NExT SGD model**. The proposed multi-national NExT SGD working group would consist of scientists whose research crosses disciplinary boundaries (hydrogeologists, geochemists, oceanographers, and global water cycle modelers). This collaboration will provide the mechanistic understanding of controls on groundwater-derived water and constituent fluxes to the ocean necessary for global extrapolations and predictions with this novel NExT SGD model. The currently available data on SGD and nutrient fluxes is extensive and has increased exponentially during the last years (e.g., more SGD data is available now than what previously existed for initiating the NEWS global river flux model 10 years ago) and it is representative of a broad array of aquifer, coastal zone and climate regimes. To ensure the success of this working group we will interact with other working groups and programs (e.g., GEOTRACES, GlobalNEWS and LOICZ) as well as with members of former SCOR working groups (e.g., SCOR 112 "*Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes***"**) and learn from their experiences in compiling large databases, identifying and filling potential data gaps and developing and distributing protocols for best practices.

Rationale

The overarching goal of this proposed SCOR working group is to develop a global model for assessing water and constituent (nutrients, gases, carbon, metals) fluxes to the ocean via groundwater (NExT SGD). Current data availability (**Fig 1**) and conceptual understanding of the processes controlling groundwater discharge to near-shore coastal regions and the associated nutrient and other constituent fluxes is sufficient for formulating a numerical global model for assessing land–ocean material transport fluxes, similar to the river flux global model (GlobalNEWS) constructed about a decade ago (*Seitzinger and Harrison*, 2005). Indeed, the first global models of river constituent fluxes were developed based on a far smaller database than available for SGD today (e.g., *Gibbs and Kump, 1994).*

Figure 1 Snap-shot of the newly created web site by the working group for compiling the available data (>100 locations worldwide presented as red dots). More data are available but not plotted on the map yet. (*from* http://sgd.snu.ac.kr/home/gis_main.jsp).

The global NExT SGD model, will not only enable prediction of SGD and constituent fluxes for any location worldwide for present, past and future climate conditions, but provide the tools to *test potential feedbacks* in the ocean-land-atmosphere earth system. Such a global model will transform our predictive abilities of this important, yet poorly constrained part of the hydrological cycle. Indeed, one of the pioneers in the SGD field advised, "*The **oceanographic and hydrogeologic** communities should recognize the **local and global** importance of SGD and **work together** to achieve a better understanding of the processes that control SGD and its constituents*" (*Moore,* 2010).

Because the model will be capable of capturing nutrient and flow changes triggered by short and long- term anthropogenic activities and climate, it will allow the examination of various scenarios and their *ecological effects on ecosystems and economic effects on societies*. For example, excess nutrient loading due to SGD can initiate and sustain harmful algal blooms (HABs) in coastal areas (*Lee et al*., 2010, *Lecher et al.*, 2015). The predictive power of a large-scale model will allow the identification of locations susceptible to HABs triggered by SGD. Thus, the NExT SGD model will not only significantly improve our understanding of the magnitude of groundwater-derived nutrients and other constituent budgets for the global ocean, but will be extremely useful as a tool to highlight the need for water management assessments in some areas where no data are available.

The global NExT SGD model will enable us to *improve Earth System Models (EMS)*, which at this stage neglect groundwater as a transport pathway from land to sea. For example, alkalinity supplied by groundwater may change the modeled pH response to increased atmospheric CO2 concentrations (*Cyronak* et al. 2013). Given the potential importance of SGD for material fluxes into the ocean, its inclusion in the EMS will be important for allowing accurate predictions of the effect of global change, including changes in sea-level on the oceans, and a global SGD model is a necessity to enable that inclusion. EMS, like the ORCHIDEE model (http://orchidee.ipsl.jussieu.fr/) could easily be extended to include subsurface material fluxes by forcing existing parameters with outputs from the NExT SGD model.

The NExT SGD model will include coastal aquifer systematics and related controls on SGD (**Fig. 2*b***) and will *aid in determining fluxes from the little explored offshore*

freshwater seepages on the continental shelf (**Fig. 2a**) which could have future value as a fresh water source in densely populated coastal regions (*Post et al.*, 2013).

Scientific Background

What is SGD and where does it occur? Submarine groundwater discharge (SGD) "*includes any and all flow of water on continental margins from the seabed to the coastal ocean, regardless of fluid composition or driving force"* (*Burnett et al.* 2003, *Moore,* 2010) (**Fig. 2*a*,*b***).

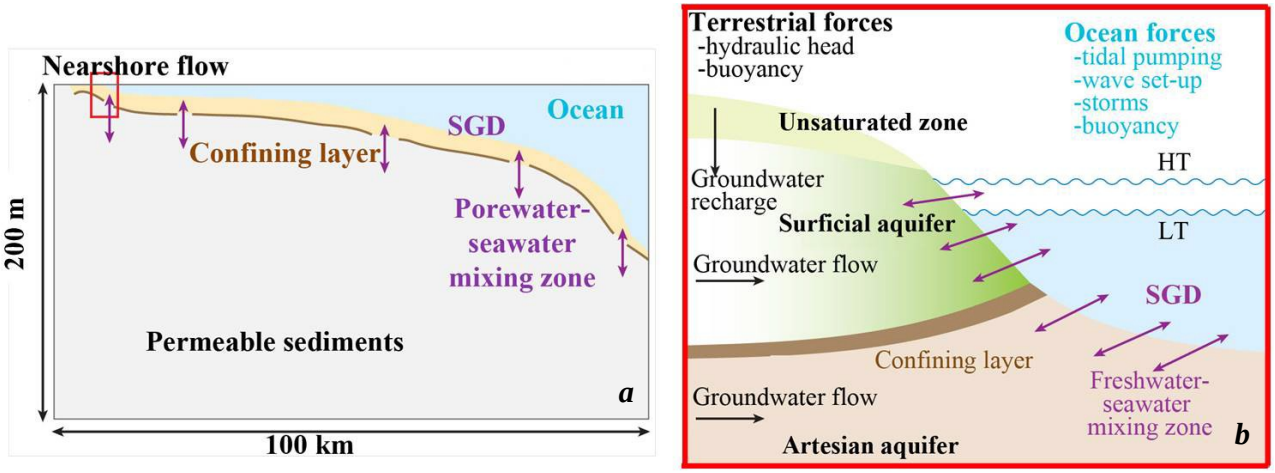

Figure 2 (***a***) SGD extends from the red box labeled "*Nearshore flow*" throughout the continental shelf. The offshore flow on the continual shelf is driven by interactions of ocean forces with geothermal heating and over-pressurized zones beneath discontinuous confining layers. ***(b)*** Near the shoreline SGD (red box) is driven by a combination of terrestrial and ocean physical forces operating in a complex geological environment (*modified from Moore,* 2010).

The NExT SGD model *will capture nearshore fluxes* (**Fig. 2b**) that include (*i*) fresh and (*ii*) recirculated seawater where most of the SGD data were collected and where most of the terrestrial groundwater- derived constituents are discharged (**Fig. 1**). However, the NExT SGD model can be expanded to include offshore fluxes on the continental shelf once sufficient data from these areas are available. This will be possible because the offshore flows on the continental shelf are channeled through artesian aquifers that have the same hydrogeological properties as nearshore shallower aquifers and will be already embedded in the global model. Moreover, knowing the near-shore fluxes will enable general estimates of the offshore component to be calculated based on ocean-scale radium (Ra) mass-balance models (*Moore,* 2010, *Kwon et al*., 2014).

Despite the rich body of literature characterizing the transport of material fluxes via SGD to the nearshore environments (**Fig. 1**), to date attempts to upscale and evaluate water fluxes on regional or global scales are limited. However, in a recent study of global upscaling, *Kwon et al*. (2014) estimated SGD to amount to 3-4 times the river flux. Nevertheless, the radium

mass-balance approach used in this and other studies is not based on a mechanistic understanding of driving forces; hence its predictive and exploratory abilities are limited. The *lack of a process-oriented model* is a very substantial knowledge gap, especially considering the links between ***SGD, the global carbon cycle, and climate change***. For example, in a key study, *Cole et al*. (2007) showed that SGD could contribute a similar amount of DIC to the coastal ocean as rivers. *Beusen et al*. (2013) established a global model on SGD-derived nitrogen fluxes, but neglected the marine recirculated SGD component, which often has a much larger volume than freshwater SGD (e.g., *Burnett et al.*, 2003; *Waska and Kim,* 2011). The proposed multifaceted modeling approach will allow connecting ***hydrogeological and marine factors*** (e.g., net precipitation, surface runoff, recharge, groundwater pumping rates, hydraulic heads, aquifer size and aquifer characteristics, topography, lithology, beach morphology, the presence and level of development of stream systems, waves, and tides) affecting SGD to ***nutrient and other constituents loading controls*** (e.g., land use, sewage and agriculture influxes, population growth, groundwater redox state and residence time) in coastal areas on a global scale. For most of the above-listed controls, spatial data are available at very high resolution. For example, a similar approach was used by *Seitzinger and Harrison* (2005) to estimate export from ~6,000 watersheds globally. Results from these modeling efforts demonstrated the power of numerical models, which can be used not only *to create geospatial databases* of the magnitude of water fluxes but also *to reveal relationships* between controlling factors and drivers, which in turn, transform our understanding about the coupled nature of these export fluxes at larger scales. Physical measurements from field-based studies are crucial for calibrating models and performing sensitivity analyses. Sufficient data are now available through the abundant SGD tracer- based coastal oceanographic studies of the last 20 years (**Fig. 1**) and the some assimilation of many local studies in large databases is done (e.g., *Moosdorf et al.*, 2015). The model will help identify data gaps if any exist.

The available spatial SGD data is *highly heterogeneous*; it was produced by many different research groups and government agencies employing different measurement techniques and reporting standards. Hence, the planned NExT SGD model will require a sophisticated data compilation process. The international scientific network of the proposed SCOR working group will set guidelines for compilation of available data in a unified manner and suggest best practices for future data collection.

In addition, the parameters needed for the NExt SGD model development will be identified and assessed and model feasibility tested in a cutting-edge *proof-of-concept* study.

Terms of Reference

Disciplinary boundaries in the scientific community working at the land-ocean interface (i.e., oceanography community, hydrogeologists, and experts in global water flux modeling) have hindered the advancement of the mechanistic understanding of the significance of groundwater-derived water and constituent fluxes to the ocean on a global scale. The NExT SGD WG recognizes SCOR as the perfect platform to encourage and stimulate the unique and timely needed collaboration between these disciplines, an issue that was previously also recognized by the SCOR 112 WG.

The group's work will focus on the following terms of reference:

1. Set up a database of available SGD data and initiate the global NExT SGD model (*deliverable 1*, **Table 1**).
2. Collaborate with other working groups and projects (GEOTRACES, Global NEWS, LOICZ, members of former SCOR working groups) to inform the NExT SGD model and connect it to ESM (e.g. ORCHIDEE) (*deliverable 2*, **Table 1**).
3. Produce a "*best practices*" handbook recommending sampling strategies, parameter measurements, and guidelines for sample processing, and handling and sharing of acquired data (*deliverable 3*, **Table 1**).

We foresee the initiation and development of this unique collaboration proceeding in several stages (**Table 1**) which will be centered on in-person meetings, held in conjunction with international conferences or hosted by the National Water Center (NWC) of the University of Alabama. We will organize a virtual seminar series (Webinar) to be delivered quarterly, by different members of the SCOR WG with focus on the progress of the NExT SGD modeling.

Working Plan and Deliverables

Constructing a global model to assess constituent fluxes via SGD is a pressing task. Our in-person meetings (as shown in **Table 1**) will be structured to address specific stages of model development necessary to establish the foundation for successful model outcomes. The groundwork for the NExT SGD model will be achieved through the following specific goals:

Deliverable 1: Set up a database and initiate global NExT SGD model

The NExT SGD SCOR working group will develop specific technical guidelines in the form of *metadata forms* that will be embedded in an existing Global SGD webpage (see URL) and will be filled out for each site. Aquifer-specific regions will be assigned to research groups based on their involvement in data collection. Previously, a SCOR WG (112), which had mainly focused on the detection and quantification of SGD, had come to the conclusion that six major types of aquifers determine SGD dynamics. These types of aquifers will now be used for our NExT SGD model.

Scientific sub-groups will be assigned to aquifer types and collaborate to ensure that all available data are compiled and correctly inserted. After filling out the available information, each form will be saved in the SGD database. This will ensure (*i*) *quality control* of the data to be used for the model; and (*ii*) the creation of a *uniform record* that will be independent of the field data collection and techniques. For areas without published data on a specific type of aquifer, high-resolution lithological data from *Hartmann and Moosdorf* (2012) will be used in combination with hydrogeological interpretation (e.g. Gleeson et al., 2014). To adjust the model in terms of constituent fluxes, conceptual understanding of weathering influences on water chemistry will be used until data become available (**Fig.3**). The result will be used as input data into the Next SGD model, which will be developed as process-oriented empirical model by the workgroup members.

Deliverable 2: Set up a global network of scientists and "ecosystem task force" through collaboration with other working groups to advance the NExT SGD model (NEWS Model and GEOTRACES)

The working group will discuss with developers of earth system models to implement SGD water and constituent fluxes into their terms. This should be done based on the controls and structure of the NExT SGD model. The group thus ensures information transfer both from the ESM community into the NExT SGD model development and in the other direction. In particular, potential ecosystem feedbacks of SGD will be focused. Relevant factors for inclusion in the NExT SGD model will be identified by adding field knowledge of the submarine groundwater discharge community to factor setups of existing models (e.g., Global NEWS by *Seitzinger and Harrison*, 2005). The unique combination of terrestrial and marine factors and their interplay is a special challenge to this working group. This will be reflected in the model input data (e.g. land cover and population density, as well as tidal range and wave intensity). This part of the work ensures the compatibility of the NExT SGD model with other global scale nutrient flux models and Earth System models, and the necessary simplification. While at the same time the group will safeguard a realistic representation of the complex processes associated with the subterranean estuary.

Deliverable 3 Establish a handbook of best practices for sampling strategies, sample processing, and data handling and reporting for SGD data collection to be used in the NExT SGD model

Constructing a model that has the ability to be improved and updated by including future data is important. The NExT SGD model *will capture nearshore fluxes* that include fresh and recirculating seawater where most of the SGD data was collected in the last two decades (**Fig. 1b**). We will seize the opportunity of this international network of hydrogeologists and biogeochemists to compare, assess, and optimize *in situ* investigations of SGD magnitudes and associated constituent fluxes from local to regional scales. Furthermore, our working group will collaborate with the GEOTRACES community to plan for the collection of offshore SGD data and make sure it is compatible with the model requirements (http://www.geotraces.org/science/science-highlight/1019-submarine-groundwater-discharge-as-a-major-source-of-nutrients-in-the-mediterranean-sea). This will enable an expansion of the model to include offshore fluxes from the continental shelf. Based on these recommendations and model needs a best practices handbook will be composed and disseminated broadly.

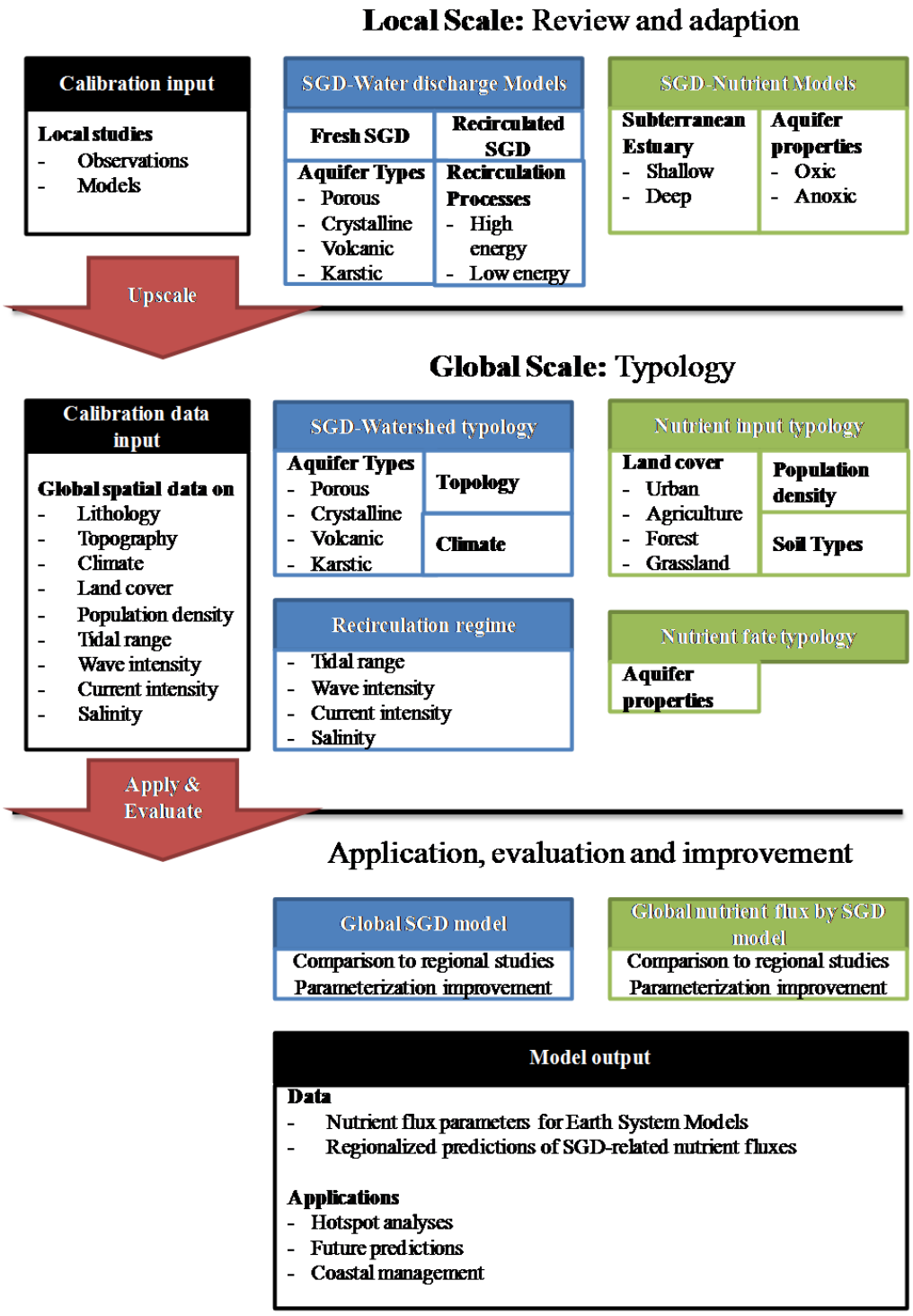

Figure 3 Flowchart presenting the logical step-wise procedure in developing the NExT SGD model

Table 1 Detailed timetable of the scientific activities, and expected deliverables of the working group

	Group activities and deliverables	Deadlines/meeting reports
Initial coordination and data management	1. Classifying sites into the 6 major domains based on aquifer type. 2. Developing specific technical guidelines for building a uniform metadata base of hydrogeological and nutrient parameters and topology. 3. Making initial decisions on governing parameters and boundary conditions for groundwater flow model 4. Extending participation on regional level to facilitate compilation process and disseminate future results.	SPRING: 2016 Ocean Sciences Meeting (proposed special session), 21-26 February, New Orleans, USA followed by first meeting at NWC Tuscaloosa, UA campus. FALL 2016: 26th Goldschmidt Conference, Yokohama, Japan
Global Model Development	1. Performing real-time simulations of flow models in different domains at the NWC University of Alabama; discussing model parameters and sensitivity. 2. Making decisions on constituents adjustments and data gaps: a) Land coverage and use b) Identifying sources and sinks of nutrients: natural (non-point-) versus anthropogenic (point-) sources c) Climate and climate change effects via sea level change and glacial melting.	SPRING 2017: European Geosciences Union (EGU) 17-22 April, Vienna, Austria FALL 2017: Second meeting at NWC Tuscaloosa, UA campus; USA
Model Calibration	1. Performing real-time simulations of constituents flux models in different domains at the NWC University of Alabama; discussing model parameters and sensitivity. 2. Working on model parameterization and refinement 3. Obtaining first assessments of significance of nutrient fluxes (fresh and recirculated) versus river fluxes. 4. Working on dissemination of results in publications (G3) and meetings. 5. Writing and dissemination of the best practices handbook.	SPRING 2018: Third meeting at NWC Tuscaloosa, UA campus, USA FALL 2018: Final meeting December 2018 AGU Special session, San Francisco, USA

Capacity Building

Within the proposed group, we bring together global modeling experts from the riverine and groundwater *modeling communities* (e.g., Cohen, Harrison, Michael, Slomp) with specialists in *large database* creation and management and holders of large SGD datasets (e.g., Kim, Moosdorf, Michael) as well as field scientists for SGD from the *terrestrial* (Cable, Dimova, Santos) *and marine* (Burnett, Dimova, Paytan, Waska) realm. In addition to the broad scientific backgrounds, the proposed working group was assembled on the principle of geographical, economical (developed and countries in transition), gender and career stage diversity. The NExT SGD WG includes members from 15 countries spanning four continents with 30% female representation, and 30% members from developing and transition countries (**Tables 2 and 3**). Opportunity for broader involvement of the scientific community will be made possible through open thematic sessions in large meetings and via open Webinars.

The uniqueness of this working group is its initiation largely by early-career young scientists, which has helped crossing traditional boundaries between the research fields of coastal oceanography, hydrology, and global numerical modeling. We will expand on traditional

approaches for outreach and funding by actively including social media via Facebook, Twitter, NExT SGD webpage Blogs, virtual seminars (Webinars) and crowdsourcing as part of our portfolio. Establishing the SCOR NExT SGD working group will foster further interdisciplinary collaboration and may catalyze new studies in areas where data gaps are identified during the compilation process. Developing this network will facilitate information exchange between scientists from developed countries and countries in transition. In most developing countries, nutrient enrichment of coastal waters due to SGD is unknown phenomenon. Interactions among group members will aim to create opportunities for student exchange and contribute to the enhancement of graduate programs in these counties which in turn, will promote wider public understanding of the effects of groundwater discharge to the ocean.

Working group meetings (as shown in **Table 1**) will be organized at least twice a year. We plan to meet each year at the NWC on University of Alabama campus, for which most of the funding from SCOR (US$15,000) will be utilized (e.g., to support travel and meeting expenses). The use of the building, audio-visual and computer facilities will be provided at no cost for this project. To allow for broader participation and more frequent interactions we plan to also meet during large international meetings (through town halls and special sessions) in which most WG members participate. The location of these meetings will rotate between the USA, Europe and Asia to distribute the cost of participation among group members.

We will seek funding from additional sources such as UNESCO, IAEA, LOIZ, as well as national and bi-national organizations (NSF, NERC, etc.). We will also establish a donation link on our web page to create an opportunity for private organizations to support our group. Funding through these alternative sources will be independent of that provided by SCOR.

Table 2 Full Members of the SCOR Working Group on Global Groundwater Fluxes to the Ocean

	Member	**Gender**	**Place of work**	**Expertise relevant to proposal**
1	Natasha Dimova (co-chair)	female	University of Alabama, USA	Radionuclides, coastal and freshwater hydrology
2	Nils Moosdorf (co-chair)	male	Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, Germany	Global empirical modeling
3	Guebuem Kim	male	Seoul National University, Korea	Radionuclides and nutrient cycling
4	Isaac Santos	male	Southern Cross University, Australia	Carbon cycling
5	Holly Michael	female	University of Delaware, USA	Numerical & field modeling of coastal groundwater dynamics
6	Caroline Slomp	female	Utrecht University, The Netherlands	Geochemical modeling

7	Makoto Taniguchi	male	Research Institute for Humanity and Nature, Japan	Regional and global groundwater hydrology
8	Bo Chao Xu	male	Ocean University of China	Coastal hydrology, geochemistry
9	Gopal Krishan	male	National Inst. of Hydrology, Uttarakhand, India	Hydrology
10.	Robert Delinom	male	Indonesian Institute of Sciences, Indonesia	Hydrogeology of tropical islands

Table 3 Associate Members* of the SCOR Working Group on Global Groundwater Fluxes to the Ocean

	Member	Gender	Place of work	Expertise relevant to **proposal**
1	Hannelore Waska#	female	University of Oldenburg, Germany	Groundwater hydrology and geochemistry
2.	Adina Paytan#	female	UC Santa Cruz, USA	Biogeochemistry and nutrient cycling
3.	Jaye Cable	female	University of North Carolina, USA	Groundwater hydrogeology
4	Sagy Cohen	male	University of Alabama, USA	GIS, global numerical modeling, geomorphology
5	Kazi Matin Uddin Ahmed	male	University of Dhaka, Bangladesh	Groundwater contamination
6	Howard Waldron	male	University of Cape Town South Africa	Coastal zone water quality
7	Thomas Stieglitz	male	Institut Universitaire Européen de la Mer, France	Geophysics and SGD
8	Yishai Weinstein	male	Bar-Ilan University, Israel	Hydrogelogy
9	Felipe Luis Niencheski	male	Fundação Universidade Federal do Rio Grande, Brazil	Environmental Chemistry
10	John Harrison	male	Washington State University, Vancouver, USA	River-derived nutrient fluxes

**We realize that there are 4 associate members from the USA in the team, however we emphasize that the members represent distinct strengths and areas of expertise needed for a successful WG, (Cable – Hydrology and SGD; Paytan – Biogeochemistry; Cohen – Modeling; Harrison – River fluxes and GlobalNEWS. These are key areas instrumental for the WG and involvement of world experts is needed regardless of nationality.*

[#]*We would like to acknowledge specially HW and AP whose insightful comments were critical in preparation of this proposal.*

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Appendix

Natasha Dimova (co-chair): Dr. Dimova is a coastal oceanographer and hydrogeologist with expertise in the radon-based tracer techniques in marine and freshwater systems. Dimova initiated the SCOR NExT SGD working group proposal and has been ***working on compilation of SGD data*** with Sagy Cohen (associate member) for establishing a global SGD model. She is an early-career female scientist who has been collaborating with scientists worldwide, including Asia, USA and Europe.

1) Paytan, A., Lecher, A., L., Dimova, N., Sparrow, K. J., Kodovska, F. G-T., Murry, J., Tulaczyk, S., and Kessler, J. D., 2015. Methane transport from the active layer to lakes in the Arctic using Toolik Lake, Alaska as a case study, *Proceedings of National Academy of Sciences*, doi/10.1073/pnas.1417392112.
2) Dimova, N.T., W.C. Burnett, J.P. Chanton, and J.E. Corbett, 2013. Application of radon-222 to investigate groundwater discharge into small shallow lakes, *Journal of Hydrology*, 486: 112–122.
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4) Dimova, N.T., W.C. Burnett, K. Speer, 2011. A natural tracer investigation of the

hydrological regime of Spring Creek Springs, the largest submarine spring system in Florida, *Continental Shelf Research*, 31: 731-738.
5) Dimova, N.T. and W.C. Burnett, 2011. Evaluation of groundwater discharge into small lakes based on the temporal distribution of radon-222, *Limnology and Oceanography*, 56 (2): 486– 494.

Nils Moosdorf (co-chair): Dr. Moosdorf is a hydrogeologist, specialized in estimating large scale geochemical material fluxes via statistical methods based on large datasets. His experience lays in ***large scale river constituent flux modeling.*** Since August 2014 Dr. Moosdorf leads a junior research group on ecological impacts of SGD at different scales. He also specialized on global scale datasets based on lithological information. He is involved in several cooperative projects with scientists primarily in the USA, but also in Europe and Asia.

1) Moosdorf, N., Stieglitz, T., Waska, H., Dürr, H.H. & Hartmann, J., 2015. Submarine groundwater discharge from tropical islands: a review, *Grundwasser*, 20(1): 53-67.
2) Gleeson, T., Moosdorf, N., Hartmann, G. & Van Beek, L.P.H., 2014. A glimpse beneath earth's surface: GLobal HYdrogeology MaPS (GLHYMPS) of permeability and porosity, *Geophysical Research Letters*, 41(11): 3891-3898.
3) Hartmann, J. & Moosdorf, N., 2012. The new global lithological map database GLiM: A representation of rock properties at the Earth surface, *Geochemistry Geophysics Geosystems*, 13: Q12004.
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Guebuem Kim: Dr. Kim's expertise is in radionuclides (Rn and Ra), organic matter, REE and ***nutrient cycling in subterranean estuaries on a regional and global scale***. Dr. Kim established a webpage for SGD data compilation for initiating the NExT SGD working group.

1) Yan, G., and G Kim, 2015. Sources and fluxes of organic nitrogen in precipitation over the southern East Sea/Sea of Japan, *Atmospheric Chemistry and Physics*, 15(5): 2761-2774.
2) Kwon, E. Y., G. Kim, F. Primeau, W. S. Moore, H-M. Cho, T. DeVries, J. L. Sarmiento, M.
A. Charette, Y-K. Cho, 2014. Global Estimate of Submarine Groundwater Discharge Based on an Observationally Constrained Radium Isotope Model, *Geophysical Research Letters*, 41(23): 8438–8444.
3) Kim, I, and G. Kim, 2014. Submarine groundwater discharge as a main source of

rare earth elements in coastal waters, *Marine Chemistry*, 160 (20): 11-17.
4) Kim, T-H., and G. Kim, 2013. Changes in seawater N:P ratios in the northwestern Pacific Ocean in response to increasing atmospheric N deposition: Results from the East (Japan) Sea, *Limnology and Oceanography*; 58(6): 1907-1914.
5) Kim, T-H., H. Waska, E. Kwon, I. Gusti Ngurah Suryaputra, G. Kim, 2012. Production, degradation, and flux of dissolved organic matter in the subterranean estuary of a large tidal flat, *Marine Chemistry* 142-144: 1-10.

Isaac Santos: Dr. Santos was invited to be part of the NExT SGD working group because of the wide spectrum of research topics he has been involved with and his knowledge of the ***carbon and nutrient cycling in subterranean estuaries,*** specifically in carbonate sandy aquifers and coral reef environments.

1) Santos, IR, S Ruiz-Halpern, DT Maher, 2013. Carbon dioxide dynamics driven by groundwater discharge in a coastal floodplain creek ML Atkins, *Journal of Hydrology* 493: 30-42
2) Santos, IR., B.D Eyre, and M. Huettel, 2012. The driving forces of porewater and groundwater flow in permeable coastal sediments: A review, *Estuarine, Coastal and Shelf Science* 98: 1-15
3) Santos, IR, R.N. Glud, D. Maher, D. Erler, B.D Eyre, 2011. Diel coral reef acidification driven by porewater advection in permeable carbonate sands, Heron Island, Great Barrier Reef, *Geophysical Research Letters* 38 (3), doi: 10.1029/2010GL046053.
4) Santos, IR, D Erler, D Tait, B.D Eyre, 2010. Breathing of a coral cay: Tracing tidally driven seawater recirculation in permeable coral reef sediments, *Journal of Geophysical Research*: *Oceans*, 115, C12, doi: 10.1029/2010JC006510
5) Santos, IR, W. C Burnett, J. P. Chanton, B. Mwashote, and IGNA Suryaputra, 2008. Nutrient biogeochemistry in a Gulf of Mexico subterranean estuary and groundwater-derived fluxes to the coastal ocean, *Limnology and Oceanography* 53 (2): 705-718

Holly Michael: Dr. Michael was invited to this working group because of her unique expertise in both ***numerical modeling and radio tracer field techniques***. Holly has established a connection between the two fields and plays an important role in breaking the boundaries between hydrogeology and coastal oceanography.

1) Sawyer, AH, O Lazareva, KD Kroeger, K Crespo, CS Chan, T Stieglitz, and HA Michael, 2014. Stratigraphic controls on fluid and solute fluxes across the sediment-water interface of an estuary, *Limnology & Oceanography,* 59(3):997–1010.
2) Michael, HA, CJ Russoniello, and LA Byron, 2013. Global assessment of vulnerability to sea-level rise in topography-limited and recharge-limited coastal groundwater systems, *Water Resources Research*, 49 (4): 2228-2240.
3) Michael, HA, MA Charette, and CF Harvey, 2011. Patterns and variability of groundwater flow and radium activity at the coast: a case study from Waquoit Bay,

Massachusetts, *Marine Chemistry,* 127: 100-114.
4) Michael, HA, AE Mulligan, and CF Harvey, 2005. Seasonal oscillations in water exchange between aquifers and the coastal ocean, *Nature*, 436: 1145-1148.
5) Michael, HA, JS Lubetsky, and CF Harvey, 2003. Characterizing submarine groundwater discharge: a seepage meter study in Waquoit Bay, Massachusetts, *Geophysical Research Letters*, 30 (6): doi: 10.1029/2002GL016000, 6.

Caroline Slomp: We invited Dr. Slomp as a full member because of her in-depth quantitative understanding of the cycling of elements in marine environments that will be essential in the mechanistic understanding of nutrient fluxes via SGD in nearshore coastal areas. Additionally, Dr. Slomp's research is broad in scope and involves field and laboratory work that is typically ***integrated with large scale ocean and river modeling*.**

1) Beusen, A.H.W., Slomp, C.P. and Bouwman, A.F., 2013. Global land-ocean linkage: direct inputs of nitrogen to coastal waters via submarine groundwater discharge, *Environmental Research Letters*, 8 (3), doi:10.1088/1748-9326/8/3/034035.
2) Dürr, H.H., Laruelle, G.G., van Kempen, C.M., Slomp, C.P., Meybeck, M., Middelkoop, H., 2011. Worldwide Typology of Nearshore Coastal Systems: Defining the Estuarine Filter of River Inputs to the Oceans. *Estuaries and Coasts*, 34(3): 441-458.
3) Spiteri, C., Slomp, C.P., Tuncay, K. and Meile, C., 2008. Modeling biogeochemical processes in subterranean estuaries: Effect of flow dynamics and redox conditions on submarine groundwater discharge of nutrients, *Water Resources Research*, *44*, W02430, doi:10.1029/2007WR006071.
4) Slomp, C.P. and Van Cappellen, P., 2007. The global marine phosphorus cycle: sensitivity to oceanic circulation, *Biogeosciences*, 4: 155-171.
5) Slomp, C.P. and Van Cappellen, P.S.J., 2004. Nutrient inputs to the coastal ocean through submarine groundwater discharge: controls and potential impact, *Journal of Hydrology*, 295: 64-86.

Makoto Taniguchi: Dr. Taniguchi has long-term experience in working on different aspects of groundwater and its significance for the global hydrological cycle. His contribution will be specifically in ***connection between societies - water resources-climate change***. Dr. Taniguchi is also a former member of the SCOR 112 WG *Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes*

1) Taniguchi, M., 2015. The basic act on the water cycle with groundwater, *Journal of Groundwater Hydrology* 57(1):83-90.
2) Taylor, RG, B. Scanlon, P. Döll, M. Rodell, R. van Beek, Y. Wada, L. Longuevergne, M. Leblanc, J. S. Famiglietti, M. Edmunds, L. Konikow, T.R. Green, J. Chen, M. Taniguchi, M. F. P. Bierkens, A. MacDonald, Y. Fan, R. M. Maxwell,

Y. Yechieli, J. J. Gurdak, D. M. Allen, M. Shamsudduha, K. Hiscock, P. J.-F. Yeh, I. Holman & H. Treidel, 2013. Groundwater and climate change, *Nature Climate Change*. DOI:10.1038/nclimate1744.

3) Taniguchi, M., Yamamoto, K., and Aarukkalige, P. R. 2011, Groundwater resources assessment based on satellite GRACE and hydrogeology in Western Australia, *GRACE, Remote Sensing and Ground-based Methods in Multi-Scale Hydrology (Proceedings of Symposium J-H01 held during IUGG2011 in Melbourne, Australia, July 2011)* 343 :3-8.
4) Taniguchi, M, 2011. What are the Subsurface Environmental Problems? Groundwater and Subsurface Environmental Assessments Under the Pressures of Climate Variability and Human Activities in Asia, *Groundwater and Subsurface Environments: Human Impacts in Asia Coastal Cities* :3-18. DOI:10.1007/978-4-431-53904-9_1.
5) Taniguchi, M., A. Aureli, and J.L. Martin, 2009. Groundwater resources assessment under the pressures of humanities and climate change. *IAHS Publication* 334.

Bo-chao Xu: The contribution of Dr. Xu for this working group will be primarily in his understanding of ***SGD impacts on large estuaries*** and the geochemical transformations of nutrients at the sediment-water interface.

1) Meng, J., P. Yao, T. S. Bianchi, D. Li, B. Zhao, B. Xu, Z. Yu, 2015. Detrital phosphorus as a proxy of flooding events in the Changjiang River Basin, *Science of the Total Environment*, 517: 22-30.
2) J. Sui, Z. Yu, X. Jiang, B. Xu, 2015. Behavior and budget of dissolved uranium in the lower reaches of the Yellow (Huanghe) River: Impact of Water-Sediment Regulation Scheme, *Applied Geochemistry*, 61: 1-9.
3) Xu, Bo-Chao, W. C. Burnett, N. T. Dimova, H. Wang, L. Zhang, M. Gao, X. Jiang, Z. Yu, 2014. Natural ^{222}Rn and ^{220}Rn Indicate the Impact of the Water-Sediment Regulation Scheme (WSRS) on Submarine Groundwater Discharge in the Yellow River Estuary, China, *Applied Geochemistry,*http://dx.doi.org/10.1016/j.apgeochem.2014.09.018
4) Xu, Bo-Chao, W. C. Burnett, N. T. Dimova, G. Liu, T. Mi, Z. Yu, 2013. Hydrodynamics in the Yellow River Estuary via radium isotopes: ecological perspectives, *Continental Shelf Research*, doi.org/10.1016/j.csr.2013.06.018.
5) Xu, Bo-Chao, N. T. Dimova, L. Zhao, X-Y. Jiang, and Z.-G. Yu, 2013. Determination of water ages and flushing rates using short-lived radium isotopes in large estuarine system, the Yangtze River Estuary, China, *Estuarine, Coastal and Shelf Science,* 121-122: 61–68.

Gopal Krishan: Dr. Krishan's research is in the field of natural resource management, isotope hydrology, RS and GIS applications. His extensive work in ***groundwater systems in India*** and coastal areas on Bengal Bay is extremely valuable for the NExT SGD working group because of the relatively sparse data available in this part of the world.

1) Krishan, G., M. S. Rao, C.P. Kumar, S. Kumar, and M. R. A. Rao, 2015. A study on identification of submarine groundwater discharge in northern east coast of India, *Aquatic Procedia,* 4: 3 – 10.
2) Lohani AK and Krishan G, 2015. Application of Artificial Neural Network for Groundwater Level Simulation in Amritsar and Gurdaspur Districts of Punjab, India, *Earth Science and Climate Change*, 6 (4), doi: 10.4172/2157-7617.1000274.
3) Krishan, G., Rao, M.S. and Kumar C.P., 2014a. Estimation of Radon concentration in groundwater of coastal area in Baleshwar district of Odisha, India. *Indoor Built Environ*. doi:10.1177/1420326X14549979.
4) Krishan, G., Rao, M.S. and Kumar C.P., 2014b. Radon Concentration in Groundwater of East Coast of West Bengal, India. *Journal of Radioanalytical and Nuclear Chemistry*. doi: 10.1007/s10967-014-3808-4.
5) Krishan, G., M.S. Rao, R.S. Loyal, A.K. Lohani, N.K. Tuli, K.S. Takshi, C.P. Kumar, P. Semwal, and S. Kumar, 2014. Groundwater level analyses of Punjab, India: a quantative approach, *Octa Journal of Environmental Research*, 2(3): 221-226.

Robert Delinom: Prof. Delinom is ***hydrogeologist*** who leads a working group which researched submarine groundwater discharge on different Indonesian islands. His perspective will highlight the ***tropical regions***, where particularly tropical islands can contribute significantly to global fluxes and show strong local impacts of SGD.

1) Bakti, H., Naily, W., Lubis, R.F., Delinom, R., Sudaryanto, S., 2014. PENJEJAK KELUARAN AIRTANAH DI LEPAS PANTAI (KALP) DI PANTAI UTARA SEMARANG DAN SEKITARNYA DENGAN ^{222}RADON. Riset Geologi dan Pertambangan, 24(1): 43-51. (In Indonesian)
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3) Umezawa, Y., Onodera, S., Ishitobi, T., Hosono, T., Delinom, R., Burnett, W.C., Taniguchi, M., 2009, Effects of urbanization on groundwater discharge into Jakarta Bay, Trends and Sustainability of Groundwater in Highly Stressed Aquifer. IAHS Publication 329, IAHS Press, Vamsi Art Printers Pvt. Ltd. Hyderabad.
4) Lubis, R., Sakura, Y., Delinom, R., 2008. Groundwater recharge and discharge processes in the Jakarta groundwater basin, Indonesia. *Hydrogeology Journal*, 16(5): 927-938.
5) Umezawa, Y., Hosono, T., Onodera, S., Siringan, F., Buapeng, S., Delinom, R., Yoshimizu, C., Tayasu, I., Nagata, T., Taniguchi, M., 2008. Sources of nitrate and ammonium contamination in groundwater under developing Asian megacities. *Science of the Total Environment*, 404(2-3): 361-376.

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

Turner

1. Summary

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

2. Scientific Background and Rationale

2.1 Importance of subsurface ocean temperature observations

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

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

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

expansion, accounting for about 1/3 of the observed global mean sea level rise (Church et al., 2013).

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

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

2.2 The challenge

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

2.3 The IQuOD initiative

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

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

France, Germany, India, Japan, Mexico, Norway, Russia, Senegal, Spain, South Africa, UK, and USA.

2.4 Rationale and timeliness for an IQuOD-SCOR working group

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

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

Strong international participation is essential to draw on the widest possible pool of expertise and for IQuOD to be adopted as the definitive database for ocean and climate research activities. The IQuOD community has shown itself to be a well-organized international group – having already held two international workshops (in Hobart, Australia June 2013 and Silver Spring, USA in June 2014). However, insufficient funding has prevented key members from attending these workshops. Funding from SCOR would allow the IQuOD initiative to gain 'critical mass' to ensure good progress over the next 3 years. This progress would be used to leverage further funding for task team activities as well as to expand the membership of the IQuOD community.

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

3. Terms of Reference

1. To develop, implement and document algorithms for assignment of "intelligent" metadata – i.e. an informed guess as to likely values for missing information – for temperature profiles where crucial metadata is missing.
2. To evaluate and document the most effective combination of automated quality control (AutoQC) procedures for temperature profile observations. International collaboration

will be required for the design and coordination of benchmarking experiments using high quality reference datasets.

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

4. Work Plan

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

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

The main activities for the work plan are:

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

We will develop and apply algorithms to attach "intelligent metadata" to historical temperature profiles with missing metadata. These algorithms will be developed as informed guesses, based on the available metadata. For instance, XBT manufacturer can often be inferred by the nationality of the vessel or research cruise, and likely probe type can be inferred from profile termination depth. Our initial focus will be on improving XBT metadata,

but will later be expanding to include additional instrument types. XBT data comprise the largest fraction of the historical temperature observations and about 50% of these observations in the World Ocean Database have missing metadata (e.g., probe type, manufacturer, logging system, etc; Abraham et al., 2013). Inclusion of intelligent metadata will facilitate refinements to instrumental bias corrections and will promote a more homogeneous long-term ocean record critical for climate change research, data assimilation and modeling efforts.

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

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

(3) Development of uncertainty estimates

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

(4) Global database assembly and distribution

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

Timeline

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

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

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

5. Deliverables

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

6. Capacity Building

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

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

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

7. Working Group Composition

7.1 Full members

	Name	**Gender**	**Place of work**	**Expertise**
1	TVS Udaya Bhaskar	M	Indian National Centre for Ocean Information Services (INCOIS), **India**	Automated and manual quality control; data processing; development of gridded products; web hosting; and ocean climate science.
2	Tim Boyer	M	National Centers for Environmental Information (former NODC), NOAA, **USA**	Data aggregation, quality control; database management; interoperability (file format); gridded data products; web hosting, and ocean climate change science.
3	Marcela Charo	F	Departamento Oceanografía, Servicio de Hidrografía Naval, Ministerio de Defensa, **Argentina**	Quality control; database management (Southwestern Atlantic Ocean); calibration and sensor expertise; software development, and ocean climate science.

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

7.2 Associate members

	Name	Gender	Place of work	Expertise
1	Lijing Cheng	M	International Center for Climate and Environment Sciences, Institute of Atmospheric Physics Chinese Academy of Sciences, Beijing, **China**	XBT bias assessment, development of bias correction, and ocean climate science.
2	Mauro Cirano	M	Oceanographic Modeling and Observation Network (REMO), Tropical Oceanography Group (GOAT), Federal Univ. of Rio de Janeiro, **Brazil**	Data assimilation, numerical modeling, observational and modeling network.
3	Rebecca Cowley	F	CSIRO Marine and Atmospheric Research, **Australia**	Hydrographic data calibration and processing, quality control, data management, instrumental bias correction, and ocean climate science. Chair of XBT SOOPIP (Ship of Opportunity Implementation Program) under WMO-IOC JCOMMOPS (Joint Technical Commission for Oceanography and Marine Meteorology in situ Observations Programme Support Centre).
4	Sergey Gladyshev	M	P.P. Shirshov Institute of Oceanology, Moscow, **Russia**	Quality control, data management, ocean instrumentation and ocean climate science.
5	Simon Good	M	UK Met Office Hadley Centre, **UK**	Data aggregation, quality control; database management; interoperability (file format); gridded data products; software development, web hosting, and ocean climate change science.
6	Francis Bringas Gutierrez	M	Atlantic Oceanographic and Meteorological Laboratory, (AOML, NOAA), **USA**	Data acquisition, quality control, and management.

7	Katherine Hutchinson	F	University of Cape Town - Department of Oceanography (UCT), **South Africa**	Instrumental bias assessment and Southern Ocean science.
8	Gabriel Jorda	M	University of the Balearic Islands, Mediterranean Institute for Advanced Studies (IMEDEA CSIC-UIB), **Spain**	Hydrographic data analysis, atlas production (Mediterranean), ocean modeling and ocean climate science.
9	Sergio Larios	M	Centro Nacional de Datos Oceanograficos, Universidad Autonoma de Baja California, Instituto de Investigaciones Oceanologicas (CENDO - IIO – UABC), **Mexico**	Data acquisition and processing, quality control, database management, web hosting, outreach (teaching data visualization tools).
10	Toru Suzuki	M	Marine Information Research Center, **Japan**	Data archaeology, quality control and data management.

8. Working Group Contributions

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

Tim Boyer oversees the World Ocean Database (WOD) project for the National Center for Environmental Information (NCEI, former National Oceanographic Data Center (NODC)) at the National Oceanographic and Atmospheric Administration (NOAA) in the United States. He has been involved in collaborative international work for the World Data Center – Oceanography (WDC-O) and in using ocean temperature profile data to study ocean heat content change.

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

Christine Coatanoan is an expert on quality control applied to oceanographic datasets (floats, buoys, research vessels, ships of opportunity, drifters, gliders, sea mammals), which are

collected at the Coriolis data center in France. She is also involved in the Argo program, and has experience in data validation using objective analysis.

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

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

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

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

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

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

9. Relationship with Other Programs and SCOR Working Groups

International Oceanographic Data and Information Exchange (IODE)

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

The IOC Committee on International Oceanographic Data and Information Exchange,

Recognizing that the goal of the International Quality-controlled Ocean Database

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

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

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

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

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

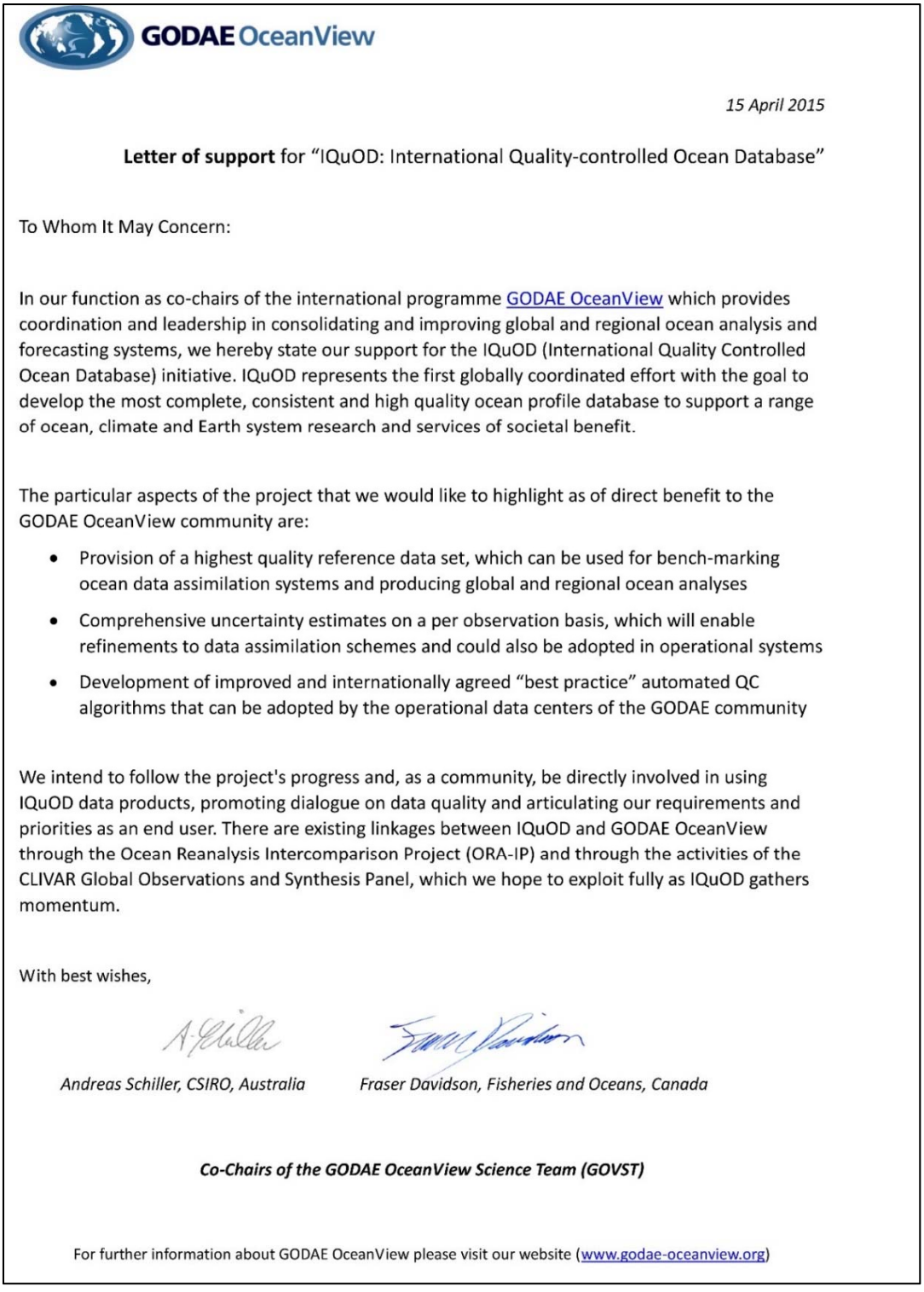
Recommends the establishment of IQuOD as an IODE project; the establishment of the IODE Steering Group for the International Quality controlled Ocean Database (SG-IQuOD); and that the membership of the Steering Group shall initially include the Chair of GTSPP, representatives of WOD and GODAR projects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

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

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

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

Global Ocean Data Assimilation Experiment (GODAE)



GODAE OceanView

15 April 2015

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

To Whom It May Concern:

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

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

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

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

With best wishes,

Andreas Schiller, CSIRO, Australia

Fraser Davidson, Fisheries and Oceans, Canada

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

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

Program for Climate Model Diagnostics and Intercomparison (PCMDI)

Program for Climate Model Diagnosis and Intercomparison
Lawrence Livermore National Laboratory
Mail Code L-103, 7000 East Avenue, Livermore, CA, U.S.A 94550
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PCMDI

IQuOD Science Team
23rd April 2015

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

To Whom It May Concern:

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

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

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

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

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

Yours sincerely,

Paul J. Durack and Peter J. Gleckler
Program for Climate Model Diagnosis and Intercomparison
Lawrence Livermore National Laboratory
pauldurack@llnl.gov

US CLIVAR

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

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

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

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

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

CLIVAR Global Synthesis and Ocean Panel (GSOP)

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

WCRP Grand Challenge on regional sea level change and coastal impacts

Thermal expansion induced by ocean heat storage is one of the two major contributions to the global mean sea level rise observed during the late 20th century. Thermal expansion is also expected to be a major component of future sea level rise. Improvement of the data quality,

consistency and completeness of the global temperature database as part of the IQuOD activities will be critical to refine the global and regional sea level budgets as well as to constrain sea level predictions (near term) and projections (long term scenarios). Catia Domingues (one of the IQuOD co-chairs for the proposed SCOR working group) has been a co-chair for the scoping team and is now co-leading one of the work packages for the WCRP Grand Challenge on sea level change.

Other WCRP and CLIVR research activities (not listed above)

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

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

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

We are planning to submit a proposal to IAPSO to financially co-sponsor IQuOD jointly with SCOR. There have been already some discussions with Isabelle Ansorge, Chris Meinen and Ken Ridgway, who were fully supportive of our plan and encouraged us to submit a proposal. As noted above, IQuOD has been already endorsed by IOC/IODE.

SCOR sponsored project – Southern Ocean Observing System (SOOS)

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

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

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

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

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

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11. Appendix – 5 key publications for full members

TVS Udaya Bhaskar

1. A Chaterjee & co-authors (incl. **TVS Udaya Bhaskar**) (2012) "A new Atlas of temperature and salinity for the Northern Indian Ocean", Journal of Earth System Science, Vol 121(3), pp 559 - 593.
2. **TVS Udaya Bhaskar** & co-authors (2013) "GUI based interactive system for visual quality control of Argo data", Indian Journal of Geo-Marine Sciences, Vol 42 (5), pp 580 - 586.
3. **TVS Udaya Bhaskar** & co-authors (2013) "A note on three way quality control of Argo temperature and salinity profiles - A semi-automated approach at INCOIS" International Journal of Earth Sciences and Engineering, Vol 5 (6), pp 1510 - 1514.
4. RV Shesu & co-authors (Incl. **TVS Udaya Bhaskar**) (2013)" Open Source Architecture for Web-Based Oceanographic Data Services" Data Science Journal, Vol 12, pp 47 - 55.
5. **TVS Udaya Bhaskar** & co-authors (2006) "Inferring mixed layer depth variability from Argo observations in the western Indian Ocean", Journal of Marine Research, Vol 64(3), pp 393 - 406.

Tim Boyer

1. **Boyer, T. P.**, V. V. Gopalakrishna, F. Reseghetti, A. Naik, V. Suneel, M. Ravichandran, N. P. Mohammed Ali, M. M. Rafeeq, and R. A. Chico (2011) "Investigation of XBT and XCTD biases in the Arabian Sea and the Bay of Bengal with implications for climate studies", J. Atmosph. Ocean. Tech. , 28, doi: 10.1175/2010jtecho784.1, 266-286.
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observations: Implications for ocean heat content estimates and climate change", Reviews of Geophysics , Vol. 51, pp 450-483.

Marcela Charo

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Christine Coatanoan

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Catia Domingues (co-chair)

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

Miloslavich

Summary/Abstract

The goal of this working group is to unravel the interdisciplinary feedbacks between physical and ecological processes, and to develop a robust framework to understand and manage the future of vegetated shorelines. The world's coastlines are highly dynamic regions subject to oceanic energy in the form of waves, tides and storm surge. Marine vegetation like tidal marshes and mangroves have been shown to provide defense against these often-destructive forces while simultaneously providing ecological co-benefits, such as providing critical habitat for economically-valuable flora and fauna and serving a vital role in the sequestration of blue carbon. All of these roles are threatened by the predicted hydrodynamic changes associated with a changing climate (such as sea level rise and increased storminess) and anthropogenic developments (such as reservoir and dam construction). However, the complex biophysical feedbacks between sediment, hydrodynamics and vegetation are still not well understood, and these gaps in knowledge limit our ability to successfully apply ecosystem-based management of these threatened and highly populated regions. This proposed working group includes members spanning the globe and encompassing the many different areas of expertise required to make significant jumps forward in this interdisciplinary space. The group aims to meet yearly for three years and produce two peer-reviewed scientific reviews (one focused on physical processes and one on management) and an applied report for managers and policy-makers, in addition to keeping the wider community involved through development of a website and the proposal to organize an AGU Chapman Conference.

Scientific Background and Rationale

Rationale

A growing amount of attention and research has focused on the roles that marsh or mangrove vegetation plays in estuaries. From an ecological perspective, coastal vegetation supports functions that are critical to numerous ecosystem services and the economic value of this natural capital is being increasingly recognized (Costanza *et al.*, 1997, Barbier et al., 2008). Furthermore, coastal wetlands have been shown to play a substantial role in blue carbon storage. Both tidal marshes and mangrove swamps posses the ability to sequester disproportionately large quantities of CO_2, with a burial capacity, which is estimated at six times that of the Amazonian rainforest and 180 times that of the open ocean (Nelleman et al., 2009; Donato et al., 2011; McLeod et al., 2011; Breithaupt et al., 2012). Lastly, in addition to providing ecosystem services, attention in recent years has focused on the ability of coastal wetlands to provide protection, buffering shorelines against damage (Arkema *et al.*, 2013; Temmerman *et al.*, 2013), even during extreme conditions such as large wave events (Möller *et al.*, 2014) or tsunamis (Wolanski, 2007).

The use of 'ecodefense', or protecting coastlines through nature offers a cost effective alternative to traditional hard structures, which often are accompanied by negative effects such as fragmenting habitats and reducing ecological connectivity (Peterson and Lowe, 2009). Conversely, 'soft' solutions can enhance resilience, improve water quality and

provide habitat for biodiversity offsetting (Jones et al., 2012). However, habitat creation has achieved differing degrees of success and improved understanding of the underlying biophysical processes is necessary in order to raise the success of these remediation measures. Moreover, there is growing acknowledgement of the enhanced vulnerability of coastlines in the face of global climate change, with some areas predicted to encounter more frequent and stronger extreme storm events (e.g. Webster *et al.*, 2005; Knutson *et al.*, 2010), while other areas face significant sea level rise (Sallenger *et al.*, 2012). This vulnerability, coupled with the recent disappearance and accelerating rate of decline of estuarine wetlands and mangroves (Duke, 2007; IPCC, 2013), has brought the topic to the forefront of coastal science.

Substantial progress has been made in the area of the interaction between vegetation and flow, at small (Nepf 2012a, 2012b) and large scales (D'Alpaos *et al.*, 2007; Fagherazzi *et al.*, 2012, Coco *et al.,* 2013; Zhou *et al.,* 2014). However, many large challenges persist. At the small scale, much previous work has been conducted in laboratory flumes using mimics or plants with approximately uniform or simplified morphologies. It remains an open question of how to best scale these results to incorporate the huge range of heterogeneity of bathymetry, densities and vegetation characteristics (e.g. stiffness, lengths etc.) observed within even one marsh area (Bouma *et al.*, 2007). One way forward is to develop hydrodynamic models that include vegetation dynamics, and indeed some modeling packages have incorporated flow over vegetation (e.g. Delft3d, Baptist *et al.*, 2007). Further work is needed on how to parameterize and integrate plant growth models (e.g. incorporating effects such as seasonal die back). Vegetation has been observed to both enhance erosion, particularly through scouring at marsh edges, but to also enhance sediment deposition through damping of energy. The precise balance between these two processes and feedbacks with plant growth, particularly on the larger scales from multiple patches to entire marsh scales only begins to be addressed (Marani *et al.*, 2010). Other biota can also modulate these processes through bioturbation and biostabilisation. Combining all of these processes over long-time scales, covering both extreme and normal conditions is a significant challenge (Bouma *et al.*, 2014). Even after these scientific challenges have been addressed, there remains the significant challenge of connecting the existing and future scientific knowledge with societal values, which can then be translated into policy.

Given the broad scope and interdisciplinary nature of these challenges and the relevance for policy-making and management of estuaries, we propose that the research area is ideally suited to being tackled by a SCOR working group. This working group would provide opportunities to bring together specialists whose work encompasses a range of scales, skills and processes. The group would bring together the mangrove and saltmarsh communities and also combine laboratory experimentalists, field-based scientists, and numerical modelers and scientists heavily involved with policy-making and assessment frameworks. Now is an excellent time to make progress on the key questions especially in light of new instrumentation allowing high- resolution measurements (Mullarney *et al.*, 2015) and improved remote sensing techniques (Silvestri and Marani, 2004). We note that to stay within the constraints of working group membership we have focused on saltmarshes

and mangroves. However, it is envisioned that the wider community (for example seagrass and kelp researchers) would also be integrated through the proposed Chapman Conference on the broader topic of vegetation ecohydrodynamics.

The working group would provide assistance to integrate scientists from developing countries, who sometimes lack resources to attend international meetings. This involvement is crucial, noting that it is often in these regions that salt marsh and mangrove areas are being destroyed at the fastest rates (e.g. Vietnam, Thu and Populus, 2007).

Scientific Background

The presence of vegetation introduces significant spatial variation to flow, much of which is associated with the heterogeneity of natural canopies. Within a plant canopy, the key length scales are defined by the stem diameter and stem spacing (Figure 1). This change of scale results in damping of larger scale motions, but introduces turbulence (through vortex shedding) at the smaller stem scale. Inside a canopy, the bulk canopy drag increases with the density of vegetation. This additional drag reduces mean flow speeds and turbulence intensities with distance from the seaward marsh edge (Leonard and Luther, 1995) or can cause flow routing around areas of higher densities. Vegetation can also induce mechanical lateral and longitudinal dispersion owing to particles becoming caught in eddies behind stems.

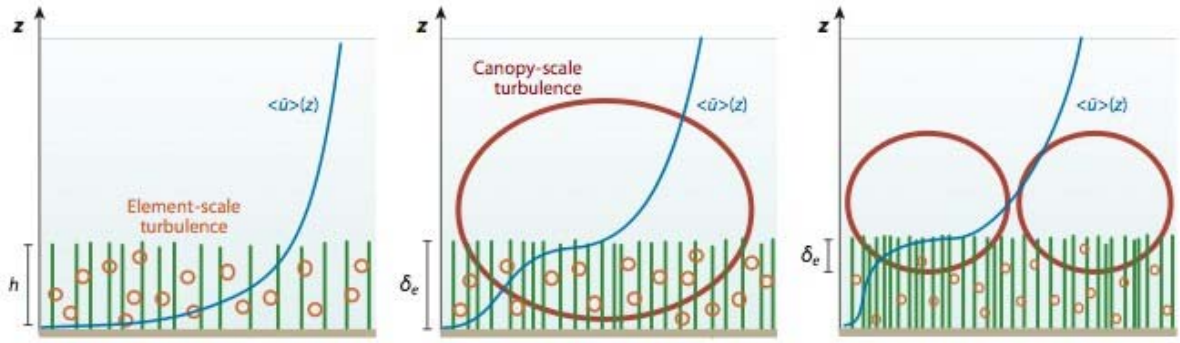

Figure 1: Schematic showing the change in velocity profiles and length scales associated with the presence of vegetation from sparse (left) to transitional (middle) to dense (right) submerged canopies. For the dense vegetation, shear at the top of the canopy induces monami (or waving) and canopy scale turbulence. Figure from Nepf (2012a).

Both laboratory and field studies have demonstrated that seagrass, sedges and mangroves are capable of dissipating wave energy. Indeed, salt marshes have been shown to effectively dissipate waves even during larger wave events and high water levels (Möller *et al.*, 2014). However, the extent of this dissipation is frequency dependent and also depends strongly on the vegetation characteristics (Mullarney and Henderson, 2010).

The tendency for vegetation to slow currents and dissipate waves can create sheltered regions of low flow, where sediments can deposit and marshes typically experience enhanced deposition (Coco *et al.*, 2013). However, recent measurements have demonstrated scour

around stems at the marsh edge and the precise balance between the erosional and accretional processes is not yet clear (Tinoco and Coco, 2013). Despite these differences in observed sedimentation between studies, it is generally acknowledged that the three-dimensional structure of the vegetation is an important factor influencing sedimentation patterns within a salt marsh. Hence the vegetation, in part, controls the longer-term marsh scale evolution. However, as noted by Fagherazzi *et al.* (2012), many recent process based models are developed for specific locations and individual species and the wider-applicability of these models is not yet known. A working group would provide an excellent opportunity to answer some of these questions at this critical time.

Terms of Reference

The goals of this working group are as follows:

- Synthesize current knowledge of salt marsh and mangrove swamp evolution, focussing on the key processes (and similarities and differences between the two systems). Hence identify key gaps in understanding and make recommendations for collaborative future research directions. Particular attention will focus on growth and disappearance of marshes, ecosystem services such as wave attenuation, importance for birds/fisheries and carbon sequestration.
- Facilitate collaboration between observational and numerical modeling studies of saltmarsh and mangrove systems. In particular, we aim to:
    - Promote the migration of existing data sets into numerical models
    - Select benchmark dataset(s) that can be used to parameterize and validate numerical models.
    - Identification of existing models and discussion on their strengths and weaknesses.
- Produce a short article on management and restoration of these systems for policymakers. It is envisaged that this article will contain a 'salt marshes for dummies' section on the physics, chemistry and biology of salt marshes and mangroves, describing the key processes from a long-term perspective, and a section that quantifies the ecosystem services (benefits) of these systems that includes several case- studies/lessons learned.
- Convene international working group meetings and document the work of the group on a website.
- Produce two open-access review articles, one focused on the physical processes (possible journals – *Reviews of Geophysics*, *Estuarine Coastal and Shelf Science*, *Advances in Water Research*) and a second focused on management (possible journals - *Conservation Letters*, *Ecological Engineering*, *Restoration Ecology*).
- Write a proposal for a 2018 AGU Chapman Conference on the wider topic of vegetation ecohydrodynamics.

Working plan

Our first working group meeting will be held in 2016 in conjunction with the Fall AGU meeting in December. This meeting will focus on the following:

- Reviewing the terms of reference and adjusting them as necessary.
- Formulating a concrete action plan for the group.
- Review the state of knowledge and identify critical gaps.
- Discussion of existing data sets. Identify which are best suited for use by modeling community and strategies to make these datasets available.
- In light of the above, compiling components of the review article.
- Discussion and identification of potential sources for further funding.

The second meeting will be held in 2017 (likely at the international conference River, Coastal and Estuarine Morphodynamics) and efforts will be concentrated on the following:

-
- Final discussion on the review articles with an aim to submitting shortly after the meeting.
- Initial discussions on a Chapman conference – identifying key participants (i.e conveners).
- Outlining report for policy makers and managers. Discussion on the best strategy for production.
- Ensure the website is up and running

The third meeting should be held in early 2018 (likely at AGU ocean sciences) and involve:

- Final discussion on applied report. Dissemination shortly afterwards.
- Prepare a final report outlining progress made and future directions of research.
- Continued organization for the Chapman Conference, which should be held before the end of the year.

Deliverables

The group will strive to produce the following outputs:

1. A final report detailing the work of the group, including results of discussions on the identification of key knowledge gaps to guide future research.
2. An article designed for policy makers on the management and restoration of salt marsh and mangrove ecosystems.
3. An up-to-date website of the group's activities.
4. Two review papers (one focusing on physical processes and the other on management) in a peer-reviewed open access international journal.
5. A proposal for an American Geophysical Union Chapman Conference

Capacity Building

With members spanning the 5 continents, our proposed group will help to build scientific capacity globally. In particular, we hope to build scientific capacity in Tanzania, Vietnam,

and South America. As noted above, many developing regions are threatened by the conversion of wetland and mangrove areas; and by improving capacity in these countries, we hope to raise awareness of the ecological and economic values of these ecosystems. We will also seek advice from the SCOR committee on capacity building on how our working group can further enhance scientific development around the globe. Many members are associated with a range of international programs and this working group will enable all members to widen their professional networks.

Working Group composition

Our proposed group has three co-chairs – Julia Mullarney, Iris Möller and Eric Wolanski. We have selected a chair covering all career stages and from both hemispheres. Each chair will take responsibility for a key deliverable and organizing one meeting (Mullarney will also take on the responsibility of organizing the first meeting and will be the overall point of contact for SCOR).

Our proposed working group contains 10 full members and 10 associate members, representing a balance of geographic locations, interdisciplinary expertise, seniority (all career stages are involved) and gender (see table). Given a large focus of the group is the parameterization of key processes for inclusion into numerical models; we have two members strongly linked to Delft Hydraulics (one associate and one full member). We have ensured membership encompasses scientists bringing together all currently available tools such as field observationalists, laboratory experimentalists, numerical modelers and members with expertise in remote sensing. Additionally, given one of the aims of the group is to bridge the gap between science and policy, we have several members with expertise in coastal policy; ecosystem based management, biodiversity offsetting, and integrated assessment frameworks. We are also currently exploring options for co-funding and support from other organizations such as LOICZ and the United Nations Environment Programme and are currently awaiting responses to our initial inquiries. We note that several other scientists have expressed interest in collaborating with the group in an informal capacity.

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

Name	Gender	Place of work	Expertise relevant to proposal	Career Stage
1 Julia Mullarney Co-chair	Female	University of Waikato, New Zealand	Small scale turbulence inside canopies/vegetation movement	J/I
2 Eric Wolanski Co-chair	Male	James Cook University, Australia	Estuarine ecohydrology	S

3 Iris Möller Co-chair	Female	University of Cambridge, England	Bio-physical interactions in salt marsh systems and their significance for decadal scale marsh stability, wetland science communication and stakeholder involvement	I
4 Hong-Phuoc Vo-Luong	Female	National University of Science, Ho Chi Minh City, Vietnam	Flows and sedimentation within mangroves	I
5 Tjeerd Bouma	Male	Royal Netherlands Institute of Sea Research (NIOZ), the Netherlands	Spatial ecology, conservation ecology, nature based coastal defense	S
6 Jasper Dijkstra	Male	Deltares, The Netherlands	Numerical modeling of vegetated regions	J/I
7 Heidi Nepf	Female	Massachusetts Institute of Technology, USA	Vegetated hydrodynamics and morphodynamics	S
8 Giovanni Coco	Male	University of Auckland, New Zealand	Geomorphology and biophysical interactions	I/S
9 Halima Kiwango	Female	The Nelson Mandela African Institution of Science and Technology, Tanzania	Estuarine ecohydrology (specifically water quality) and mangrove ecology.	J
10 Zeng Zhou	Male	Hohai University, Nanjing, China	Ecomorphodynamics	J

Associate Members (no more than 10)

Name	Gender	Place of work	Expertise relevant to proposal	Career Stage
1 Fernando Mendez	Male	University of Cantabria, Spain	Climate and waves, extremes, coastal climate change	I
2 Andrea D'Alpaos	Male	University of Padova, Italy	Ecomorphodynamics	

3 Dano Roelvink	Male	UNESCO-IHE, The Netherlands	Morphodynamic numerical modeling	S
4 Sergio Fagherazzi	Male	Boston University, USA	Geomorphic evolution of salt marshes/remote sensing of vegetated regions	I/S
5 Gerado Perillo	Male	Argentinian Institute of Oceanography, Bahia Blanca, Argentina	Oceanography, physical- biological interactions, sediment transport	S
6 Alice Newton	Female	University of Algarve, Portugal and Norwegian Institute of Air Research,	Coastal lagoons, integrated assessment frameworks (SAF and DPSIR)	S
7 Gail Chmura	Female	McGill University, Canada	Carbon fluxes and impacts of nutrient enrichment	S
8 Chen Wang	Female	Satellite Environment Center of the Ministry of Environmental Protection, China	Remote sensing/satellite imaging and GIS of coastal wetlands	J
9 Mike Elliott	Male	University of Hull, UK	Effects of human activities on biological systems, coastal policy, biodiversity offsetting	S
10 Marco Marani	Male	Duke University, USA	Observations and modeling interactions between vegetation species, erosion/deposition, intertidal landforms, and biodiversity	S

Working Group contributions

The working group has been designed to bring together people with complementary primary areas of expertise. Mullarney focuses on smaller-scale observation measurements within vegetated environments and the movement of vegetation under hydrodynamic forcing. Wolanski is a leading expert in the areas of coastal oceanography and ecohydraulics. Vo- Luong's research focuses on flows and sediment transport within mangrove forests, and she takes a field and theoretical approach. Nepf is a world expert in flows within vegetated canopies, with particular emphasis on laboratory experiments. Bouma is a spatial ecologist with key research areas of ecological restoration and plants as ecosystem engineers. Dijkstra specializes

in numerical modeling of vegetated regions (and salt marshes in particular). Coco has experience in laboratory and numerical modeling of biophysical interactions in estuarine environment; Zhou has recently completed a novel model that addresses feedbacks between marshes, physical processes and carbon dynamics. Moeller is a coastal geomorphologist with a research focus on the linkage between short term (event-based) plant-wave interaction and its significance for decadal scale coastal wetland evolution in the face of climate changed induced alterations to storm frequency and magnitude. More recently Möller has also been actively involved in addressing the communication gap between the academic community and stakeholders involved in coastal management. Kiwango's research into estuarine ecohydrology focuses specifically on water quality (physical, chemical and biological) and mangrove ecology.

Relationship to other international programs and SCOR Working groups

Many working group members have substantial linkages to other international programs and have been involved in successful SCOR working groups in the past (Wolanski, Perillo and Elliott). Mullarney and Vo-Luong (full members) and Fagherazzi and Roelvink (associate) are participants in the USA Office of Naval Research funded departmental research initiative "Dynamics of tropical deltas" studying flows and sediment transport in the Mekong Delta.

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Appendix

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

Julia Mullarney

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Eric Wolanski

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Jasper Dijkstra

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3.0 LARGE-SCALE OCEAN RESEARCH PROJECTS

3.1 Global Ecology and Oceanography of Harmful Algal Blooms Program, **p. 3-1** *Enevoldsen, Sun Song*

3.2 Integrated Marine Biogeochemistry and Ecosystem Research, **p. 3-6** *Burkill*

3.3 GEOTRACES, **p. 3-32** *Naqvi*

3.4 Surface Ocean – Lower Atmosphere Study, **p. 3-60** *Sarma, Turner*

3.5 International Quiet Ocean Experiment, **p. 3-80** *Urban, Shapovalov*

3.6 Second International Indian Ocean Expedition**, p. 3-82** *Hood, D'Adamo, Burkill*

3.1 Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB)/GlobalHAB (joint with IOC) *Sun*

Terms of Reference:
The Scientific Steering Committee of the GEOHAB Programme will

1. Coordinate and manage GEOHAB Core Research Projects (CRPs) in accordance with the GEOHAB Science and Implementation Plans.
2. Identify gaps in knowledge required to execute CRPs, and encourage targeted research activities to fill those gaps.
3. Review progress on CRPs over time and initiate new CRPs in priority research areas.
4. Foster framework activities to facilitate implementation of GEOHAB, including dissemination and information tools.
5. Establish appropriate data management activities to ensure access to, sharing of, and preservation of GEOHAB data, taking into account the data policies of the sponsors.
6. Promote comparative and interdisciplinary research on harmful algal blooms by providing coordination and communication services to national and regional research groups, encouraging explicit affiliation with GEOHAB via the endorsement process.
7. Collaborate, as appropriate, with intergovernmental organizations and their subgroups (e.g., ICES, PICES, FANSA, ANCA, WESTPAC/HAB, HANA, NOWPAP), as well as related research projects (e.g., GLOBEC, LOICZ, IMBER) and observational systems such as the Global Ocean Observing System and its regional alliances.
8. Report regularly to SCOR, the IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB), and the global HAB research community on the state of planning and accomplishments of GEOHAB, through annual reports and, as appropriate, the GEOHAB Web site, a GEOHAB Newsletter, *Harmful Algal News*, special sessions at scientific meetings, and other venues.
9. Interact with agency sponsors to stimulate the support of GEOHAB implementation through various mechanisms (e.g., direct support of GEOHAB initiatives and integration of the GEOHAB approach in national programs).

Acronyms
ANCA = IOC HAB working group for Central America and Caribbean Sea
FANSA = IOC HAB working group for South America
HANA = IOC HAB working group for North Africa
GLOBEC = Global Ocean Ecosystem Dynamics project
ICES = International Council for the Exploration of the Seas
IMBER = Integrated Marine Biogeochemistry and Ecosystem Research project
IOC = Intergovernmental Oceanographic Commission
LOICZ = Land-Ocean Interactions in the Coastal Zone project
NOWPAP = UNEP Northwest Pacific Action Plan
PICES = North Pacific Marine Sciences Organization
SCOR = Scientific Committee on Oceanic Research
WESTPAC/HAB = IOC SubCommission for the Western Pacific HAB working group

3-2

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Patricia Tester	USA
Gires Usup	MALAYSIA

Ex-officio Member: Gires Usup (IOC IPHAB)
IOC Staff: Henrik Enevoldsen
Executive Committee Reporter: Sun Song

The GEOHAB SSC is continuing work until their synthesis products are completed.

SCOR-IOC
United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission

GEOHAB
Global Ecology and Oceanography of Harmful Algal Blooms

International Council for Science
SCOR
Scientific Committee on Oceanic Research

Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB)

Program Activities, 2014-2015

This document presents the last activities of the GEOHAB project that finished at the end of 2014, and the transition period along 2015 toward its continuation as the new initiative GlobalHAB.

Raphael Kudela and Elisa Berdalet, Chair and Vice-chair of GEOHAB, respectively, representation of all the SSC members along the life of the program, as well as the whole scientific community engaged in the research on harmful algal blooms, **express their deep gratitude to the SCOR to this programme and its continuation as sustained support of GlobalHAB**.

1. Representation at IPHAB Meeting, April 2015.

GEOHAB was represented by the SSC Vice-Chair (Elisa Berdalet) at the XII IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB-XII) meeting held in Paris, on 28-30 April 2014. The Progress Report presented at the IPHAB meeting can be found at http://hab.ioc-unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15021.

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

Berdalet acknowledged the decision of SCOR to accept to co-sponsor GlobalHAB, which was also appreciated by IOC IPHAB. With this funding, GlobalHAB will initiate the GlobalHAB SSC and foster the implementation of recommended workshops and activities agreed at the Final Open Science Meeting of GEOHAB (Paris, April 2013). **Berdalet emphasized the need for IPHAB member states to contribute additional funds to the implementation of GlobalHAB.** She briefly presented the main components of GlobalHAB, as they had been presented to SCOR in its 2014 General Meeting (Bremen, September 2014). Namely, the Terms of Reference, the

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

2. Science Highlights

2.1. Summary for policy makers

This document, that constitutes one of the final products of GEOHAB, was led by Raphael Kudela, Elisa Berdalet, and Henrik Enevoldsen. The *Summary for Policy Makers* was delivered on June 2015 and disseminated by IOC (http://www.unesco.org/new/en/natural-sciences/ioc-oceans/single-view-oceans/news/new_publication_on_harmful_algal_blooms_for_policy_makers/#.VeXWJngdzsJ. It can be download free at this link and it is also included in the Addendum of this document.

2.2. Co-sponsoring and participation at the Scientific Symposium on Harmful Algal Blooms and Climate Change

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

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

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

3. Publications

GEOHAB Open Science Meeting Report

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

Publication of a special issue

As part of the synthesis, the GEOHAB SSC, in coordination with the GEOHAB Core Research Projects (CRPs0, identified a series of publications targeting *Oceanography* magazine. The additional funds received in August 2015 (H. Enevoldsen) will allow the publication of 6 papers in the mentioned journal by Spring-Summer 2016.

3.2 Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) (joint with IGBP) *Burkill*

Terms of Reference

- To develop the IMBER Science Plan and Implementation Strategy, in accordance with guidance from the sponsoring organisations.
- To oversee the development of IMBER in accordance with its Science Plan and Implementation Strategy.
- To collaborate, as appropriate, with related projects of the sponsors IGBP and SCOR, and other related programmes and organisations (e.g., IHDP, DIVERSITAS, IOC and the Global Ocean Observing System (GOOS), etc.)
- To establish appropriate data management policies to ensure access to, sharing of, and preservation of IMBER data, taking into account the policies of the sponsors.
- To report regularly to SCOR and IGBP on the state of planning and the accomplishments of IMBER.

The IMBER SSC, its subsidiary groups and International Project Office shall operate in accordance with the operating procedures for IGBP Projects and the requirements of the other co-sponsors.

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Katrin Rehdanz (F), GERMANY
Tatiana Rynearson (F), USA
Svein Sundby, NORWAY
Sinjae Yoo (M), KOREA

Executive Committee Reporter: Peter Burkill
Executive Officer: Einar Svendsen

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Annual Report to SCOR

August 2015

A. Introduction

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

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

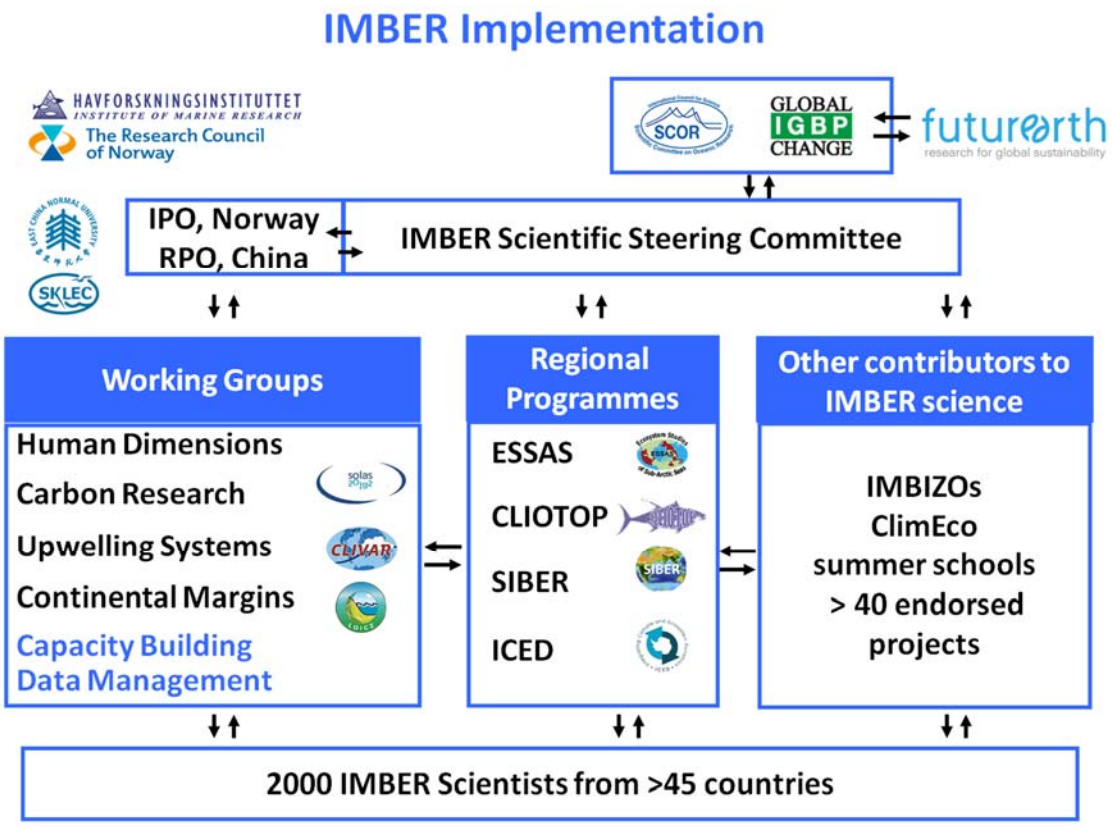

Fig. 1. Structure of IMBER.

B. Selected recent IMBER discoveries and highlights

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

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

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

1. The Atlantic Multidecadal Oscillation (AMO), with a 60-80 year periodicity (Fig. 2), was shown to extend into the high latitudes and Arctic regions, as observed in temperature and

sea-ice data (*Drinkwater et al*., 2014)

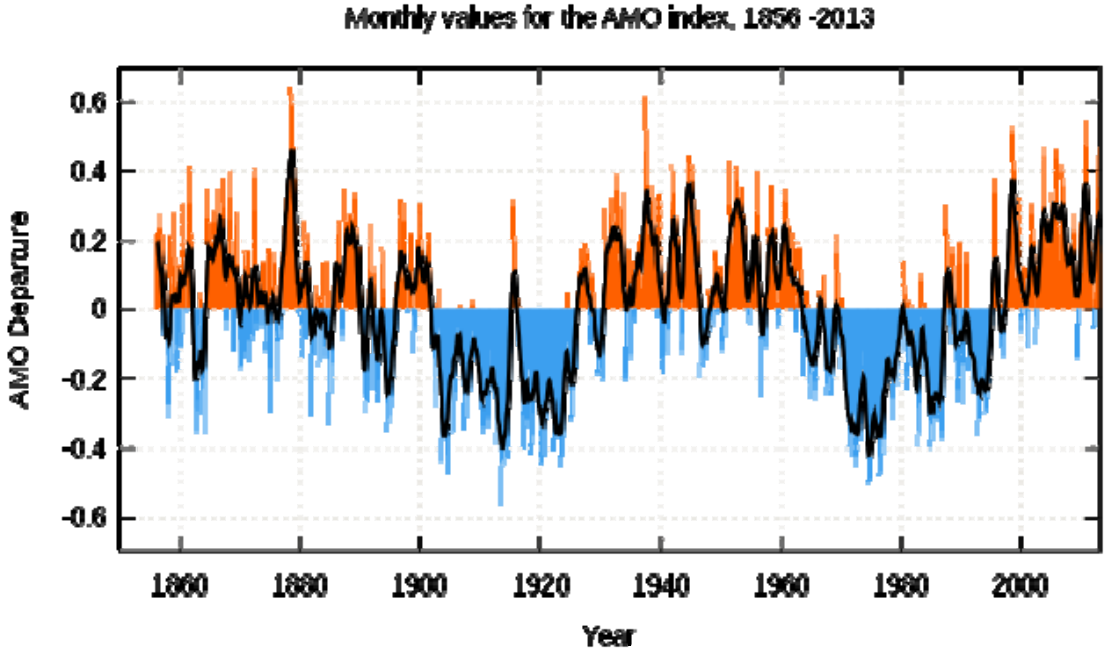

Fig. 2. 157 year development of the Atlantic Multidecadal Oscillation Index expressed as standardized anomalies and de-trended, i.e. excluding the anthropogenic signal. (http://www.esrl.noaa.gov/psd/).

2. Contrary to the general perception of increased primary production in frontal regions, enhanced production is not observed in association with the Polar Front in the Barents Sea and the Arctic Front in the Norwegian Sea. The International Polar Year (IPY) project NESSAR (Norwegian component of the ESSAS) was the first to demonstrate that these frontal regions are primarily density compensating with strong interleaving between the warm, saline Atlantic waters and the cold, low saline Arctic waters. Turbulence near the fronts is relatively weak. Although mixing occurs through both double diffusion and current shear, it is not strong enough to mix nutrients into the surface layers during the stratified period. No secondary upwelling circulation was observed and, hence nutrients are low in the frontal region once the spring bloom is over (*Drinkwater and Tande, 2014*).

3. Circulation on the Bering Sea shelf, through the Bering Strait and on the Chukchi Sea shelf, is tightly coupled, with transport anomalies through the Strait driven by the longitudinal location of the Aleutian Low (*Danielson et al., 2014).*

4. Much of the diatom production on the Bering Sea shelf is consumed by protists in the microzooplankton, rather than by zooplankton such as copepods and krill, as previously believed. These microzooplankton are also important in the food web, supporting a large summer zooplankton biomass on the shelf, when they can be more abundant than phytoplankton (*Sherr et al., 2013; Stoecker, et al., 2014).*

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

5. Antarctica's Ross Sea is projected to lose more than half its summer sea ice by 2050 and more than three quarters by 2100. This will be a dramatic change for the area, which is one of the few polar regions that has experienced an increase in summer sea ice coverage over the past few decades. This loss of sea ice has important implications for biological production of the Ross Sea (*Smith et al., 2014).*

6. Winter fast-ice trends over the past 100 years for the South Orkney Islands, Antarctica, demonstrate marked inter-annual variability and long-term changes. These findings indicate the need for caution in interpreting changing ice conditions based on shorter-term satellite series (*Murphy et al., 2014).*

7. Despite inhabiting one of the strongest currents in the world's oceans, Antarctic krill appear to be able to influence their distribution at large oceanic scales through behavior that facilitates maintenance of population centers (*Tarling and Thorpe, 2014)*.

8. Due to warming, species richness may increase in Antarctic water masses as sub-Antarctic species increasingly encroach southwards (*Ward et al., 2014*).

9. Changes in penguin abundance and distribution can be used to understand the response of species to climate change and fisheries pressures, and to gauge of ecosystem health (*Waluda et al., 2014)*.

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

11. Dissolution dominating calcification processes in polar pteropods are close to the point of Aragonite undersaturation (*Bednaršek et al., 2014)*.

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

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

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

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

14. From the 137-year long record of the El Niño-Southern Oscillation (ENSO), no significant trend can be detected, and the recent multi-decadal variability is similar to earlier decades. ENSO has not fundamentally changed over the period of large increase in atmospheric CO_2, and the potential of predicting the future states of the fisheries and ecosystems are quite limited. *(Harrison and Chiodi, 2015)*

15. Major uncertainties in modelling frameworks are broadly categorised into those associated with (i) deficient knowledge in the interactions of climate and ocean dynamics with marine

organisms and ecosystems; (ii) lack of observations to assess and advance modelling efforts and (iii) an inability to predict with confidence natural ecosystem variability and longer term changes as a result of external drivers (e.g. greenhouse gases, fishing effort) and the consequences for marine ecosystems. As a result of these uncertainties and intrinsic differences in the structure and parameterisation of models, users are faced with considerable challenges associated with making appropriate choices on which models to use. A key research direction is the development of management systems that are robust to this unavoidable uncertainty. *(Evan et al., 2015)*

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

16. The Surface Ocean CO_2 Atlas (SOCAT, www.socat.info), compiled by the international marine carbon community, provides access to quality-controlled surface CO_2 data (Fig. 3). The first two versions were released in 2011 and 2013, respectively. Version 2 contains 10.1 million quality-controlled, surface ocean fCO_2 (fugacity of CO_2) values from 1968 to 2011 for the global oceans and coastal seas. Version 3 of the Atlas was released on 7 September 2015 *(Bakker et al., 2014; Pfeil et al., 2013; Sabine et al., 2013).*

17. Scientific applications of SOCAT include: 1) quantification of the ocean carbon sink and 2) ocean acidification and their temporal and spatial variation, 3) validation of ocean carbon models and coupled climate carbon models, and 4) provision of constraints for atmospheric inverse models used to estimate land carbon sink (*Landschützer et al., 2014; Lauvset et al., 2015; Rödenbeck et al., 2014; Séférian et al., 2014; Tjiputra et al., 2014).*

18. SOCAT synthesis products represent an impressive achievement in coordinating international researchers to deliver publicly accessible and uniformly quality-controlled data for marine carbon and ocean acidification research that can be used for research and to inform international policy and climate negotiations.

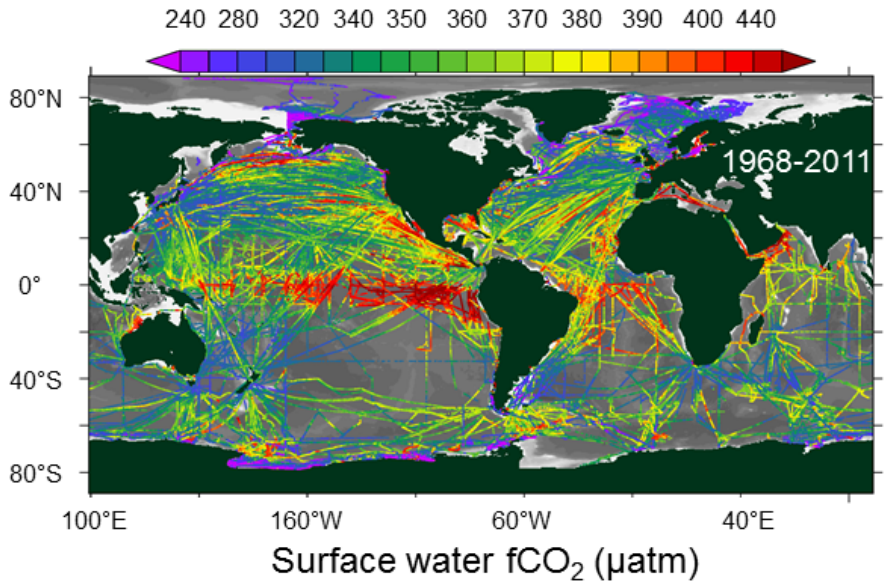

Fig. 3. The global distribution of surface water fCO2 values in SOCAT version 2 for 1968 to 2011 (http://www.socat.info/; Bakker et al. (2014))

From: Capacity Building Task Team:

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

From: Human Dimensions Working Group (HDWG):

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

From: Continental Margins Working Group:

21. The quest for resources is driving exploration and exploitation on continental margins, including the Arctic margins. Disasters, such as the 2010 BP-Deepwater Horizon oil spill, are likely to occur with increasing frequency and exacerbate on-going threats, such as coastal hypoxia. The IMBER-LOICZ Continental Margins Working Group (CMWG) found that the prevailing Law of the Sea promotes exploitation, but with insufficient responsibility and accountability to stem unsustainable development on continental margins. Recommendations from CMWG activities focus on reforms based on better understanding of the social-ecological systems (*Levin et al., 2015*), assessment of risks associated with development, and effective governance (*Glavovic et al., 2015*).

From Endorsed projects:

GALATHEA

22. Nutrient availability is considered to be a primary control on size structure of phytoplankton communities, with small cells being more competitive at low nutrient concentrations. However, research from the GALATHEA project indicates that temperature also appears to have a direct effect, with small cells dominating the community structure in warmer water. This temperature effect on cell size has implications for the ocean as a carbon sink because of the slower sinking rate of small cells (*Mousing et al., 2014).*

23. Localised vertical mixing between 200 m and the depth of the deep chlorophyll maximum (DCM, approximately 130 m) stimulates phytoplankton activity and alters the distribution of

zooplankton. Eel larvae in the Sargasso Sea tend to be concentrated in areas of deep mixing. This deep localized mixing may be responsible for heterogeneity in plankton distributions. Research continues to better understand the processes leading to this vertical mixing (*Richardson et al., 2014).*

24. It is expected that ocean warming will lead to increased bacterial activity and faster remineralisation of particulate organic carbon (POC) in the surface layers, which increase POC export to deep waters, potentially decreasing the strength of the biological pump. This temperature sensitivity of remineralisation in the global ocean has now been quantified and is an important input for modelling of the ocean carbon cycle (*Bendtsen et al., 2015).*

PERSEUS

25. Changes in the structure and functioning of the Black Sea food web between 1960 and 2000 were investigated with four models developed to evaluate trophic transfers. These models showed new energy pathways resulting from changes in trophic components and the conversion of significant amounts of system production to detritus. This shift in the food web led to various ecosystem-wide changes *(Akoglu et al., 2014).*

26. The project provided the first climatology of the seasonal thermocline slope and the upper-ocean heat storage rate in the Mediterranean Sea. This has Implication of sub-basin circulation patterns and the ocean heat storage. Climatologies of the mixed layer depth and temperature in the Mediterranean Sea was also updated *(Houpert et al., 2014)*

27. Biogeochemical data of the surficial and sub-surficial sediments of the Adriatic Sea were processed using statistical Q factor data analysis. Four different biogeochemical facies were identified, indicating that the biogeochemical and sedimentary processes of the Adriatic Sea have changed slightly in the last century *(Spagnoli et al., 2014)*

28. The connection between climate variability and anchovy spawning and recruitment in the Black Sea and other ecosystems, was studied using a two-way coupled lower trophic level and anchovy bioenergetics model. Temperature was the dominant factor influencing early life stages and the population dynamics of Black Sea anchovy through its effect on anchovy egg production and recruitment success. Each 2°C decrease in summer mean temperature resulted in a 12- to 19-day delay in egg production. This strong link between climate variability and anchovy spawning and recruitment could have important prediction potential for short-term anchovy stock estimations for fisheries management *(Guraslan et al., 2014).*

29. Human activities, such as shipping, aquaculture, and the opening of the Suez Canal, have led to the introduction of nearly 1000 alien species into the Mediterranean Sea. The local taxonomic identity of the alien species is dependent on the dominant maritime activities/interventions and the related pathways of introduction. Further research is needed to better understand how biodiversity changes will affect Mediterranean Sea food webs, ecosystem functioning, and the provision of ecosystem services *(Katsanevakis et al., 2014).*

30. Climate variation has increased surface temperature and stratification, producing a decrease in winter mixing. Oxygen and nutrient dynamics in the middle pycnocline have been decoupled. Nutrient concentrations in the upper layer decreased with the decrease in

anthropogenic eutrophication. Warm periods (series of warm winters) led to a decrease of oxygen in the Cold Intermediate Layer (CIL), an elevation of the hydrogen sulphide boundary and a decrease of nutrients in the surface layer. Cold periods (series of cold winters) lead to an increase of oxygen in the CIL, deepening of the hydrogen sulphide boundary and increase of nutrient in the surface layer *(Pakhomova et al., 2014)*.

31. Biomass size distribution, light absorption properties and carbon and nitrogen uptake rates were analysed in phytoplankton assemblages along coast–offshore gradients in the Alboran Sea. Surface nitrate concentration was >1 μM at the coastal stations and less than the detection limit at the offshore stations. Phytoplankton community biomass was dominated by diatoms at the coastal sites; dinoflagellates and picoplankton contributed <30 and 7%, respectively *(Mercado et al., 2014)*.

32. Studies of nutrients and phytoplankton during a deep convection episode showed that nutrient supplies were equivalent to the annual river discharge and that these events counterbalance decreased surface silicate to nitrate ratio. New hypotheses were proposed to explain triggering of the intense spring bloom *(Severin et al., 2014)*.

33. An overview of the pressures impacting the Southern European Seas (SES) and their roles in altering the environmental status was undertaken. Additional knowledge and improved understanding is needed to undertake a scientific Good Environmental Status (GES) evaluation. Some of the indicators for the *Marine Strategy Framework Directive* (MSFD) are almost impossible to evaluate for operational purposes (e.g. those related to biodiversity, food web structure, marine litter and microplastics, underwater noise and energy). Additional targeted scientific priorities were identified for the SES to help reduce uncertainties and gaps in data and knowledge *(Crise et al., 2015)*

34. The swarms of Portuguese Man-of-War (*Physalia physalis*) that appeared in summer 2010 in the Mediterranean Sea had dramatic consequences, including the region's first recorded human fatality attributed to a jellyfish sting. Analyses of the meteorological and oceanographic conditions of the Northeast Atlantic Ocean in the months prior to the appearance of *P. physalis* and simulation of the probable drift of Atlantic populations into the Mediterranean basin suggested that the swarms resulted from an unusual combination of meteorological and oceanographic conditions the previous winter, and was not a permanent invasion due to favourable climatic changes *(Prieto, et al., 2015)*.

35. Trawls in the coastal areas of the Eastern Mediterranean and Black Sea found up to 1211 items of litter per km^2. Plastics were the most abundant (mostly bags and bottles) litter, up to 95% of the total, in all study areas. More than half of marine litter items were of medium size: 10 × 10 cm, <20 × 20 cm. The results are presented in a recent report, supporting the Marine Strategy Framework Directive (MSFD) implementation, as well as efforts to discourage plastic carrier bag use *(Ioakeimidis et al., 2015)*.

36. A visual census of marine litter on the seafloor of the Saronikos Gulf (Greece) was combined with environmental education in a novel two-day research cruise, in which schoolchildren actively participated in using a Remote Operated Vehicle (ROV). Marine litter proved to be

an ideal theme to enhance the environmental awareness of schoolchildren *(Ioakeimidis et al., in press)*.

37. The first observation-based acidification trends in the water masses of the Atlantic basin over the past two decades were presented and compared with climate model results. Observations and model output confirm that pH changes in surface layers are dominated by the anthropogenic component. In mode and intermediate waters, the anthropogenic and natural components are of the same order of magnitude and sign (about -0.002 yr^{-1}). Large changes in the natural component of newly formed mode and intermediate waters are associated with latitudinal shifts of these water masses caused by the Southern Annular Mode in the South Atlantic and by changes in the rates of water mass formation in the North Atlantic *(Aida et al., 2015)*.

CARBOCHANGE

38. Identifying the magnitude of a trend and the point in time when this signal emerges from the background noise of natural variability is essential for the detection of climate change. Even strong trends, in both the physical climate and carbon cycle system, can be masked by variability over decadal timescales in areas with high natural variability. Because natural variability, unlike the trend, is affected by the seasonal cycle, observational data must be interpreted with caution. Intra-annual variability may obscure the representiveness of irregularly sampled seasonal measurements taken over a year and, thus, the interpretation of any observed trends *(Keller et al., 2014)*.

39. Global CO_2 emissions from fossil-fuel combustion and cement production will increase by 2.5% (1.3–3.5%) to 10.1 ± 0.6 GtC in 2014, 65% above 1990 emissions. The cumulative emissions of CO_2 (from 1870–2014) will reach about 545 ± 55 GtC *(Le Quéré et al., 2014)*.

40. It has been argued that controlling only the Earth's temperature (e.g. the 2°C target) may not be sufficient to control the other impacts of climate change. Six target variables (air temperature, sea-level rise, aragonite, primary production levels, soil, and carbon loss) were analysed under different limits using a state-of-the-art cutting-edge Earth system model. The results showed that allowable carbon emissions were considerably reduced, suggesting that mitigation efforts focused solely focus on a temperature target will not limit the risk arising from human-induced emissions *(Steinacher et al., 2013)*.

41. By 2100, under the high CO_2 emission scenario RCP8.5, pH reductions exceeding -0.2 (-0.3) units are projected to be about 23% (~15 %) for waters of North Atlantic deep-sea canyons and ~8% (3 %) waters over seamounts, including seamounts proposed as sites for marine protected areas. The spatial pattern of impacts reflects the depth of the pH perturbation and does not scale linearly with atmospheric CO_2 concentration. Impacts may cause negative changes of the same magnitude, or exceeding the current target of 10% of preservation of marine biomes set by the Convention on Biological Diversity, implying that ocean acidification may offset benefits from conservation/management strategies that rely on regulation of resource exploitation *(Gehlen et al., 2014)*

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

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

C. Activities of IMBER Regional Programmes

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

The ESSAS programme (www.imr.no/essas) focuses on the impacts of climate change on sub-Arctic and Arctic marine ecosystems and their sustainability. The recent expansion of ESSAS research interests into the Arctic resulted in modifying the name to Ecosystem Studies of Sub-Arctic and Arctic Seas, which retains the programme acronym. Comparative ecosystem studies are an important part of ESSAS research and this provides a basis for interactions with other IMBER regional programmes.

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

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

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

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

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

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

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

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

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

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

CLimate Impacts on Oceanic TOp Predators (CLIOTOP) Regional Programme

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

A special issue of *Deep-Sea Research II* (26 papers) was published following the 2nd CLIOTOP symposium. Meetings organized by CLIOTOP Working Groups have generated a large amount of scientific results as indicated by the publications listed on the IMBER website at (http://imber.info/Science/Regional-Programmes/CLIOTOP).

CLIOTOP has been ongoing for almost 10 years, and is now assessing its scientific objectives and structure in terms of the new IMBER SPIS. Currently, CLIOTOP research is done through working groups, several of which will soon be concluded. The CLIOTOP SSC is now discussing a new structure for a proposed CLIOTOP phase III, for the next five years. As a start towards this process, the IMBER SSC at its meeting in June 2015 supported the continuation of CLIOTOP as a regional programme, gave a mandate to modify the programme structure, and recoginized the need for flexibility in how limited resources are allocated.

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

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

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

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

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

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

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

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

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

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

D. Activities of IMBER Working Groups and Task Team

SOLAS-IMBER Carbon (SIC!) Working Group

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

Surface Ocean Systems (SIC!-SOS)
The main goal of this group is the continued development of the Surface Ocean Carbon Atlas (SOCAT).

Interior Ocean Carbon (SIC!-IOC)
This working group co-ordinates international research on interior ocean changes in carbon and biogeochemistry, undertakes synthesis activities, and aims to develop sustainable observing systems, including the addition of oxygen sensors to the international ARGO float programme (ARGO-O_2). Recent activities focused on the analysis of carbon data from hydrographic surveys to determine the change in the ocean's anthropogenic CO_2 content since the 1990s. This analysis is now in the final stages (paper draft completed) and the synthesis project should be completed by early 2016. This group also contributed to the planning of the upcoming joint GO-SHIP/Argo/IOCCP meeting in Galway on the topic of "Sustained ocean observing for the next decade" http://www.gaic2015.org, assisted in the development of essential ocean variables (EOV), led by IOCCP (see http://www.ioccp.org/foo), and also assisted in the development of global dataset of ocean interior variables (GLODAPv2, led by CarboChange).

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

The Ocean Acidification International Coordination Centre (OA-ICC), initiated and mainly driven by the SIOA, is in its final year of funding (2013-2015), and a proposal has been submitted to IAEA in Monaco for three additional years of support. The Centre aims to foster scientific collaboration at the international level, promote best practices, improve observational capacities and databases, and facilitate communication and outreach. The OA-ICC is supervised by a science coordinator (SIOA's current chair). The OA-ICC advisory board includes all SIOA members and is chaired by a SIOA member. The OA-ICC produced several key products that have become fundamental building blocks for the ocean acidification research community and ocean acidification science users, including the OA-ICC web site, www.iaea.org/ocean-acidification; OA-ICC news stream at news-oceanacidification-icc.org; OA-ICC bibliographic database, http://tinyurl.com/oaicc-biblio; OA-ICC data compilation at http://tinyurl.com/oaicc-data (now including data from almost 600 publications); an SIOA / IOCCP / CARBOCHANGE comparison study of the seven publicly available software packages that compute marine carbonate chemistry was published in *Biogeosciences Discussions*; and the OA-ICC slide set *Things you should know about ocean acidification*, produced for scientists to facilitate making presentations on ocean acidification to non-scientists https://www.iaea.org/ocean-acidification/download/Resources/OA_slides-generalaudience_17feb2013.pdf .

The 4th Ocean in a High-CO_2 World Symposium will be held in Hobart, Australia on 3-6 May 2016. SIOA organised several side events at the IPCC *Our Common Future Under Climate Change* conference in Paris in July 2015, and produced a variety of outreach material.
Continental Margins Working Group (CMWG)

The CMWG is co-sponsored by IMBER and Future Earth Coasts (previous LOICZ). As human activities dominate key global processes in the Anthropocene, there is an urgent need to secure sustainability by implementing transformative governance strategies to safeguard Earth's life-support systems for long-term human well-being. Nowhere is this endeavour in greater demand

than at the ocean-land interface – the continental margins, which are experiencing pressures from:

- Population growth, development intensification and rising demands for energy-intensive resources;
- Ecosystem degradation and loss;
- Rising CO_2 concentrations, climate change and alteration of marine biogeochemistry and ecosystems; and
- Ecosystem tipping points and rapid and irreversible changes in social-ecological systems and societal responses.

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

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

Data Management Committee (DMC)

The Data Management Cookbook (http://imber.info/index.php/Science/Working-Groups/Data Management/Cookbook) remains an important and significant product of the DMC. Data management workshops have been organised at the IMBIZOs and the OSC. At IMBIZO IV the DMC will provide advice and guidance on all data-related issues. The SSC discussed if a separate committee is still needed for data management. The consensus was that continuation of DMC would be only with a revised focus and mandate (e.g. social science data use), which will require membership with different expertise. It is noted that even managing just a meta-database requires a dedicated data liaison person. Making use of international *in situ* data organizing activities, e.g. "Data kind.org" might be an approach for submitting metadata that identifies IMBER data. A plan for the future is needed if DMC shall continue, however the DMC has earlier recommended: to fully integrate data management activities in all IMBER project-wide events; to ensure that endorsed projects are prepared to comply with IMBER DM policies; and to organise a meeting of data scientists of IMBER-endorsed projects and regional programmes.

Capacity Building Task Team (CBTT)

The CBTT objectives are to enhance marine research capabilities in less developed countries, enhance research capabilities globally in relevant IMBER activities, and strengthen graduate education in ocean sciences. The IMBER SSC believes that the CBTT has completed its mandate and will disband this group. Capacity building will continue as it is now included in all regional programmes and working groups, and through activities, such as the summer schools and IMBIZOs.

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

Human Dimensions Working Group (HDWG)

The HDWG focuses on the interactions between human and ocean systems, and aims to create an integrated and interactive natural-social science marine research community within IMBER. One of its major achievements has been the development of the I(MBER)-ADApT decision support tool (see section B). .

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

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

IMBER-CLIVAR Upwelling Working Group

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

E. Other IMBER activities

ClimEco Summer Schools

IMBER ClimEco Summer Schools are held every two years and are a successful capacity building mechanism for engaging students and early-career scientists. The ClimEco4 Summer School titled, '*Delineating the issues of climate change and impacts to marine ecosystems: Bridging the gap between research, assessment, policy and management*', was held in early August 2014, at East China Normal University, Shanghai, China. It focused on indicators that inform about the impact of global change on marine ecosystems and the human populations that depend on them, and on how to combine them so that they can be used to inform policy and decision-making. Sixty-four participants from 30 countries were selected from almost 170 applications received. SCOR provided support for two students from developing countries.

Topics covered in lectures included an overview of climate change impacts on marine ecosystems from a biophysical and human perspective, information about indicators, models, analysis, linking indicators to a regulatory or management perspective, and bridging the gap between research and information that is practically useful for management. Practical sessions

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

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

IMBIZO IV

The IMBIZO IV will be held in Trieste, Italy on **2**6-30 October 2015. The IMBIZO has been expanded to four concurrent workshops and several integration sessions. Funding has been secured from several sponsors, including SCOR, to support students and early career researchers. The planning and preparation for the IMBIZOs is a major effort for the IPO.

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

The new SPIS is based on a position paper that was discussed at the IMBER Open Science Conference (OSC) in June 2014. The current version includes a new vision and research goal for IMBER, and is developed around three Grand Challenges (GC) and four Innovation Challenges (IC). Specific research questions relating to the GCs and ICs are intended to provide the basis for implementation of research programs. The SPIS will be submitted to SCOR and Future Earth (FE) in October 2015 for joint review.

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

IMBER contributions to IGBP synthesis and celebration at AGU

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

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

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

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

Status of the International Project Office (IPO, Norway) and the Regional Project Office (RPO, China)
The IPO will continue to be hosted by the Institute of Marine Research (IMR) in Bergen, Norway until April 2017. In February 2015, Einar Svendsen (oceanographer from IMR) was appointed as Executive Officer of IMBER. In spring 2015, the IPO was relocated within IMR to be closer to the management team of the *Hjort Centre for Marine Ecosystem Dynamics*, sponsored by the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, the University of Bergen and Uni Research. This has increased interaction with a broader research community, and allows easy exchange of information on activities and publications. Discussions with the Norwegian Research Council and the leadership of IMR have been initiated to secure funding for a second 5-year period.

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

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

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

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

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

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

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

G. IMBER cooperation

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

a. *Too Big To Ignore (TBTI)*
   IMBER is a partner of the TBTI project. TBTI has reached its midpoint and now includes over 200 scientists from 45 countries. TBTI is conducting a global analysis, based on information systems, to better understand small-scale fisheries (SSF). IMBER information that might relate to SSF can be added at http://issf.toobigtoignore.net, and this can be used for case studies for I-ADApT. There will be collaboration at IMBIZO IV. It is suggested that a transdisciplinary cluster might provide topics for the ClimEco5 summer school.
b. *Ocean Carbon Biogeochemistry (OCB)*
   OCB continues to actively support IMBER by advertising its activities and events, and by providing financial support for activities. This year OCB is providing travel support for five participants from the USA to attend IMBIZO IV. There are plans to hold a half-day session on IMBER science at the 2016 OCB summer workshop.
c. *GEOTRACES*
   Deals with biogeochemical cycles and large scale distribution of trace elements and isotopes, featuring a worldwide set of sampling transects across ocean basins.
d. *WCRP*
   CLIVAR, a core project of WCRP and its Indian Ocean panel work closely with SIBER. CLIVAR will hold an OSC on 19-23 September 2016 in Qingdao, China and several

IMBER-related sessions will be convened as this conference. IMBER and CLIVAR ard forming a Joint Upwelling WG.

e. GOOS/Copernicus
SIBER has strong connections with IO-GOOS, and IMR is involved with EURO-GOOS through Copernicus (European Programme to establish European capacity for Earth Observation). GOOS uses a system of global and regional models of different parts of the world ocean, which consider primarily ocean physics but with some primary production included. Increased alignment with GOOS will help IMBER deal with the challenge of ocean data.

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

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

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

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

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

H. Selected IMBER Publications

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

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Communication and Outreach

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

The *IMBER Update Newsletter*, www.imber.info/index.php/News/Newsletters, is emailed to ~2000 scientists three times each year, and re-directed through multiple channels to about 10,000 researchers:

- ***Issue n°28*** - June 2015, included articles about a new ESSAS Arctic project, Canadian research in the North, a generic concept for the vertical behaviour of fish eggs in the world oceans, observing changes in the surface ocean carbon, and a world-wide evaluation of the use of ecosystem drivers of stock production in tactical fisheries management.
- ***Issue n°27*** - September 2014, included articles about science highlights from the IMBER Future Oceans Open Science Conference in Bergen. This included the following:

    - Predicting Fish from Physics: Strengths, weaknesses and ways forward;
    - Mesopelagic fishes in the California Current: ecosystem role, climate change impacts and the need for global observations of marine fish populations;
    - From watching to acting: adaptation in marine systems;
    - *Trichodesmium* Growth Rates: Modelling the Fundamental Niche;
    - *Phaeocystis pouchetii* bloom from the perspective of heterotrophic bacteria;
    - Should we shift towards collaborative management? Case study of the Asturian (northern Spain) gooseneck barnacle fishery;
    - Time of emergence of trends in ocean biogeochemistry;
    - Recent climatic changes enhance ongoing ocean acidification in the California Current System;
    - Diving depth of elephant seals influences mercury bioaccumulation in the north Pacific.

Other IMBER-related activities that were included featured GLODAPv2, a new and updated global ocean carbon data product, and The 2014 Community Event of the Surface Ocean CO_2 Atlas.

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

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

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

I. Support from SCOR

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

Funding request

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

Amount requested: 7,500 USD

J. Strategic development

IMBER is in the last year of its initial 10-year science plan. The IMBER science community has clearly indicated a desire for the project to continue. The enthusiasm and support shown at the June 2014 OSC indicated that there is a strong community of researchers engaged in IMBER science. The new Science Plan and Implementation Strategy will provide guidance for marine research for the next phase of IMBER.

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

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

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

K. Budget

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

3.3 GEOTRACES *Naqvi*

Terms of Reference:

- Organize national and international planning workshops as well as special sessions at international conferences to obtain community input on the design and implementation of GEOTRACES.
- Establish priorities for research on the sources, sinks, internal cycling, transport, speciation and fate of TEIs, and develop this information into an International Science Plan.
- Promote intercalibration of analytical methods, and the development of standard reference materials.
- Identify new instrumentation and related infrastructure that will help achieve GEOTRACES objectives.
- Define a policy for data management and sample archival.
- Forge scientific linkages with other research programs holding overlapping interests to create synergies where possible and avoid duplication of efforts. To the extent practical, this will involve cross-membership between the GEOTRACES Planning Group and the Planning Groups and Science Steering Committees of other programs.
- Interact with SCOR Working Groups that share common interests including, but not limited to, SCOR/IMAGES WG 123 on Reconstruction of Past Ocean Circulation (PACE) and SCOR/IMAGES WG 124 on Analyzing the Links Between Present Oceanic Processes and Paleo-Records (LINKS).

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Jordi Garcia-Orellana	SPAIN	Katherina Pahnke	GERMANY
Vanessa Hatje	BRAZIL	Micha Rijkenberg	NETHERLANDS
Tung-Yuan Ho	CHINA-Taipei	Alakendra Roychoudhury	S. AFRICA
Phoebe Lam	USA	Géraldine Sarthou	FRANCE
Maeve Lohan	UK	David Turner	SWEDEN
Maria Maldonado	CANADA	Angela Wagner	BRAZIL
		Liping Zhou	CHINA-Beijing

Executive Committee Reporter: Wajih Naqvi

GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2014/2015
June 2015

1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

Co-Chairs
Ed Boyle, USA
Reiner Schlitzer, Germany

Members
Andrew Bowie, Australia
Ludmila L. Demina, Russia
Jordi Garcia-Orellana, Spain
Vanessa Hatje, Brazil
Tung-Yuan Ho, China-Taipei
Phoebe Lam, USA
Maeve Lohan, UK
Maria T (Maite) Maldonado, Canada
Olivier Marchal, USA
Hajime Obata, Japan
Katharina Pahnke, Germany
Micha Rijkenberg, Netherlands
Alakendra Roychoudhury, South Africa
Géraldine Sarthou, France
David Turner, Sweden
Angela Wagener, Brazil
Liping Zhou, China-Beijing

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

2. Progress on implementation of the project

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

2.1 Status of GEOTRACES field programme

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

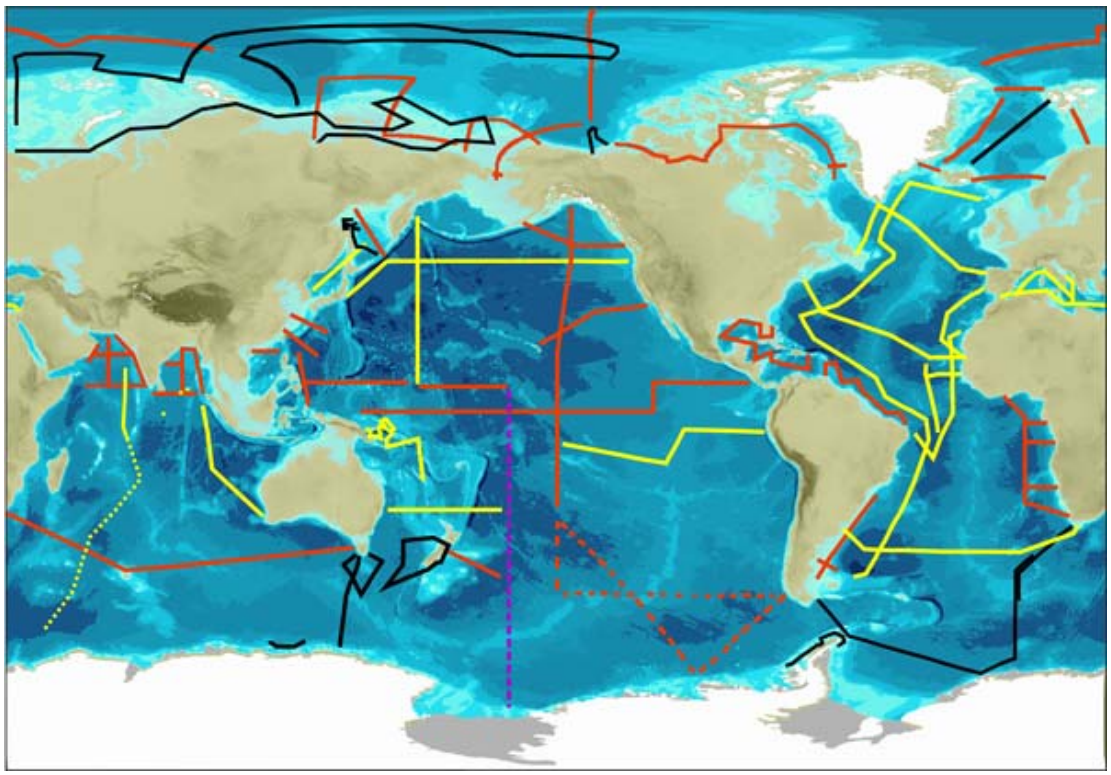


Figure 1: *Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey (dotted purple, completed during the past year).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

2.2 GEOTRACES Intermediate Data Product 2014

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

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

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

GEOTRACES Intermediate Data Product 2014 survey

In order to help improve future Intermediate Data Products, GEOTRACES designed a survey to collect feedback from users of the IDP2014. The survey collected 262 responses, from which only 16% of the respondents were data contributors. Results from the survey can be grouped on: (1)

completion of the product and suggestions for improvement; (2) use of data; (3) and dissemination. Results from each of these categories are described below:

- Completion of the product and suggestions for improvement

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

- Use of data

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

- Dissemination

76% of the respondents were aware of the IDP2014 prior to the survey (the survey served as an effective means of dissemination for the other respondents). When asked about how users learned about the IDP2014, GEOTRACES media (website and mailing list) was listed first (total of 44% of the respondents), followed by the GEOTRACES 2014 Ocean Sciences Town Hall and SCOR Booth (24% of the respondents). Word of mouth was listed in third position.

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

2.3 GEOTRACES Publications

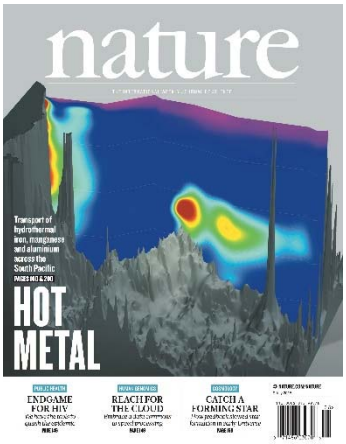
The GEOTRACES publications database (http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers) includes 548 GEOTRACES publications available from the beginning of the project. The following three new Special Issues have been published this year and four more are in preparation:

Progress in Oceanography (Volume 133, Pages 1-78, April 2015)
GEOTRACES Synthesis and Modeling: The role of particles in the marine biogeochemical cycles of trace elements and their isotopes
Edited by Catherine Jeandel, Olivier Marchal, Phoebe J. Lam and Robert F. Anderson
http://www.sciencedirect.com/science/journal/00796611/133

Deep Sea Research Part II: Topical Studies in Oceanography (Volume 116, Pages 1-342, June 2015)
GEOTRACES GA-03 - The U.S. GEOTRACES North Atlantic Transect
Edited by Edward A. Boyle, Robert F. Anderson, Gregory A. Cutter, Rana Fine, William J Jenkins and Mak Saito
http://www.sciencedirect.com/science/journal/09670645

Marine Chemistry (Volume 173, Pages 1-342, July 2015)
SCOR WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean
Edited by Sylvia Sander, Kristen Buck and Maeve Lohan
http://www.sciencedirect.com/science/journal/03044203/173

GEOTRACES findings featured on the cover of Nature



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

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

2.4 GEOTRACES Science highlights

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

Dissolved Iron Sources in the North Atlantic Ocean Quantified

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

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

Since Fe is an essential marine micronutrient for phytoplankton, the scarcity of dissolved Fe in surface waters limits biological productivity over much of the oceans. Thus, changes in Fe inputs from different dissolved Fe sources have important implications for patterns of marine productivity

and the global carbon cycle. This study therefore represents a significant contribution to our understanding of how dissolved Fe may influence past and future global change.

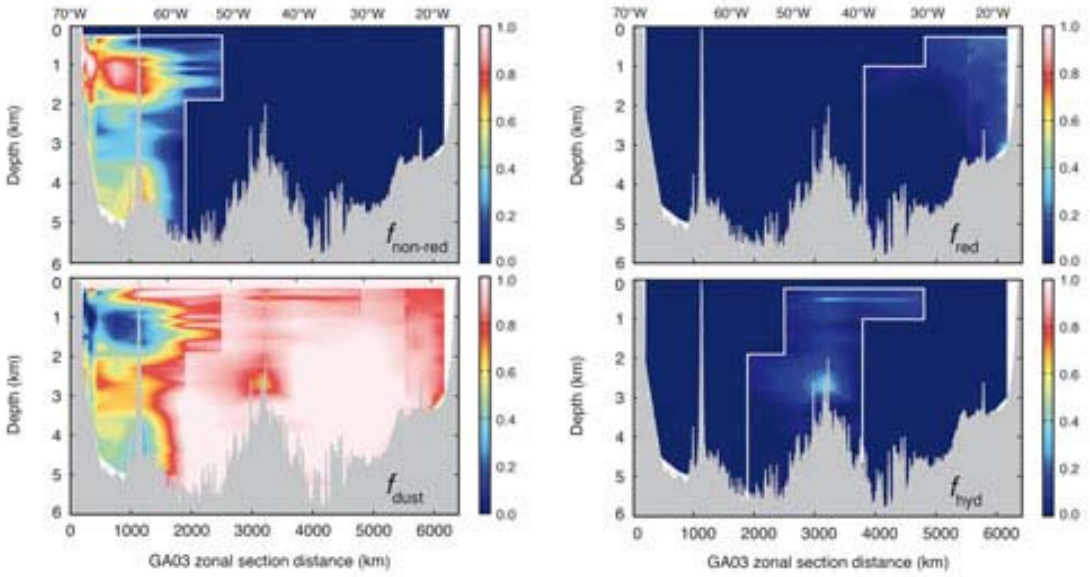


Figure 2: *The figure shows the fraction of the seawater-dissolved Fe across the GA03 North Atlantic section that originates from each of four distinct sources : 1. Fe from oxygenated sediments on the North American margin (fnon-red); 2. Fe released by dissolution of atmospheric dust (fdust); 3. Fe from reducing sedimentry porewaters on the West African Margin (fred); and 4. Fe from hydrothermal venting on the Mid-Atlantic Ridge (fhyd).*

Reference:

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

Field Data Constrain Ocean Mercury Budget

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

Global budgets of total mercury suggest that there has been a tripling of the surface water mercury content and a ~150% increase in the amount of mercury in thermocline waters above preindustrial levels.

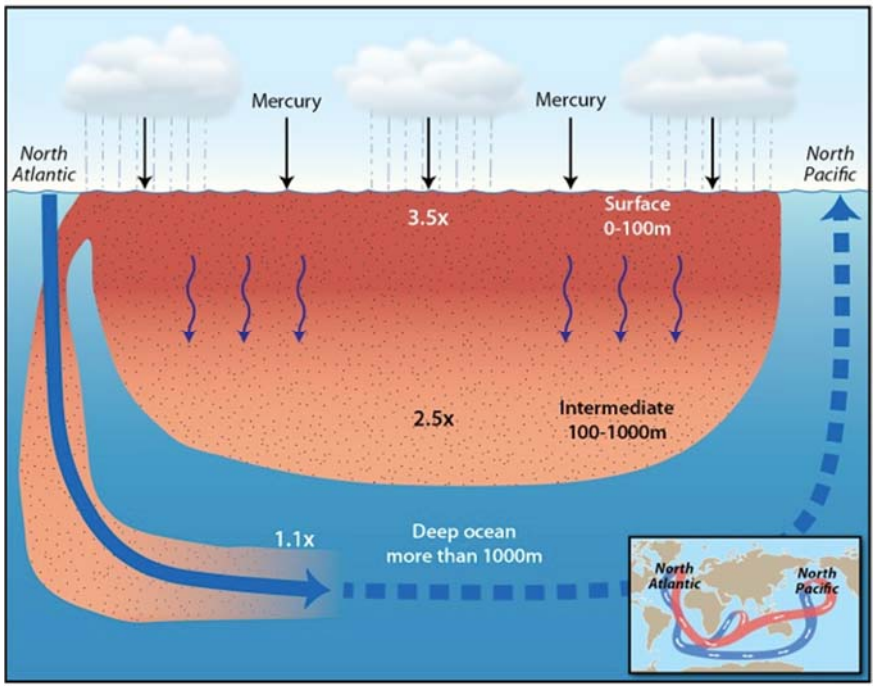


Figure 3: *GEOTRACES researchers led by Carl Lamborg found that anthropogenic mercury (primarily atmospheric emissions produced by coal burning and cement production, as well as gold mining) have caused ocean waters down to 100 meters depth to be enriched in the toxic element up to 3.5 times the background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

Reference:

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

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

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

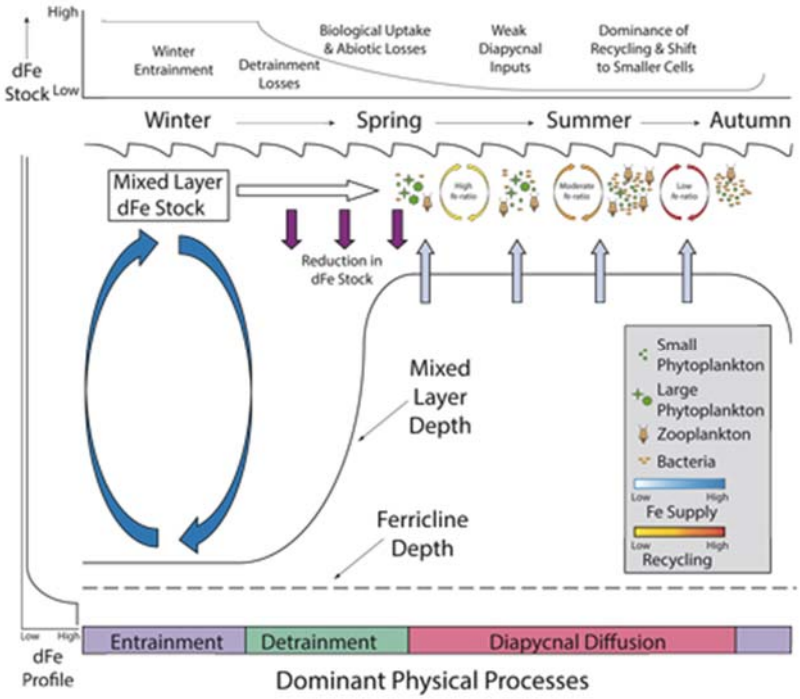


Figure 4: *This diagram represents the seasonal variability in Southern Ocean iron (Fe) cycling.*

Reference:

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

What Controls the Copper Isotopic Composition in Oceanic Waters?

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

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

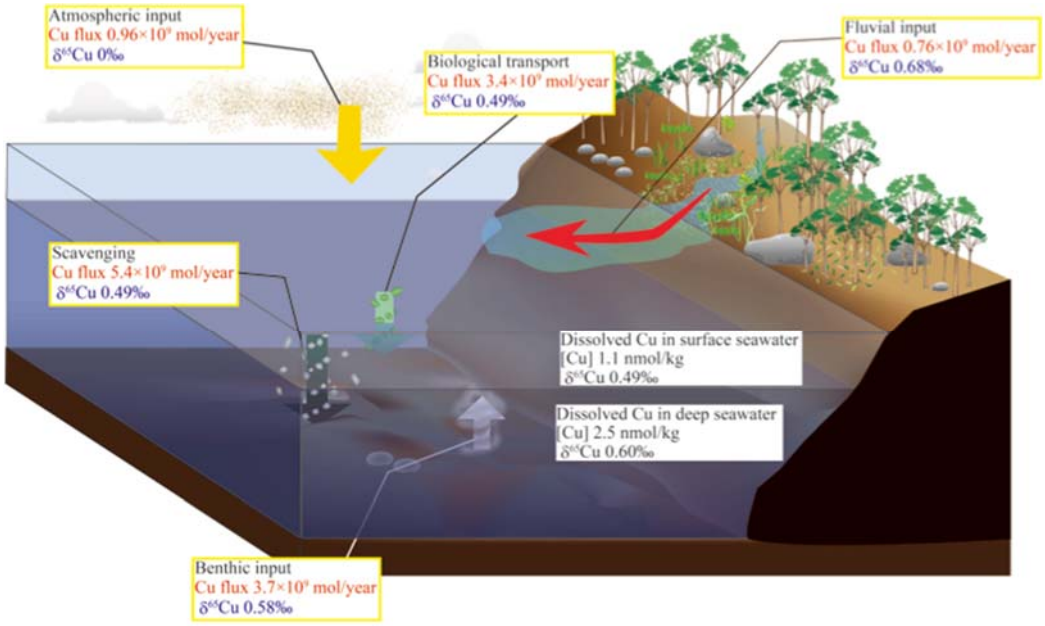


Figure 5: *A box-model of Cu in the ocean based on both Cu concentration and isotopic composition.*

Reference:

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

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

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

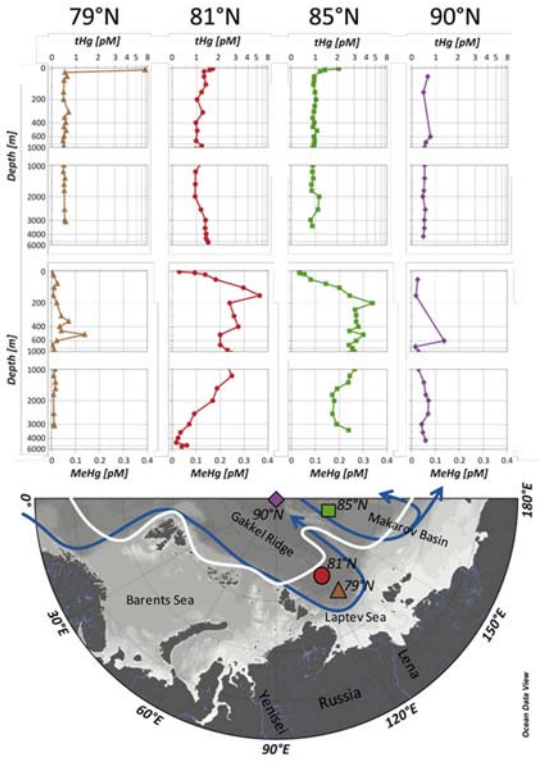


Figure 6: *Total mercury (tHg) and methylmercury (MeHg) profiles in picomoles per litre (pM) at the coastally influenced open-water Laptev Sea station (PS78/280:79°N; brown triangles), the open-water Amundsen Basin station at the sea ice edge (PS78/273:81°N; red dots), the > 75% sea ice-covered Makarov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

References:

Heimbürger, L.-E., Sonke, J. E., Cossa, D., Point, D., Lagane, C., Laffont, L., Galfond, B.T., Nicolaus, M., Rabe, B., van der Loeff, M. R. (2015). Shallow methylmercury production in the marginal sea ice zone of the central Arctic Ocean. Sci. Rep., 5. DOI: 10.1038/srep10318.

Rudels, B. Arctic Ocean circulation and variability - advection and external forcing encounter constraints and local processes. Ocean. Sci. 8 261–286 (2012).

Unexpected Magnitude of the Hydrothermal Iron Inputs in the Deep Pacific

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

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

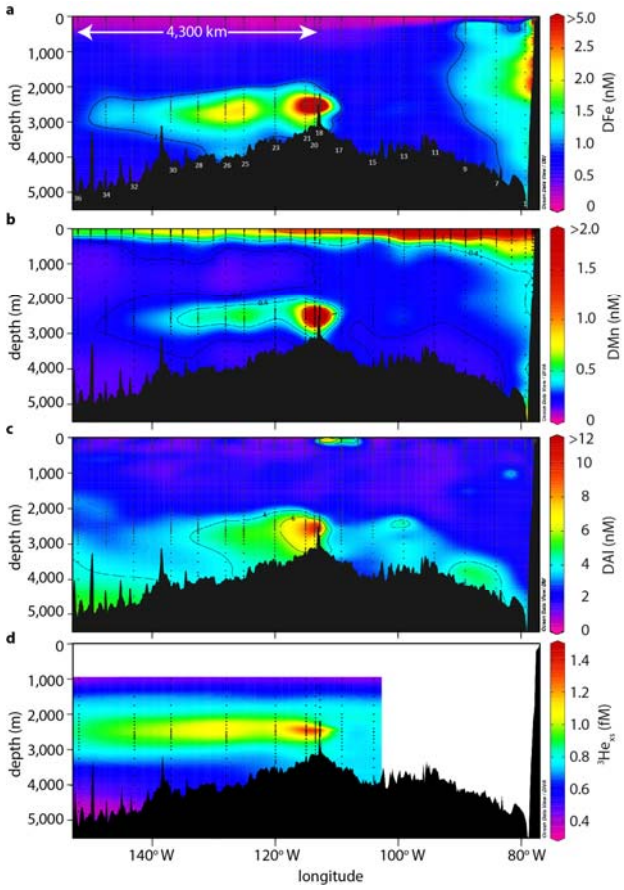


Figure 7: *The top three panels show concentrations of dissolved iron, manganese and aluminum measured during the voyage. The bottom panel shows concentration of a form of helium that marks the water as coming from a hydrothermal vent, and its decreasing concentration away from the ridge reflects mixing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

Reference:

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

Coupling Rare Earth Elements Concentrations, Neodymium And Radium Isotopes: A Powerful Tool to Decode Environmental Processes

For the first time, neodymium (Nd) isotopic compositions have been measured together with dissolved and colloidal Rare Earth Elements (REE) concentrations in the Amazon estuary salinity gradient, as part of the GEOTRACES process study AMANDES (Chief scientist: Catherine Jeandel). The sharp drop of REE concentrations in the low-salinity area (already observed in several estuaries) is clearly driven by the coagulation of colloidal material. While dissolved REE concentrations increase again at mid-salinities, Nd isotopic ratios allow tracing that these REE are released by lithogenic material, weathered and transported by the river to the Atlantic Ocean. The original coupling with radium (Ra) isotopes demonstrates that these dissolution processes are occurring within three weeks in the Amazon plume.

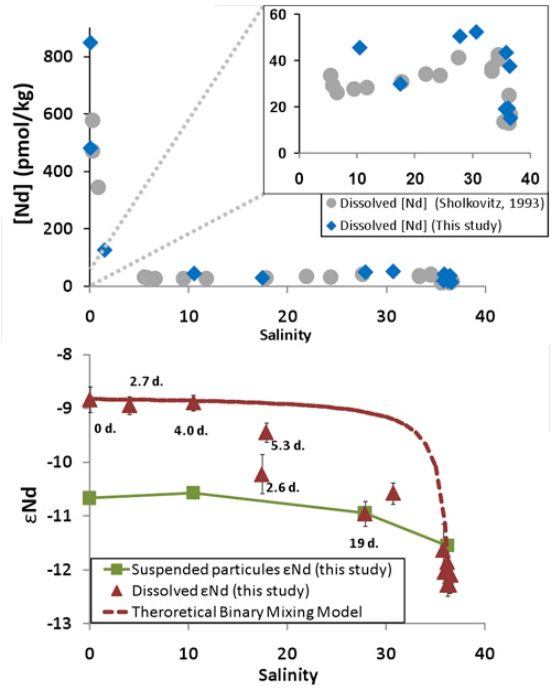


Figure 8: *Nd concentrations and isotopic composition in the Amazon River estuary.*

Upper panel: *Amazon estuary [Nd] from Sholkovitz' 1993 study (grey circles) and this study (Blue diamonds) are reported against the salinity gradient. We observe the non conservative mixing between the Amazon river and the Atlantic waters. The sharp drop in [Nd] in the low salinity region is attributed to the coagulation of colloids, the main REE carriers within river. This drop in concentrations is followed by an increase with salinity before reaching typical low Nd levels of marine waters.*
Lower panel: *Amazon estuary dissolved (Red triangles), particulate (Green squares) εNd and apparent radium ages (in days) values are reported against the salinity gradient. A simple two-endmember (Amazon and Atlantic dissolved Nd) mixing model (red dashed line) is not sufficient to explain εNd variation within the salinity gradient. The dissolved Nd phase rapidly (19 days) homogenizes with a third source, the suspended sediments.*

Reference:

Rousseau, T. C. C., Sonke, J. E., Chmeleff, J., Beek, P. van, Souhaut, M., Boaventura, G., Seyler, P., Jeandel, C. (2015). Rapid neodymium release to marine waters from lithogenic sediments in the Amazon estuary. Nature Communications, 6, 7592. doi:10.1038/ncomms8592.

3. Activities

3.1 GEOTRACES Intercalibration Activities

After the preceding and very busy year reviewing all intercalibration results for the first IDP release, the Standards and Intercalibration (S&I) Committee had a far less stressful, but productive, year. In addition, three new members joined the committee: Karen Casciotti (Stanford University, California, USA) covering N and C isotopes, Walter Geibert (Alfred Wegner Institute, Germany) handling radionuclides, and Tina van de Flierdt (Imperial College, London, UK) covering radiogenic isotopes such as neodymium. Both Karen and Tina were elemental coordinators in the initial 2008-2009 phase of the GEOTRACES Intercalibration programme and cruises, while Walter stood in for Michael van der Loeff for one meeting during the same phase of the programme. Thus, the new members of the committee are experienced with the processes of intercalibration and evaluating results from cruises.

The major accomplishment of the Committee in this period was completion and posting of the newest (Version 2.0) "Sampling and sample handling protocols for GEOTRACES cruises" cookbook on the GEOTRACES website, http://www.geotraces.org/images/stories/documents/intercalibration/Cookbook.pdf. This version has many updates for the various TEIs throughout the document and also includes a new section on artificial radionuclides that did not make it into the original version. Additionally, the hydrography requirements and methods were updated to be fully compliant with the GO-SHIP programme protocols. More significantly, the specifications for meeting intercalibration criteria were tightened up, changing the recommendations to requirements. The Committee decided that the cookbook will be updated every two years, so the next update will be in 2017 unless something critical needs to be updated/modified before this. To complement the cookbook, two Intercalibration Procedure documents, one for cruises with crossover stations and one for those without them, were created to help investigators undertake intercalibration before the S&I Committee sees the results (http://www.geotraces.org/science/intercalibration/89-intercalibration-documents). Both documents are only two pages long and should facilitate intercalibration between the relevant investigators largely independent of the Committee.

The Committee met in Galway, Ireland in January 2015 at the National University of Ireland and hosted by Peter Croot. In attendance were Per Andersson attending his last S&I meeting, Peter Croot, Greg Cutter, Walter Geibert, and Maeve Lohan; Karen Casciotti participated via conference software/internet connection. Topics discussed included calibration and reference materials for GEOTRACES TEIs; the latest compilation of TEI acceptability criteria to achieve intercalibration (e.g., nutrients within 2%); updates on recent intercalibration efforts including mercury, ligands (SCOR Working Group 139), cobalt, silicon isotopes, and particles; status of data from post-2014 IDP cruises; data review procedures for the next IDP; and timelines for reviews and plans for the Committee's next meeting. With respect to the latter, the Committee would like to meet in June 2016 and Karen Casciotti offered to host the meeting at Stanford University. Finally, to better track the status of cruises, relevant investigators, and intercalibration status for each TEI, the Committee began a spreadsheet with all the relevant information. This document will be shared with the Data Management Committee to better coordinate and inform collaborations for ensuring a timely and accurate IDP.

For the next year, 2015-2016, the major activities of the S&I Committee will be contacting cruise investigators to ensure that they are conducting their intercalibrations via the established procedures and submitting their results to the Committee, and reviewing these results for the next IDP. With respect to the latter, the Committee will work much more closely with the Data Management Committee to ensure the timely and accurate incorporation of cruise data into the 2017 IDP. The Committee also will continue to identify suitable dissolved and particulate reference materials for the diverse suite of TEIs examined in GEOTRACES and monitor on-going intercalibration activities (e.g., chemical speciation). Finally, Lars-Eric Heimbürger at University of Bremen (Germany) will join the Committee as its newest member, with expertise in mercury and other contamination-prone trace elements.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanographic Data Centre (BODC), whose headquarters is located in Liverpool. The GEOTRACES Data Manager is based at the BODC Southampton, UK office. Regular communication is maintained between the two sites so that support and assistance can be offered to the GEOTRACES Data Manager when required.

GDAC is responsible for the entirety of the GEOTRACES data activities from inception to completion. This takes into account the following components:

- interaction between PIs and national data centres in order to encourage regular and timely data and metadata submissions
- maintaining and modifying GDAC webpages to include updated ocean basin maps (http://www.bodc.ac.uk/geotraces/cruises/section_maps/) and upcoming cruises on the programme page (http://www.bodc.ac.uk/geotraces/cruises/programme/)
- liaising with the Data Management Committee and Standards and Inter-calibration Committee to ensure that issues and questions relating to GEOTRACES and its progression as a project can be discussed, and deadlines can be met accordingly.
- input of metadata and data into the BODC database and compilation of documentation to include analysis methodologies
- Collation of data and metadata for the 2017 Intermediate Data Product

GDAC, until recently, has been staff by a single person. This was Edward Mawji up until February 2015, at which point Abigail Bull took his place as the GEOTRACES Data Manager. BODC has provided extra resources to the GEOTRACES Project in order to aid and provide support to Abigail, primarily with the data processing. When the GEOTRACES Project expects to experience busy periods (i.e., in the lead up to the 2017 IDP) this extra resource will be invaluable. This data management report will highlight tasks that have been the focal point of GDAC since this Abigail Bull became the Data Manager in February 2015.

Working with the IPO

A sound working mechanism has been established between the GEOTRACES IPO and GDAC, even with the changeover of staff members at BODC. The IPO has been particularly useful in providing guidance to the new GEOTRACES Manager so the GEOTRACES project can continue to run efficiently. When there is a change in staff there is often a period of time dedicated to learning and development – the IPO has provided unending support in this matter and has made the new GEOTRACES Project Manager feel welcome. The IPO has also helped GDAC stay up to date with new cruises, as well as serving reminders of when certain people should be contacted in order to extract various information at relevant times.

Meetings attended

Various visits have been made since stepping into the GEOTRACES Data Manager role. These are essential for building good relationships with national data centres. The meetings attended including the following:

- Visit to the IPO Office in Toulouse, where Abigail met with Elena Masferrer Dodas and Catherine Jeandel. The GEOTRACES Project as a whole was discussed, as well as ways in which the IPO could support Abigail in her new role. Meeting significant GEOTRACES Project participants in person has solidified working relationships. This meeting also presented an opportunity to ask questions and clarify any outstanding issues. Also present was Catherine Schmechtig (Data Manager at French data centre - LEFE Cyber) The formats and submission of French data were discussed, along with retrieval of outstanding cruise reports for French cruises. This proved beneficial, as there is now a strong working relationship and communication method between the French data centre and GDAC.

- Meeting with Reiner Schlitzer in Bremen, Germany. The aim was to meet Reiner before the DMC/SSC meeting in July 2015, and to discuss various data-related items. These included version 2 of the 2014 IDP, the possibility of an interactive map on the GDAC website, IDP parameter codes, and preparation techniques for the 2017 IDP. The meeting was extremely useful in regards to identifying priorities for the project, as well as ascertaining items which should be discussed at the DMC meeting in order to clarify unanswered questions.

- Regular meetings with Alessandro Taglibue (DMC co-chair) in Liverpool – these one-to-one meetings have provided guidance and support to Abigail as the new GEOTRACES Data Manager. Data discussions as well as GDAC DMC items have been addressed in these informal meetings.

- Meeting with Cyndy Chandler (BCO-DMO) in Liverpool – discussion centred around BCO-DMO (the U.S. data centre) and what it can do to assist GDAC in its responsibilities. Further discussions regarding this will take place between 8 and 10 July, when Abigail and Graham Allen (Head of BODC) visited BCO-DMO at Woods Hole, MA, USA.

Data overview

The data management of the GEOTRACES Project is a large undertaking, with a total of 66 cruises (including all cruise legs) associated with the project (this takes into account all section cruises,

process studies and "compliant" data). More than 800 scientists have taken part in GEOTRACES cruises, with 15 different nations having run a major GEOTRACES IPY/section/process study cruise.

2014/2015 has been a successful period, where contact has been made with PIs owing data to GDAC: submissions of data and metadata are becoming more forthcoming. It has been recognised that a way of encouraging PIs to submit their data to GDAC more readily is to use inclusion of a PI's data in the 2017 IDP as an incentive.

Summary of completed GEOTRACES cruises to date:

Section cruises	**IPY cruises**	**Process studies**	**Compliant data**
27 cruises (including all legs) with 19 sections	11	21 (including all legs) with 17 sections	5

In addition, 2 intercalibration cruises have been completed.

Since Abigail Bull started as GEOTRACES Data Manager, one process study cruise has taken place: NBP1409 (GPpr08 Leg2 - PHANTASTIC II cruise)). The PHANTASTIC I cruise NBP1310 02 (GPpr08 Leg1) took place in December 2013–January 2014. This cruise has recently been approved as a GEOTRACES Process Study and so it is new to the GDAC programme page (http://www.bodc.ac.uk/geotraces/cruises/programme/). The SSB (Shelf Seas Biogeochemistry) GEOTRACES cruise is on its way to completion, with leg 3 (DY033 – GApr04 leg3) still to take place between 11 July and 3 August 2015. DY018 (GApr04 Leg1) and DY029 (GApr04 Leg2) are already complete. One section cruise, KH14-6 (GP19), undertaken by Japan in the Western South Pacific and Antarctic Sea, took place at the beginning of 2015.

Summary of forthcoming GEOTRACES cruises to take place in 2015/2016:

This year the International GEOTRACES Arctic research programme focuses on field effort from the Unite States, Canada and Germany. Three Arctic cruises have been planned and funded and will take place between July and October 2015. German cruise M121 (GA08) is scheduled in the SE Atlantic with planned cruise dates of 21 November-27 December 2015.

In summary

The collection and processing of data to be included in the 2017 IDP will be a priority over the coming year. GDAC continues to receive data and metadata from completed cruise. In order to encourage more timely submission, the incentive of having data in the 2017 IDP as well as the recognition that results from such inclusion, will be more formally advertised.

3.3 GEOTRACES International Project Office

The GEOTRACES International Project Office (IPO) is based at the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France. The IPO is staffed by a

single person, the IPO Executive Officer, Elena Masferrer Dodas. She works under the scientific supervision of Catherine Jeandel (CNRS, LEGOS, France).

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

Outreach effort

Outreach has been the top priority for the GEOTRACES IPO this year. Firstly, several actions have been undertaken to publicize the Intermediate Data Product 2014 (e.g. presentations in international conferences or other international programmes conferences, sending announcements to other international programmes mailing lists). Secondly, the IPO is collecting GEOTRACES outreach materials and activities developed during the five years of the programme and promoting them to be used not only through the GEOTRACES Community but also to other communities. For this, the IPO has developed an Outreach website:

- GEOTRACES Outreach website
  An important effort has been made by the IPO to create a website devoted to outreach. This public website displays all the GEOTRACES outreach materials and activities:
  http://www.geotraces.org/outreach
  Example of materials available on the website are: cruise blogs, webinars, cartoons, videos, podcasts, textbooks, brochures, posters, publicity documents, etc.

Thirdly, the IPO has helped GEOTRACES national programmes in developing and promoting their outreach initiatives, as for example:

- GEOTRACES Webinar series: Ben Twining (U.S. GEOTRACES) has developed a webinar series devoted to GEOTRACES in collaboration with the Centers for Ocean Sciences Education Excellence (COSEE). The webinar hosted by the COSEE-Ocean Systems office at University of Maine is available here:
  http://www.geotraces.org/outreach/other-outreach-materials/webinars

- Toulouse Knowledge Festival (La Novela) and sharing science with prisoners (Association the stars shine for all): During the French GEOVIDE cruise, Catherine Jeandel (IPO science director, France) set up a project with the Seysses Prison (Toulouse, France). During 6 months (April-October 2014), GEOVIDE scientists communicated with prisoners (via their teachers). They did this before the cruise, during the cruise (thanks to a cruise blog) and after the cruise. The project ended with a session at the Toulouse Knowledge

Festival (called La Novela) in October 2014 where a video was projected followed by a debate. For further information: http://www.geotraces.org/outreach/other-outreach-materials/videos/1079-geovide-sharing-oceanography-with-prisioners

In addition, we would like to highlight the following tasks:

- Major GEOTRACES website overhaul: One important task this year was to overhaul the GEOTRACES website. While keeping the same structure to facilitate access to information, the website now has a dynamic new design that provides more visibility to GEOTRACES products, including outreach activities. At the same time, the link within the GDAC website and the IPO website has strengthened. Special thanks to Olivier Boebion (Obs. Oceano. Villefranche sur Mer) and Paule Dossi (DOoWEB) for their technical assistance and advice in upgrading the website.

- Twitter account: Since February 2015, GEOTRACES has a Twitter account that counts 111 followers at the time this report is written. This is in complement to the GEOTRACES Facebook page, which has 235 followers (and with 1453 people reached on a post).

- International Conferences: With the aim of publicising GEOTRACES towards other communities, two abstracts have been submitted and accepted to international conferences presenting the GEOTRACES Programme:

    - « GEOTRACES highlights in the Indian Ocean and plans for the future », oral presentation, presented by L. Demina[4] (26th IUGG General Assembly, IAPSO Symposium, special session on *the 50th Anniversary of the Indian Ocean Expedition,* Prague, 22 June- 02 July 2015)
    - « Highlights from the GEOTRACES International Programme », poster, to be presented by G. Henderson on Monday 17 August at 17h (Goldschmidt 2015, Prague, August 16-21, 2015)

- Working with GDAC: A very nice working relation has been established between the IPO and the new GEOTRACES Data Manager, Abigail Bull. On March 2015, the IPO organized a meeting in Toulouse for Abigail Bull to meet not only the IPO staff, but also the French Data Manager Catherine Schmechtig.

- Intermediate Data Product 2014 Survey:
  The GEOTRACES IPO has assisted DMC co-chairs and the SCOR Executive Director in disseminating the IDP2014 Survey and analysing and presenting the results.

- Some statistics:
  80 highlights published (24 since last reporting period)
  15 eNewsletter published (bimonthly newsletter)
  120 researchers included in the GEOTRACES Researchers Analytical Expertise Database
  548 peer-reviewed papers included in the GEOTRACES Publication Database

3.4 GEOTRACES Workshops

First GEOTRACES Brazil Workshop, 21-22 March 2015, Santos, Brazil.
As a result of the Latin America workshop held in 2012 (12-15 November 2012, Rio de Janeiro, a network of researchers has been established and a core community is being structured in Brazil. The *Final Statement* resulting from this workshop is available on the GEOTRACES site:
http://geotraces.org/images/stories/documents/workshops/2015_Brazil/2015_Workshop_GEOTRACES_BRASIL_final_statement_08_05.pdf

Forthcoming:

Coupled meeting and workshop to discuss and synthesise findings from the GEOTRACES programme:

*The biological and climatic impacts of ocean trace-element chemistry, 7–8 December 2015, The Royal Society, London, UK.
For further information: https://royalsociety.org/events/2015/12/ocean-chemistry/

A Royal Society Scientific Discussion Meeting to present new results and discoveries about the role of ocean in trace-element cycling in the Earth system. Speakers from eight countries will discuss the oceanic cycles of trace elements, their role in ocean biology, their use to assess past and present ocean processes, and the influence of human activity on ocean trace-element chemistry. The meeting is open to all, with registration at the above website. There is no charge to attend.

*Quantifying fluxes and processes of trace-metal cycling at ocean boundaries, 9–10 December 2015, Chicheley Hall, Buckinghamshire, UK.
For further information: https://royalsociety.org/events/2015/12/ocean-chemistry/

This is a workshop-format meeting to synthesise knowledge about the fluxes of trace elements at the four ocean boundaries: from continents across the shelf; from marine sediments; from mid-ocean-ridges; and from the atmosphere. Keynote talks will describe recent advances in data and understanding for each interface. Discussion groups and posters will enable a full exploration of the state of knowledge for each interface, identify areas of uncertainty, and consider possible future research. The programme is presently being finalised. This workshop has a limited number of places and is by invitation or application only.

3.5 Special sessions at international conferences featuring GEOTRACES findings

Several special sessions with relevance to GEOTRACES were featured or planned in major international conferences including the following:

2014 Asia Oceania Geosciences Society 11th Annual Meeting (AOGS 2014), 28 July to 1 August 2014, Sapporo, Hokkaido, Japan.

For further information: http://www.asiaoceania.org/aogs2014/public.asp?page=home.htm

*OS01: Trace elements and their isotopes in the ocean: GEOTRACES activities in Asia and Oceania
Convenors : Dr. Yoshiki Sohrin (Kyoto University, Japan), Dr. Tung-Yuan Ho (Academia Sinica, Taiwan), Dr. Pinghe Cai (Xiamen University, China), Prof. Man Sik Choi (Chungnam National University, Korea, South).

24th Earth Sciences meeting, 27-31 October 2014, Pau, France.
For further information: http://rst2014-pau.sciencesconf.org

*Session 8.5: Advances in mercury biogeochemistry. Organizers: Jeroen Sonke (GET, Toulouse) and David Amouroux (LCABIE, IPREM, Pau).

*Session 8.7 : Biogeochemical cycling of contaminants in the Arctic. Organizers: Lars-Eric Heimburger (GET, Toulouse, France) and Aurélien Dommergue (LGGE, Grenoble, France).

American Geophysical Union Fall 2014 Meeting,15-19 December 2014, San Francisco, California, USA.
For further information: http://fallmeeting.agu.org/2014/

GEOTRACES sessions:

*Trace Element and Isotope Cycling in the Coastal Environment – 40 Years of Innovations. Conveners: Greg Cutter and Pete Sedwick

*Trace metals and isotopes in the Eastern Tropical South Pacific: Results of the 2013 U.S. GEOTRACES Zonal Transect and complimentary studies. Conveners: Jim Moffett, Chris German and Martin Frank

GEOTRACES-related sessions:

*Productivity Proxies: New Developments and Records. Conveners: Fatima Abrantes, Bob Anderson and Heather Stoll

*Biogeochemical cycling of silicon in coastal transition zones. Conveners: Claudia Ehlert, Patricia Grasse, Daniel J Conley and Mark A Brzezinski

*The Biogeochemical Cycling of Mercury in the Coastal and Open Ocean.
Conveners: Robert P Mason and Arthur Russell Flegal

*Past Ocean Dynamics
Conveners: Joerg Albert Lippold, Luke Skinner and Sam Jaccard

ASLO 2015, Aquatic Sciences Meeting, 22-27 February 2015, Granada, Spain.
For further information: http://www.aslo.org/meetings/index.html

*142 - Chemical Oceanography/GEOTRACES
Convenor: Andrea Kochinsky, Jacobs University Bremen.

*037 - The Molecular Ecology of Metal-Microbe Interactions in the Ocean Environment.
Convenors: Robert Strzepek, The Australian National University; Maite Maldonado, The University of British Columbia; and Yeala Shaked, The Hebrew University in Jerusalem.

*014 - Atmospheric Deposition Effects in Aquatic Ecosystems
Convenors: Francesc Peters, Institut de Ciències del Mar (CSIC), Barak Herut, National Institute of Oceanography, Adina Paytan, Institute of Marine Sciences, Cecile Guieu, Laboratoire d'oceanographie de Villefranche, Ana M Aguilar-Islas, University of Alaska Fairbanks, Clifton Buck, Skidaway Institute of Oceanography and Simon Usher, University of Plymouth.

3rd International Symposium on the Effects of Climate Change on the World's Oceans, 23-27 March 2015, Santos, Brazil.
For further information: http://www.pices.int/meetings/international_symposia/2015/2015-Climate-Change/scope.aspx

*S3. Changing Ocean Chemistry: From Trace Elements and Isotopes to Radiochemistry and Organic Chemicals of Environmental Concern
Co-chairs: Angelica Peña (Institute of Ocean Sciences, Department of Fisheries and Oceans, Canada) and Geraldine Sarthou (LEMAR, IUEM, Brest, France)

12th International Conference on Mercury as a Global Pollutant, 14-19 June 2015, Jeju, Korea.
For further information: http://mercury2015.com/main/

*17. Integrating marine observational studies and model development
Conveners: Anne Laerke Soerensen & Lars-Eric Heimbürger

*Conference Workshop: GEOTRACES Intercalibration exercises for Hg species in seawater discussion forum
Conveners: Lars-Eric Heimbürger

Forthcoming:

Goldschmidt 2015, 16-21 August 2015, Prague, Czech Republic.
For further information: http://goldschmidt.info/2015/index

** Theme 2: Ocean Geochemistry. Present Conditions and Past Variation: fluxes, reservoirs and processes
Co-ordinators: Geraldine Sarthou (Brest University, France) and Andrew Bowie

(University of Tasmania).
Team members: Katherine Barbeau (Scripps, USA), Kristen Buck (Univ South Florida, USA), Zanna Chase (Institute for Marine and Antarctic Studies, Austra), Rob Middag (Univ Otago, New Zealand), James Moffett (Univ. Southern Carolina, USA)

*02a: Trace Metals in the Ocean: Distributions, Isotopic Variation and Speciation.
Session Convenors: Katherine Barbeau (UC San Diego, Scripps Institution of Oceanography, USA), Andrew Bowie (University of Tasmania), Kristen Buck (University of South Florida, College of Marine Science, USA), Rob Middag (Univ Otago, New Zealand), Christopher Pearce (National Oceanography Centre), Phil Pogge von Strandmann (Earth Sciences, University College London, UK), Géraldine Sarthou (LEMAR CNRS, Brest, France).

*02b: Radionuclides in the Ocean
Session Convenors: Bob Anderson (Lamont-Doherty Earth Observatory, USA), Ken Buesseler (Woods Hole Oceanographic Institution, USA), Pere Masque (Universitat Autònoma de Barcelona)

*02c: Past Changes in Ocean Biogeochemistry and Circulation and their Interaction with Climate
Session Convenors: Zanna Chase (Institute for Marine and Antarctic Studies, Australia), Martin Frank (GEOMAR Helmholtz centre for ocean research Kiel, Germany), Norbert Frank (University of Heidelberg, Germany), Katharina Pahnke (ICBM and MPI for Marine Microbiology, Germany), Laetitia Pichevin (University of Edinburgh, UK), Laura Robinson (University of Bristol, UK), Tina van de Flierdt (Imperial College London, UK), Kazuyo Tachikawa (Cerege, CNRS, France)

*02d: What are the unifying principles common to all three Oxygen Minimum Zones (OMZs)?
Session Convenors: Jim Moffett (Univ. Southern Carolina, USA), Aurélien Paulmier (LEGOS, France)

*02e: Air-Sea Exchange, the Biological Pump, and Ocean Acidification
Session Convenors: Steve Emerson (University of Washington, USA), Doug Wallace (Dalhousie University, Canada)

*02f: Biogeochemistry of Arctic and Antarctic sea ice systems
Session Convenors: Jun Nishioka (Univ. Hokkaido, Japan), Delphine Lannuzel (University of Tasmania, Australia)

*02g: Advances in marine N, P and Si biogeochemistry
Session Convenors: Damien Cardinal (University Pierre and Marie Curie, LOCEAN, Paris), Albert Colman (University of Chicago, USA), Masha Prokopenko (University of Southern California, USA), Christian März (Newcastle University, UK)

*02s: Goldschmidt 25th Anniversary
The 25th anniversary talk is an overview of the progress and breakthroughs made in this theme over the last 25 years. Invited speaker: Catherine Jeandel

22nd International Society for Environmental Biogeochemistry (ISEB) Symposium Dynamics of Biogeochemical Systems: Processes and Modeling, 28 September-2 October 2015, Piran, Slovenia.
For further information : http://www.iseb22.ijs.si

*Marine and coastal environments – Special session: GMOS and GEOTRACES

American Geophysical Union Fall 2015 Meeting, 14-18 December 2015, San Francisco, California, USA.
For further information: http://osm.agu.org/2016/

*GC067: Trace Metal Cycling in the Environment – 40 Years of Advancements
Session ID#: 8771
Convenors: Priya Ganguli, Frank Black, Sergio Sanudo-Wilhelmy and Ed Boyle

*A035: Dust in High Latitudes: From its Origins to its Impacts
Session ID#: 8015
Primary Convener: Santiago Gasso, GESTAR/NASA, Silver Spring, MD, United States
Conveners: John Crusius, USGS Western Regional Offices Seattle, Seattle, WA, United States, Gisela Winckler, Lamont -Doherty Earth Observatory, Palisades, NY, United States and Paul A Ginoux, NOAA Princeton, Princeton, NJ, United States

*OS010: Exploring the Dust-Ocean Connection in a Changing Climate
Session ID#: 8749
Primary Convener: Maurice Levasseur, Laval University, Quebec-Ocean, Quebec City, QC, Canada
Conveners: William L Miller, University of Georgia, Athens, GA, United States and Mitsuo Uematsu, University of Tokyo, Bunkyo-ku, Japan

2016 Ocean Sciences Meeting, 21-26 February 2016, New Orleans, Louisiana, USA.
For further information : http://osm.agu.org/2016/

*CT001: Atmospheric deposition and ocean biogeochemistry
Session ID#: 9243
Primary Chair: Ana M Aguilar-Islas, University of Alaska Fairbanks, Fairbanks, AK, United States
Chairs: Clifton S Buck, Skidaway Institute of Oceanography, Savannah, GA, United States and Meredith Galanter Hastings, Brown Univ-Geological Sciences, Providence, RI, United States

*CT002: Integrating approaches to understanding the distribution and transfer of trace elements in the upper water column

Session ID#: 8750
Primary Chair: Rachel Shelley, LEMAR/UBO, Brest, France
Chairs: Peter L Morton, Florida State University, Department of Earth, Ocean, and Atmospheric Science, Tallahassee, FL, United States and Sunil Kumar Singh, Physical Research Laboratory, Ahmedabad, India

*CT003: Kinetics: the force driving trace metal distributions in marine waters
Session ID#: 9486
Primary Chair: Christian Schlosser, GEOMAR Helmholtz Centre for Ocean Research Kiel, Chemical Oceanography, Kiel, Germany
Chairs: Eric P. Achterberg, GEOMAR Helmholtz Centre for Ocean Research Kiel, Chemical Oceanography, Kiel, Germany, Christoph D Voelker, Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven, Bremerhaven, Germany and Alessandro Tagliabue, University of Liverpool, Earth, Ocean and Ecological Sciences, Liverpool, United Kingdom

*CT008: The role of particles in the cycling of trace elements and their isotopes in the ocean
Session ID#: 7493
Primary Chair: Hélène Planquette, LEMAR, CNRS, Plouzané, France
Chairs: Phoebe J Lam, University of California Santa Cruz, Department of Ocean Sciences, Santa Cruz, CA, United States and Benjamin S. Twining, Bigelow Lab for Ocean Sciences, East Boothbay, ME, United States

*CT009: Trace Elements and Isotopes at the Interfaces of the Atlantic Ocean
Session ID#: 9208
Primary Chair: Geraldine Sarthou, LEMAR UMR 6539 CNRS UBO IRD IFREMER, IUEM, Plouzané, France
Chairs: Edward A Boyle, Massachusetts Institute of Technology, Earth Atmospheric and Planetary Sciences, Cambridge, MA, United States, Gideon Mark Henderson, University of Oxford, Earth Sciences, Oxford, United Kingdom and Micha J.A. Rijkenberg, Royal Netherlands Institute for Sea Research, Den Burg, Netherlands

*CT010: Trace Metal Bioavailability and Metal-Microorganism Interactions
Session ID#: 8373
Primary Chair: Julia M Gauglitz, Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry, Woods Hole, MA, United States
Chairs: Randelle Bundy, Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry, Woods Hole, MA, United States and Jill N Sutton, IUEM/UBO, Technopôle Brest-Iroise, Place Nicolas Copernic, Plouzané, France

*CT011: Trace metal speciation in seawater: measurements, modelling and impact on marine biogeochemistry
Session ID#: 9231
Primary Chair: David R Turner, University of Gothenburg, Gothenburg, Sweden

Chairs: Stan MG van den Berg, University of Liverpool, Liverpool, L69, United Kingdom, Sylvia Gertrud Sander, University of Otago, Dunedin, New Zealand and Kristen N Buck, University of South Florida Tampa, Tampa, FL, United States

GEOTRACES Tutorial:

*T014: What Controls the Distribution of Dissolved Iron in the Ocean?
Session ID#: 9303
Primary Chair: Alessandro Tagliabue, University of Liverpool, Liverpool, L69, United Kingdom

3.6 Capacity building

At-Sea Training GEOTRACES gratefully acknowledges support from SCOR to enable one scientist per year from a developing nation to participate in a GEOTRACES cruise. These opportunities are vital to the development of technical expertise in sampling and sample handling for contamination-prone elements aboard "dirty" ships.

Sampling Systems It is a goal of GEOTRACES that every nation carrying out oceanographic research should have access to a trace metal-clean sampling system. GEOTRACES offers guidance based on past experience in the design and construction of sampling systems as well as advice in operating these systems as shared facilities. A complementary goal is to establish a programme whereby scientists who have accrued experience in operating these systems can share that knowledge with scientists from nations that are in the process of acquiring clean sampling systems.

An updated status of trace metal-clean sampling systems to support GEOTRACES research is provided in the table below. Scientists interested in developing one of these systems for their own use are encouraged to contact the GEOTRACES IPO or any member of the SSC, who will arrange for contact with an appropriate person to provide technical information about the design, construction and cost of a system.

Nation	Status	System/ Carousel	Bottles	Depth
Australia	Complete	Powder coated aluminium, autonomous 1018 intelligent rosette system	12 x 10-L Teflon-lined Niskin-1010X	6000 m; 6 mm Dynex rope
Australia	2nd system (complete)	Polyurethane powder-coated aluminium autonomous Seabird rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	12 x 12-L Teflon-lined OTE external-spring Niskin-style bottles	1750 m 9mm Dyneema rope or 200 m 6 mm Dyneema rope with coupling to 6000 m CTD wire

Brazil	Complete	GEOTRACES WATER SAMPLER - 24-bottle sampler for use with 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	2300 m; conducting Vectran soon to be upgraded with 5000 m conducting Vectran 06/2013
China - Beijing	Complete	Towed fish	NA	Surface
China - Taipei	Complete	Teflon coated rosette	Multi- size GO-Flo	3000 m; Kevlar line
France	Complete	Powder coated aluminium with titanium pressure housing for CTD	24 X 12-L GO-Flo	8000 m; conducting Kevlar
Germany	CTD and bottles purchased, winch planned	Powder coated aluminium with titanium pressure housings and fittings	27 x 12-L OTE GO-Flo	8000 m; conducting Kevlar
India	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L Niskin-X	8000 m; conducting Kevlar
Israel	Complete	Powder coated aluminium, SeaBird Rosette	12 X 12-L Niskin; 8 X 12-L GO-Flo (Teflon coated)	2000 m, steel conducting cable
Italy	Complete	Go-Flo bottles on Kevlar line	5 x 20-L Go-Flos	Kevlar
Japan	Complete	Powder coated aluminium	12-L Niskin-X	10000 m; titanium armored cable
Netherlands	Complete	Titanium frame	24 X 12-liter GO-Flo	10000 m; conducting Kevlar
Netherlands	Complete	Titanium frame	24 X 27-liter ultraclean PVDF	10000 m; conducting Kevlar
New Zealand	Complete	Powder coated aluminium	5-L Teflon-lined Niskin-X	4000 m; 8 mm Kevlar line
Poland	Complete	Powder coated aluminum, SeaBird Rosette	8x 10L GoFlo	3000m, steel conducting cable
Poland	Complete	Single bottle	10l G-FLO X	300m Kevlar

			Teflon coated	
Poland	Complete	Teflon pump on-line	Surface water pump	1.5m fixed
Poland	In development	Pump CTD	Teflon hose 10mm	Up to 200m
South Africa	Complete	Powder coated aluminium, titanium housing/fittings	24 X 12-liter GO-Flo	6500 m; Kevlar cable
UK	Complete	2 x Titanium frame, Ti pressure housings	24 10-L OTE 24 10-L OTE	2 x 8000m conducting Kevlar
USA - CLIVAR	Complete	Powder coated aluminium	12 X 12-L GO-Flo	1500 m; conducting Kevlar
USA - GEOTRACES	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L GO-Flo	8000 m; conducting Kevlar
USA- University of Alaska Fairbanks	Complete	Seabird Rosette. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	No Kevlar line available yet.
USA- Old Dominion University	Complete	Seabird Rosette. SBE-19plusV2 CTD unit. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	2000 m 0.5-inch Kevlar wire
USA – Polar Programs	Complete	Powder coated aluminium with titanium pressure housings and fittings	12 X12-L Niskin-X	3000 m; conducting Kevlar

4. Plans for coming years

Field Programme

The completion of the GEOTRACES research Arctic programme (4 cruises in 2015 and 1 more planned for 2016) will be one important target of the field programme for the coming reporting year. In addition, other cruises are already planned in the Atlantic Ocean (Germany, Netherlands), Pacific Ocean (Japan and Germany) and Southern Ocean (Australia).

Next Intermediate Data Product

GEOTRACES plans to release **the second Intermediate Data Product at Goldschmidt 2017** (13-18 August 2017, Paris, France). Thus, preparing the next Intermediate Data Product will be the top priority for the GEOTRACES community. A procedure and clear timeline for data submission and review will be established and communicated in order to ensure the timely release of the next IDP.

GEOTRACES synthesis of results strategy

GEOTRACES plans to launch a three-pronged synthesis initiative. The first component focuses on sources and sinks of TEIs at ocean boundaries, starting with the workshop "The biological and climatic impacts of ocean trace-element chemistry" (7-8 December 2015, Royal Society in London, UK, see « GEOTRACES Workshops » above).

The second component focuses on internal cycling of TEIs within the ocean. This will be organised by U.S. GEOTRACES, in collaboration with the Ocean Carbon and Biogeochemistry Programme (OCB) in mid-2016.

The third component will be centered on geochemical tracers used as paleoceanographic proxies with a workshop planned for 2017. GEOTRACES is exploring a partnership with the Past Global Changes project (PAGES) in hosting this workshop.

The first two workshops will use the wealth of data in the 2014 Intermediate Data Product (IDP2014) and demonstrate to the broader oceanographic community the usefulness of the IDP2014. The 2017 workshop will have access to the first and second IDPs, as well as to the results of the 2015 and 2016 workshops.

Together, these workshops cover the main scientific goals of GEOTRACES and are designed to respond to the expectation that GEOTRACES results benefit other oceanographic disciplines.

Acknowledgements

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Written and compiled by:
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Catherine Jeandel (GEOTRACES IPO Science Director)
Elena Masferrer Dodas (GEOTRACES IPO Executive Officer)

June 2015

3.4 Surface Ocean–Lower Atmosphere Study (SOLAS) (joint with IGBP, WCRP, and CACGP) *Sarma, Turner*

Terms of Reference:

- To develop the Surface Ocean - Lower Atmosphere Study (SOLAS) Science Plan and an Implementation Strategy, in accordance with guidance of the sponsoring organisations.
- To oversee the development of SOLAS in accordance with its Science Plan/Implementation Strategy.
- To collaborate, as appropriate, with other related projects of IGBP, WCRP, SCOR and CACGP and related projects and programmes (e.g., IHDP, DIVERSITAS, IOC and the Global Ocean Observing System (GOOS), etc.)
- To establish appropriate data management policies to ensure access to, sharing of, and preservation of SOLAS data, taking into account policies of the sponsors.
- To report regularly to SCOR, IGBP, WCRP and CACGP on the state of planning and accomplishments of SOLAS.
- The SOLAS SSC, its subsidiary groups and International Project Office shall operate in accordance with the operating procedures for IGBP Projects and as required by other co-sponsors.

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Emmanuel Boss	USA	Ilan Koren	ISRAEL
Anja Engel	GERMANY	Lisa Miller	CANADA
Cristina Facchini	ITALY	Yukihiro Nojiri	JAPAN
Hui-wang Gao	CHINA-Beijing	Alfonso Saiz-Lopez	SPAIN
Christophe Garbe	GERMANY	VVSS Sarma	INDIA
Michele Graco	PERU	Brian Ward	IRELAND
Christophe Heinze	NORWAY		

Executive Committee Reporter: John Turner
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SOLAS Annual Report to SCOR

Reporting period: June 2014- August 2015
Version of 2 Sept 2015 by Dr Emilie Brévière

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

I.a. SOLAS Scientific Steering Committee

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

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

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

The current membership of the SSC is listed below (15 members including Chair):

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

Garbe	Christoph	Germany	M	Air-sea physical interaction	Theme 2: fluxes of mass and energy, ESA connection	2016
Garçon	Veronique	France	F	Marine biogeochemistry and ecosystems dynamics	Integrated topics	2017
Graco	Michelle	Peru	F	Biogeochemical cycles in upwelling systems, OMZ	Integrated topics	2017
Guieu	Cecile	France	F	Marine ecosystems/nutrients	Theme 3: Atm deposition	2015
Heinze	Christoph	Norway	M	Carbon cycle modeling/paleooceano	Theme 1: greenhouses gases	2015
Koren	Ilan	Israel	M	cloud physics	Theme 4: aerosols, clouds	2015
Levasseur	Maurice	Canada	M	Ocean biogeochemistry, dimethylsulfide, Arctic, ice algae	Theme 4: aerosols, clouds	2017
Miller	Lisa	Canada	F	Sea-ice/CO_2 exchanges	Integrated topics, PICES connection	2016
Nojiri	Yukihiro	Japan	M	Ocean carbon	Theme 1: greenhouses gases	2015
Saiz-Lopez	Alfonso	Spain	M	Atmospheric halogens/modelling	Theme 5: Atm chem., IGAC connection	2016
Sarma	VVSS	India	M	Biogeochemical cycling of C an N in the ocean and estuaries, stable isotopic geochemistry/ocean acidification	Theme 1: greenhouses gases	2017
Ward	Brian	Ireland	M	Air-sea physical interaction	Theme 2: fluxes of mass and energy, WCRP liaison	2016

In December 2015:
- Cecile Guieu, Yukihiro Nojiri and Christoph Heinze will rotate off the SOLAS SSC after two terms.
- Ilan Koren will end his first term on the SOLAS SSC.

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

Since 2008, SOLAS has supported the development of Mid-term strategy (MTS) themes, identified as areas where progress can be accelerated significantly with the support of an international programme such as SOLAS. The following publication describes the MTS themes:

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

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

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

Overview of activities:
Task Group 1 on Methodologies and Intercomparisons (Leads: Lisa Miller and Lynn Russell):
A review of sea-ice methodologies has been published in *Elementa: Science of the Anthropocene:* Miller et al. (2015) Methods for biogeochemical studies of sea ice: The state of the art, caveats, and recommendations. This paper is the first of a Special Feature in *Elementa* on sea-ice biogeochemistry that is initiated by WG 140. TG1 has stimulated discussion and compiled information on opportunities to organize an intercalibration field campaign on a reasonable time scale. Several options are still under discussion.

Task Group 2 on Data (Leads: Klaus Meiners and Martin Vancoppenolle):
The collation of chlorophyll datasets from both the Arctic and the Antarctic are almost finalized and partly published. Several new collaborations have been established around the collation of other parameters: inorganic carbon budget, organic carbon budget, macro nutrients, iron, algal biodiversity.

Task Group 3 on Modeling (Leads: Nadja Steiner and Clara Deal):
A paper on "What sea-ice biogeochemical modellers need from observationalists" has been submitted to *Elementa* as part of the WG 140 special issue. The WG 140 Special Feature within the open-access journal *Elementa: Science of the Anthropocene* is a major product of this TG and of WG 140 as a whole. It will contain a collection of synthesis papers reviewing particular biogeochemical processes in sea ice and respective model applications, but also research papers are accepted. Currently, 20 contributions are planned, of which 7 are published/submitted.

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

• Air-sea gas fluxes at Eastern Boundary upwelling systems

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

- Identification and linking existing oxygen databases
- Identification and linking real time/continuous oxygen observations and monitoring systems (Argo, moorings)
- Developing integrated oxygen research that links coasts and seas, developing global, cross-basin/teleconnection research
- Understanding oxygen interactions with other climate and human stressors
- Promoting better global and regional climate models of oxygen, understanding feedbacks between atmosphere and ocean
- Advancing understanding of forces shaping ocean oxygenation
- Linking oxygenation to fisheries production and dynamics
- Understanding animal migrations and movements in the context of ocean oxygenation
- Socio-economic consequences of oxygenation changes (gains and losses)
- Linking oxygenation to H2S emission
- Roles of oxygen in shaping global and local patterns of biodiversity
- Calibrations and proxies to learn about the roles of oxygenation in ocean biogeochemical and biodiversity from the paleo record
- Linking oxygen to harmful algal blooms

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

Other activities related to this MTS Theme include the following:

- A session has been proposed at the IMBER IMBIZO IV on 26-30 Oct. 2015 in Trieste, Italy.
- Another session entitled “Eastern boundary upwelling systems: Natural laboratories for studying the impacts of multiple stressors on marine ecosystems” has been proposed at the AGU Fall meeting in December 2015 in San Francisco, USA
- The SOLAS Chair will participate in the 9th World Ocean Forum at Busan, South Korea on 20-22 October 2015, and will give an invited lecture entitled “Biogeochemical cycles and marine ecosystems in a changing oceanic stratification“ within Session 3 Ocean Science and Climate-Environment.
- The SCOR group WG 144 “Microbial Community Responses to Ocean Deoxygenation” is preparing a “White paper” on “Recommendations for best practices for investigations in oxygen-deficient marine systems" and is holding a workshop at the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany from 30 August to 3 September 2015.

- An ITN Marie Curie VOYaGE (Variability of Oxygen in Marine ecosystems and Climate change) proposal was submitted for the 2015 call H2020-MSCA-ITN without success and will be resubmitted in 2016.

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

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

***WG1-Surface Ocean Systems.** Chair: Andrew Lenton (Australia)
The Surface Ocean CO_2 Atlas (SOCAT) is a largely volunteer, international activity by the marine carbon community, with more than 100 contributors working to assemble surface ocean carbon dioxide (CO_2) data in a uniform, quality-controlled format. Version 1 was made public in 2011, version 2 in 2013 and the release of version 3 is planned for 2015. A one-day workshop on SOCAT and SOCOM (Surface Ocean pCO_2 Mapping Intercomparison) is being planned on the Monday 7 Sept. 2015, a day before the opening of the SOLAS Open Science Conference 2015. This side event of the SOLAS OSC15 has been chosen to release the SOCAT version 3. SOCAT version 2 provided 44 years of surface water fCO_2 (fugacity of CO_2) values from 1968 to 2011 for the global oceans and coastal seas with 10.1 million unique data points. The SOCAT synthesis and gridded data products can be interrogated via interactive online viewers or downloaded in a variety of formats via the SOCAT website (www.socat.info). Three publications document SOCAT versions 1 and 2 (Pfeil et al., 2013; Sabine et al., 2013; Bakker et al., 2014). About 3 million new fCO_2 values from 1957 to 2013 have been included in SOCAT version 3. Quality control by regional groups is about to start. The quality control criteria have been adapted for version 3 to accommodate calibrated CO_2 data from new sensors and alternative platforms.

Applications of SOCAT include process studies, quantification of the ocean carbon sink, its seasonal to year-to-year variation and ocean carbon cycle modelling. The Global Carbon Budget (www.globalcarbonproject.org/carbonbudget/) uses SOCAT for quantification of the annual ocean carbon sink. The Surface Ocean pCO_2 Mapping intercomparison (SOCOM) is a recent initiative that compares surface ocean CO_2 gridded products, derived by a variety of methods, many of them based on SOCAT.

***WG2-Interior Ocean.** Chair: Nicolas Gruber (Switzerland)- update from 1 Sept 2015.
WG2 has focused its recent activities entirely on the analysis of the carbon data from the hydrographic surveys with the aim to determine the change in the ocean's anthropogenic CO_2 content since the 1990s. They are now in the final stages (paper draft completed), and hope to finish this synthesis project by early 2016. WG2 contributed also to the planning of the upcoming joint GO-SHIP/Argo/IOCCP meeting in Galway on the topic of "Sustained ocean

observing for the next decade" http://www.gaic2015.org. In addition, they continue to support the development and application of biogeochemical sensors on Argo floats, although this area has developed a lot of momentum and is strong enough to move forward without much need for help from WG2. WG2 likely will reengage in full in this area when time is ripe to address data synthesis and integration in a global/basin-scale manner.

***WG3-Ocean Acidification.** Chair: Jim Orr (France), update from May 2015
The last annual meeting of the SIOA working group was in May 2015, supported financially by SOLAS and IMBER. The Chair of the SIOA working group is Jim Orr. SIOA Members are all Members of the Advisory Board of the OA-ICC (Ocean Acidification International Coordination Centre), based at the IAEA Environment Laboratories in Monaco since 2012 for 3 years. Many SIOA Members are focal points for the OA-ICC activities, and Jim Orr is the Scientific Coordinator of the project. The IAEA Project Officer is Lina Hansson and the Programme Manager is Michel Warnau. There is an OA-ICC web site (www.iaea.org/ocean-acidification) and a news stream (news-oceanacidification-icc.org). The activities of the OA-ICC are to promote (1) the development of a global observation network; (2) use of joint platforms and facilities; (3) collaboration between natural and social sciences; (4) Intercomparison exercises; (5) Joint ocean acidification experiments; (6) best practices in OA research; (7) Online bibliographic database; (8) Data management; (9) capacity building; and (10) information sharing and communication.

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

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

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

I.d. SOLAS metadata portal
The SOLAS metadata portal was set up by the SOLAS project integration initiative (2007-2013) with the intention to help SOLAS scientists identify what data exist, the data originator and where the data are currently stored. The portal is hosted by NASA and the metadata files are

stored on the international standard Global Change Master Directory (GCMD). The resource is freely available to the entire community.

The SOLAS metadata portal is an on-going effort. Scientists can help expanding the SOLAS Metadatabase by completing a simple template available at http://tinyurl.com/328zjr5 and email it to solas@geomar.de

I.e. Task teams

SOLAS/IGAC Task Team: Halogens in the Troposphere (HitT)
The primary objective of the SOLAS/IGAC Halogens in the Troposphere task team (HitT) is to determine and quantify the importance of reactive halogen compounds in tropospheric chemistry and climate forcing. The goal of HitT is to facilitate international collaboration between laboratory, field, and model activities regarding tropospheric halogen chemistry especially in the following domains: polar regions, salt lakes, marine boundary layer (both remote and coastal), volcanoes, free troposphere, and urban areas.

The co-chairs are Roland von Glasow (University of East Anglia, UK) and Ulrich Platt (University of Heidelberg, Germany).[1] In 2015, the leaders of the task team and Alfonso Saiz-Lopez (SOLAS SSC member) met at the EGU 2015 and decided to write a Perspectives document with the envisioned future for the Task, which would include some new aspects in the field that were not specifically targeted in the Task´s White Paper. Work is under progress. Everyone interested by the activities of this task team can subscribe to the HitT mailing list at http://www.hitt-task.net/. - The EGU session 2015 "Halogens in the troposphere" was very well attended and a repeat of this session has already been approved for EGU 2016. Fall AGU in 2015 will include a session on "Wintertime Atmospheric Chemistry: emissions, dispersion, aerosols, halogens and unusual oxidants." Several other sessions at AGU will also be relevant to HitT. A workshop on "Global importance of tropospheric halogens" (main organisers Martyn Chipperfield, Leeds; Roland von Glasow, UEA); was planned for autumn 2015, but will be postponed to 2016, if new funding can be arranged.

Task Team: Asian Dust and Ocean EcoSystems (ADOES)
The goal of ADOES is to quantitatively understand the deposition flux and bioavailability of Asian dust, and its impact on biogeochemical processes and ocean ecosystem in order to provide scientific bases for the mechanism of eolian dust-ocean ecosystem-radiative gases-climate change. The co-chairs are Huiwang Gao (Ocean University of China, China), Guangyu Shi (Chinese Academy of Sciences, China) and Mitsuo Uematsu (University of Tokyo, Japan).

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

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

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

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

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

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

The IGAC/SOLAS Air-Ice Chemical Interactions Task Team (AICI) was created in 2003. The goal of AICI is to assess the significance of the processes observed in the polar regions at the air-ice interface at local, regional, and global scales by bringing together the laboratory, field, and modeling communities. The co-chairs of AICI are V. Faye McNeill (Columbia University, USA) and Thorsten Bartels-Rausch (Paul Scherrer Institut, Switzerland). The main activity of AICI/OASIS in 2014-2015 was the CASSII (Chemical Atmosphere-Snow-Sea Ice Interactions) workshop, which was held in Cambridge, UK in October 2014. Below is reported the write-up of this meeting published in the IGAC newsletter. The next workshop will take place in Paris, France in Spring/Summer 2016.

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

Within the AICI/OASIS community it is now recognized that the air-snow-sea ice system plays an important role in the global cycling of nitrogen, halogens, trace metals or carbon, including greenhouse gases (e.g. CO_2 air-sea flux), and therefore may also influence climate.

Its impact on atmospheric composition is illustrated by dramatic ozone and mercury depletion events that occur within or close to the sea ice zone (SIZ) mostly during polar spring and are catalyzed by halogens released from SIZ ice, snow or aerosol. Recent field campaigns in the

Arctic and Antarctic highlight the importance of the SIZ as a biologically active area and as a chemical reservoir and reactor, even during polar night. The growing literature on lab experiments and field studies allows to develop and improve parameterizations of processes at the snow grain or even molecular scale for use in regional or global climate models. But to date climate models with coupled snowpack or sea ice chemistry are still in their infancy. The research of the past 15 years has been reviewed recently in two AICI special issues of *Atmospheric Chemistry and Physics* (ACP 2007 & 2013).

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

I.f. SOLAS Open Science Conference 2015

The OSC15 will take place in Kiel, Germany at the Christian-Albrechts-Universitaet zu Kiel during the week of **7-11 September 2015**. The local organising committee (LOC) is composed of Hermann Bange (GEOMAR), Gernot Friedrichs (Univ Kiel), Christa Marandino (GEOMAR), Birgit Schneider (Univ Kiel), Emanuel Soeding (Future Ocean Cluster of Excellence Kiel) and a young post doc Jonathan Durgadoo (GEOMAR). The SOLAS OSC15 will be taking place in conjunction with two major events: (1) the SOPRAN final meeting, to take place on the Monday 7 Sept. in the afternoon; and (2) the OSC15 will be part of the Future Ocean Cluster of Excellence semester theme on "Processes at Ocean Interfaces: from science to society' of the summer 2015.

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

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

As side event of the conference, a workshop for early career scientists will take place in two parts, one on the 7 Sept. and the other on 11 Sept., Seventeen early career scientists will learn how to present their research to an audience in various situations. This workshop was organized by the early career scientist from the LOC. Two addition side-events will take place on 7 Sept. in parallel to the SOPRAN final event and the ECS workshop. Representatives of international programmes with a marine component will meet and discuss potential topics needing a collaborative and integrative approach across programmes to advance. And a SOCAT/SOCOM (Surface Ocean CO_2 Atlas/Surface Ocean pCO_2 Mapping Intercomparison) workshop will take place and launch the release of the SOCAT V3. On the 11 Sept., there will be a Nordic SOLAS gathering. SOLAS also took the opportunity to organize a dinner on 8 Sept. to assemble the 17 SOLAS national representatives that will be present at the conference, to promote the role that the national representatives play and also to engage them into the implementation strategy planning of the SOLAS next phase.

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

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

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

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

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

- In July 2014, following the 14th SOLAS SSC meeting in Israel, a draft of the Science Plan of the next SOLAS phase (2015-2025) was circulated to a large number of SOLAS engaged scientists, the SOLAS national representatives for example, for review.
- Over summer 2014, the SSC took the numerous reviews into account and delivered in fall/winter 2014 the final version of the plan.

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

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

In December 2014, SOLAS submitted to Future Earth its transition statement in order to get co-sponsored. In April 2015, SOLAS received the reviews from Future Earth and addressed them in May. In June 2015, SOLAS was informed by Future Earth that the application has been approved and that the Memorandum of Understanding is about to be signed. As per August 2015, SOLAS has not yet signed the MoU.[2]

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

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

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

[2]Update: The MoU was signed at the 2015 SOLAS SSC in September 2015

The topics listed so far include the following:

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

II. Activities (including capacity building) and publications that resulted from the project's work since the previous year's report

II.a. International SOLAS Summer School

The SOLAS International Summer School is a biennial, two-week program designed to immerse early-career scientists in SOLAS sciences and provide them with the skills necessary for their future scientific careers. SOLAS believes that by providing excellent training, it adequately prepares these future scientists to contribute to the understanding of global change and its significant environmental and societal challenges. Since 2003, SOLAS offered 6 Summer Schools, 5 in Cargese, Corsica and the most recent one in 2013 in Xiamen, China. Despite the success of the schools and the frequent requests of information on the next edition of the school, there is no plan underway for another school. This was prevented by the clash created by the SOLAS Open Science Conference 2015 in Kiel, location of the IPO and the uncertainty until recently of the future of the IPO in GEOMAR beyond 2015. However, a new location has been investigated: Cape Verde, in particular the INDP and Ocean Observatory in Mindelo.

***II.b. SOLAS synthesis paper in* Anthropocene**

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

The domain of the surface ocean and lower atmosphere is a complex, highly dynamic component of the Earth system. Better understanding of the physics and biogeochemistry of the air-sea interface and the processes that control the exchange of mass and energy across that boundary define the scope of the Surface Ocean-Lower Atmosphere Study (SOLAS) project. The scientific questions driving SOLAS research, as laid out in the SOLAS Science Plan and Implementation Strategy for the period 2004-2014, are highly challenging, inherently multidisciplinary and broad. During that decade, SOLAS has significantly advanced our knowledge. Discoveries related to the physics of exchange, global trace gas budgets and atmospheric chemistry, the CLAW hypothesis (named after its authors, Charlson, Lovelock, Andreae and Warren), and the influence of nutrients and ocean productivity on important biogeochemical cycles, have substantially changed our views of how the Earth system works and revealed knowledge gaps in

our understanding. As such SOLAS has been instrumental in contributing to the International Geosphere Biosphere Programme mission of identification and assessment of risks posed to society and ecosystems by major changes in the Earth´s biological, chemical and physical cycles and processes during the Anthropocene epoch. SOLAS is a bottom-up organization, whose scientific priorities evolve in response to scientific developments and community needs, leading to the decision to launch a new 10-year phase. SOLAS (2015-2025) will focus on five core science themes that will provide a scientific basis for understanding and projecting future environmental change and for developing tools to inform societal decision-making.

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

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

The IGBP event at AGU has three aims: (a) present and discuss the results of IGBP's final synthesis; (b) reflect on IGBP's science and policy legacy, and (c) mark the transition of its community to Future Earth. The activities will include trans-disciplinary and crosscutting scientific sessions, an early-career scientists' gathering (in collaboration with Future Earth), and an evening reception to celebrate the programme's legacy. IGBP is co-sponsoring over 60 scientific sessions covering a range of topics. SOLAS initiated and proposed sessions, also contributed to the planning of the other parts of the events. SOLAS will be present at the IGBP Landmark Synthesis event.

II.d. Future Earth cluster activity

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

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

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

II.e. Collaboration with ESA

The OceanFlux project series aimed at reinforcing the scientific collaboration between ESA and SOLAS. The overall project objective was twofold: (1) Support the development of novel products and enhanced EO-based observations responding to the needs of the SOLAS community and (2) Advance in the integration of EO-based products, in-situ data and models in order to contribute to SOLAS major scientific gaps. Three projects have been identified and were carried out (2011-2013):

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

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

II.f. Collaboration with PICES

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

A ½-day workshop took place on 17-26 Oct 2014 in Korea on "SOLAS into the future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth Program" at the PICES annual meeting 2014 "Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future". The workshop was proposed and run by Lisa Miller, Minhan Dai and Yukihiro Nojiri. The history of SOLAS, from the 1990s, was reviewed, as well as the activities of the 1st phase of SOLAS. Lower atmospheric aerosol sciences, iron fertilization experiments, and the establishment of the ocean surface pCO_2 database were highlighted.

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

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

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

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

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

Leticia Cotrim Da Cunha, SOLAS Brazil national representative and colleagues from Latin American countries submitted a proposal to run a one-day workshop on SOLAS jointly with BrOA (Brazilian Research on Ocean Acidification) at the PICES Climate Change Symposium 2015 in Santos, Brazil, on 23-27 March 2015. The joint workshop (W2/W6) combined invited talks by Silvana Birchenough (Cefas, UK), Rosane G. Ito (Federal University of Rio Grande, Brazil), Christian Vargas (Universidad de Concepción, Chile), and Arne Körtzinger (GEOMAR Helmholtz Centre for Ocean Research, Germany), along with other selected talks and breakout group discussions corresponding to the main BrOA network and SOLAS topics. Most of the participants were directly involved with different Ocean Acidification issues (bioassays, paleoclimate, biogeochemistry). Participants came mostly from Brazil but also from France, United Kingdom, Monaco, Germany, USA, Chile, and Portugal, and actively participated to the discussions. During the breakout discussion session. participants agreed on the need to push a common activity such as creating the Latin American OA network (LAOCA). As there was a strong OA community, it was a unanimous idea that there is a need of a common ground on standardization of methods and data management. The need to use new technologies on sensors and platforms was also agreed. Thus, it was suggested that training workshops involving

emerging research groups could be done, such as training courses focusing on standardization of procedures and new technologies for marine CO_2-system measurements. One of the ideas was to suggest the SOLAS International Project Office to have its next Summer School focusing on CO_2-system measurements, including new technologies for autonomous sensors.
A more detailed report is available in the Summer PICES Newsletter p8 at:
https://www.pices.int/publications/pices_press/volume23/PPJuly2015.pdf.

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

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

II.q. SOLAS France day workshop

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

II.h. SOLAS communication

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

SOLASNews newsletter (NL) emailed to ~2200 scientists and airmailed to ~100 scientists, mainly from developing countries. Copies are held by the SOLAS IPO for distribution at SOLAS-relevant conferences and meetings. The NL is also available from the SOLAS website. The SOLAS News is printed and airmailed from China courtesy of State Key Laboratory of Marine Environment Science, Xiamen University. Since issue 11, SOLAS also implemented an on-screen reader pdf version. Issue 17 (May 2015) proposed articles that introduced the topics and/or keynote speakers of the SOLAS Open Science Conference 2015 and some updates of partners' projects.

E-bulletins are sent to more than 2,200 SOLAS scientists roughly 10 times per year and previous issues are archived on the website at http://www.solas-int.org/archive.html. The bulletins contain news from SOLAS, opportunities for meetings, abstract submission deadlines, recent publications, vacancies and news from relevant partner project and collaborators.

Flyers. The IPO has created an A5 flyer, with the support of the IGBP designer Hilarie Cutler and the funding from the French CNRS/INSU. The flyer informs on the outline of the new science plan. The flyer has not been circulated yet.

II.i. SOLAS national networks

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

Australia: Sarah Lawson and Andrew Bowie
Belgium: Nathalie Gypens (NEW)
Brazil: Leticia Cotrim Da Cunha
Canada: Maurice Levasseur
Chile: Laura Farias
China (Beijing): Minhan Dai
China (Taipei): Gwo-Ching Gong
Denmark: Lise Lotte Soerensen and Mikael Sejr
France: Remi Losno
Germany: Hermann Bange and Ulrich Platt
India: VVSS Sarma (NEW)
Ireland: Brian Ward
Italy: Chiara Santinelli
Finland: Gerrit de Leeuw
Japan: Mitsuo Uematsu
Korea: Kitack Lee
Mexico: Jose Martin Hernandez Ayon
Netherlands: Jacqueline Stefels
New Zealand: Cliff Law
Norway: Siv Lauvset
Peru: Michelle Graco
Poland: Timo Zielinski
Russia: Sergey Gulev
Spain: Alfonso Saiz-Lopez (NEW)
Southern Africa: Carl Palmer
Sweden: Katarina Abrahamsson
Turkey: Baris Saglihoglu and Mustafa Koçak
UK: Tom Bell
USA: Bill Miller[3]

Implemented in Jan. 2009, the national representatives of the SOLAS nations are asked to report annually about the SOLAS activities in their country. To facilitate the reporting effort, a template form is provided. In January 2015, 19 reports were received and posted on the SOLAS website. The information contained in the reports has been a great source of information for the IPO to report to sponsors, but also to facilitate the coordination job and to redistribute the results and progress from some nations to the rest of the SOLAS community via the Newsletters and the website. All the reports received during the reporting period are available in an Addendum to this report (posted on the SCOR meeting page at http://scor-int.org/SCOR_EC_2015.html.

II.j. Endorsed projects

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

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

III.a. SOLAS International Project Office, Kiel

The SOLAS IPO is hosted at the GEOMAR Helmholtz-Centre for Ocean Research Kiel in Kiel, Germany. The office is currently staffed with the executive officer, Dr. Emilie Brévière and the project officer, Stefan Kontradowitz. GEOMAR provides office space and funds the executive officer salary since 1st February 2011 until August 2016. The project officer salary is supported

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

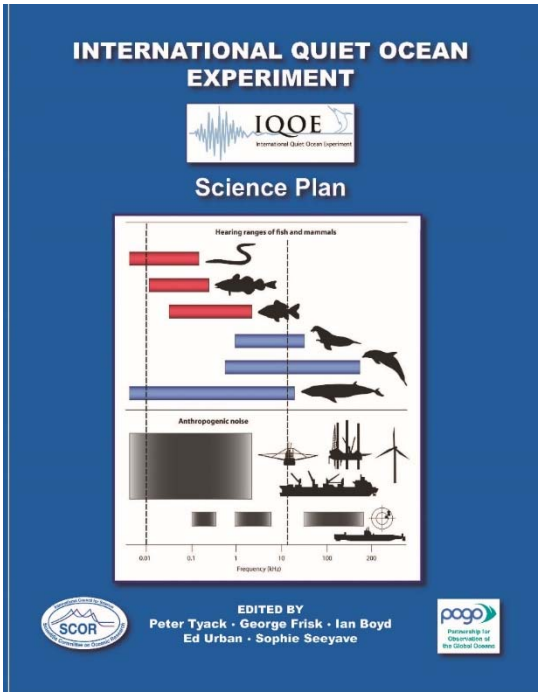
since 1 February 2013 by the German Ministry of Education and Research (BMBF) via the German national SOLAS project ‘SOPRAN’ Phase 3 until January 2016. The IPO has benefiting since mid-March 2014 from a master student help for the OSC2015 (38 hours per month) funded by BMBF until Sept 2015.

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

3.5 International Quiet Ocean Experiment *Shapovalov*

2015 Annual Report
International Quiet Ocean Experiment

The Science Plan of the International Quiet Ocean Experiment was approved by both SCOR and the Partnership for Observation of the Global Oceans (POGO) since the 2014 SCOR General Meeting. The plan was published and distributed in mid-2015. The editors of the plan were Peter Tyack (Univ. of St. Andrews), George Frisk (Florida Atlantic Univ. and Woods Hole Oceanographic Institution), Ian Boyd (Univ. of St. Andrews), Ed Urban (SCOR), and Sophie Seeyave (POGO). The document is based on an open science meeting hosted by IOC in Paris in 2012. The IQOE Science Plan is available at http://www.scor-int.org/IQOE/IQOE_Science_Plan-Final.pdf.



Since publication of the plan, the editors of the plan and financial sponsors have been working to establish a foundation of implementation activities.

Funding: SCOR budgeted US$10,000 for IQOE implementation activities in 2015. A small portion of this amount has been used for printing expenses. Additional amounts were used to partially support a meeting of editors and sponsors in Woods Hole, Massachusetts, USA and for a meeting on 29-30 September 2015 in Washington, DC with project stakeholders. An additional US$90,000 per year for three years have been committed from Monmouth University and Rockefeller University. POGO will provide 10,000 euro for an activity called "Implementing IQOE Science Recommendations on Marine Noise Exposure and Broad-Scale Acoustic Monitoring." Funding for a second year will be contingent on demonstrated progress in achieving the milestones listed in the project proposal. Funding will continue to be sought from other sources to support an IQOE International Project Office (IPO) and IQOE activities. For example, a proposal has been submitted to NERC (UK) for support of an IPO at St. Andrews. Decisions about this support should be made by the end of 2015.

Meetings: IQOE was represented by Peter Tyack at the 2015 Annual POGO meeting in January in Tenerife, Spain. POGO approved IQOE as a POGO project at that meeting. IQOE was represented Jennifer Miklas-Olds of Pennsylvania State University at International Hydroacoustics Workshop 2015 in Vienna, Austria on 29-30 June. A meeting was hosted by Jesse Ausubel in Woods Hole, Massachusetts, USA on 8-9 July to plan the initial phases of IQOE implementation. This phase will begin by identifying databases of acoustic data that could be made publicly available and discussion of potential members of the inaugural IQOE Steering Committee. IQOE will work at the intersection of scientific research, ocean observations,

industrial and naval activities, and environmental concerns, so much foundational work will need to be devoted to creating liaisons between IQOE and a wide variety of organizations.

Steering Committee: The editors of the Science Plan and IQOE sponsors put together a long list of potential IQOE SC members, from which a balanced list of potential SC members has been compiled. We are in the process of contacting the potential members to determine their willingness to serve on the SC and will submit a nomination memo to SCOR and POGO in the near future. We will aim to have the first SC meeting early in 2016. SCOR and POGO linkages will be sought in relation to all IQOE committees and activities.

Outreach: The successful launch of IQOE will depend on effective outreach to the scientific community, the potentially affected providers of acoustic data (CTBTO, industry, and navies), and sectors with an interest in appropriate regulation of sound in the ocean (industry, navies, environmental NGOs, the public). Each of these audiences will be most effectively reached by outreach tailored to their interests. It will be important to continue to stress that information produced by IQOE will not only result in better protection for marine organisms, but also will benefit sound producers as regulations and government decisions will be based on better information.

An IQOE Web site has been developed with basic information about the project (see www.iqoe.org). The site includes information about the development of the project, products that have resulted, people who have been involved, and resources for the community, such as links to relevant programs.

The IQOE Science Plan has been distributed to the scientific community. However, it was decided that a different kind of document about IQOE should be developed for industry and navies, who might perceive the science of IQOE as being designed to create stricter regulations, which is not the purpose of IQOE.

A PowerPoint slide deck has been developed for use by IQOE "ambassadors".

Jesse Ausubel will be delivering the 35th Annual Michelson Lecture on 15 October 2015 at the U.S. Naval Academy in Annapolis, Maryland (see http://www.usna.edu/NewsCenter/2015/09/jesse-ausubel-to-deliver-naval-academys-35th-annual-michelson-lecture.php). Ausubel's lecture will be on "Ocean Past, Ocean Future: Reflections on the Shift from the 19th to 21st Century Ocean" and will focus on sound in the ocean, including information about IQOE.

We look forward to reporting progress and getting feedback from the SCOR annual meeting in Goa, India in December 2015 and the POGO annual meeting in Yokohama, Japan in January 2016.

Submitted by

Ed Urban, SCOR Executive Director, and Sophie Seeyave, POGO Executive Director

3.6 Second International Indian Ocean Expedition ***Hood, D'Adamo, Burkill***

SCOR, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and the Indian Ocean Global Ocean Observing System (IO-GOOS) continue to work toward launch of the Second International Indian Ocean Expedition (IIOE-2) on 4 December 2015.

IIOE-2 Science Plan: SCOR took the lead on developing the IIOE-2 Science Plan, with the work carried out by a committee led by Raleigh Hood (USA). The IIOE-2 Science Plan was accepted by the SCOR Executive Committee in mid-2015 and adopted by the Intergovernmental Oceanographic Commission (IOC) of UNESCO at its 2015 General Assembly in June 2015. Raleigh Hood and Ed Urban are working on gathering permissions to reprint figures in the plan and high-resolution figures for the document. Several of the figures have been re-draw by a graphic artist, who is also doing the formatting for the report. Copies of the report will be printed by the time of the Indian Ocean symposium in Goa, India on 30 Nov.-4 Dec. 2015.

IIOE-2 Implementation Plan: IOC is taking the lead on creating the IIOE-2 Implementation Plan, which is also planned to be completed by the time of the Indian Ocean symposium. The work is being done through the IOC Interim Planning Committee (IPC), which is chaired by Satheesh Shenoi, who is a SCOR Nominated Member from India. Peter Burkill and Raleigh Hood are IPC members. SCOR has committed to working to help specifically with two of the themes of the Implementation Plan, related to science and capacity development.

Launch of the IIOE-2: The official launch of the IIOE-2 will take place on 4 December 2015, with a formal ceremony at Goa, India, at the end of the Indian Ocean symposium. The first cruise of the IIOE-2 will depart from Goa on that day, headed from Goa to Mauritius, on board the ORV *Sagar Nidhi.* The cruise will include significant participation of non-Indian scientists.

Town Hall Session at Ocean Sciences 2016: A Town Hall session has been proposed at Ocean Sciences 2016, led by Raleigh Hood, to update the international ocean science community about the status and progress of the project.

National IIOE-2 Committees: SCOR is encouraging the formation of national IIOE-2 committees, to coordinate national research in the Indian Ocean and promote increased funding for such work. National contributions will provide a strong foundation for the IIOE-2. Although not all these countries have formed a national committee, they have submitted abstracts for a plenary session on national IIOE-2 plans at the Indian Ocean symposium: Australia, China, Germany, India, Indonesia, Italy, Japan, Norway, and the UK. The U.S. IIOE-2 Committee held its first conference call on 1 October to organize its work.

4.0 INFRASTRUCTURAL AND OTHER ACTIVITIES

4.1 **IOC/SCOR International Ocean Carbon Coordination Project, p. 4-1** ***Fennel***

4.2 **Southern Ocean Observing System (SOOS), p. 4-25** ***Wainer***

4.3 **IAPWS/SCOR/IAPSO Joint Committee on Seawater, p. 4-33** ***Smythe-Wright***

4.4 **GlobalHAB, p. 4-37** ***Enevoldsen, Urban***

4.5 **Workshop on Seafloor Ecosystem Functions and their Role in Global Processes, p. 4-38** ***Urban***

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

International Ocean Carbon Coordination Project
Progress Report for SCOR, August 2015

The complexity of the marine carbon cycle and its numerous connections to carbon's atmospheric and terrestrial pathways means that a wide range of approaches have to be used in order to establish the role of carbon in the global climate system. The International Ocean Carbon Coordination Project coordinates this highly diverse set of activities and facilitates the development of globally acceptable strategies, methodologies, practices and standards homogenizing efforts of the research community and scientific advisory groups as well as integrating the ocean biogeochemistry observations with the multidisciplinary global ocean observing system. This report highlights the main activities of the IOCCP between September 2014 and August 2015.

Projects and Major Activities

First International IOCCP Sensors Summer Course

The IOCCP has completed its First International Summer Course on Best Practices for Selected Biogeochemical Sensors (oxygen, pH, pCO_2, nitrate). The course was held at the Sven Lovén Center for Marine Sciences in Kristineberg, Sweden on 22 June-1 July 2015.

In recent years, ocean technology has aided scientists by providing them with cost-effective tools that can measure essential biogeochemical variables autonomously, for example, by sensors on autonomous platforms. These autonomous measurements are complementary to efforts carried out by traditional ship-based sampling, with the aim of improving data coverage worldwide. Yet, despite these options becoming more readily available, there is still a gap between the technology (investigators and technicians that deploy these technologies) and end users.

The IOCCP decided to fill this gap by starting a series of summer courses with the main aim to develop proficiency in the use of a suite of biogeochemical sensors worldwide and to improve the quality of the data currently generated by autonomous biogeochemical sensors. This first 10-day summer course provided 27 trainees from 14 countries with lectures, hands-on in-situ and

laboratory experiences, and informal interactions to improve in-depth knowledge on instrument know-how, troubleshooting, data management, data reduction and quality control.

For 8 months between November 2014 and June 2015, the IOCCP Project Office (1 person at the moment) as well as 2 designated IOCCP SSG members were strongly engaged in preparing for the course. The intensity of activities increased significantly in March 2015 when participants' selection started and most of the activities listed below entered their final phase:

- fundraising (approximately 80% of costs were covered from outside the regular IOCCP budget);
- selection of Scientific Advisory Committee (SAC) and monthly SAC meetings
- selection of specific sensor types
- development of criteria to select participants
- development of the course agenda
- advanced course logistics related to hardware shipments (biogeochemical sensors, auxiliary sensors, supporting hardware, etc.)
- local logistics at the Station (accommodation arrangements, local transportation arrangements, laboratories, meals, lecture halls)
- travel arrangements for lecturers, participants and organizers
- dealing with a large number of individual questions and requests

These activities and the Course itself consumed a significant portion of Project Office's time during March-June 2015; therefore, no other activities are going to be planned around the dates tentatively chosen for the second edition of the course (June 2017). Despite this significant workload, it is clear that this activity is in high demand within our community. IOCCP received many outstanding applications (almost 100) and following a relatively strict evaluation process, this first course brought together a group of 27 participants from 14 countries. Most of rejected applicants will re-apply in 2017 (based on their communication) and new applicants are already keen to ask questions related to the application process.

We were fortunate to attract 13 excellent lecturers and 4 manufacturers (participants list attached to this report), who through their dedication, hard work and unwavering enthusiasm made this course an unforgettable experience for everyone involved. Most of the lecturers have expressed their interest in teaching this course again in the future. The agenda (attached to this report) was developed with plenaries, practical sessions, informal presentations and social time allowing our participants not only to improve their knowledge in many aspects of biogeochemical sensors observations, but also to gain an expanded network of collaborators and friends. An initial analysis of individual evaluation forms from lecturers and participants suggest that the course as a whole was a great experience for most of participants with too high intensity (most often 8am-10pm agenda) given as the only negative aspect. All the individual evaluations will be taken into account during planning of the second edition of the Course.

A more formal report based on extensive input received during the course from lecturers, participants and manufacturers will be developed over the coming months. We hope to turn it into a field manual for novice sensor users worldwide.

The Surface Ocean CO_2 Atlas (SOCAT) Project

IOCCP's coordination of the Surface Ocean CO_2 Atlas (SOCAT) continues as an activity carried out by a dedicated subset of the international marine carbon research community. SOCAT aims to improve access to surface water CO_2 data by regular releases of quality-controlled synthesis and gridded fCO_2 (fugacity of carbon dioxide, similar to partial pressure) data products for the global oceans and coastal seas. SOCAT version 1 was publicly released in 2011, version 2 followed in 2013 and version 3 will be released in September 2015. Version 3 will have 14.5 million surface water fCO_2 observations from 3630 data sets between 1957 and 2014.

Major efforts were made over the last 12 months to develop a quality-control system allowing for inclusion of sensors data and to finalize the data upload and quality-control automation system. Both efforts resulted in successful implementation (at least at a beta-version level) of operating procedures. Starting from September 2015, both sensor-borne and ship-borne data may be uploaded to SOCAT through an automated online form with many user-friendly features.

Data submission for version 4 will be closed on 31 December 2015, with quality control ending in April 2016. Beyond the standard data submission–data quality control cycle related to consecutive SOCAT releases, IOCCP plans to assist the community with following issues:

- Acknowledgements and credits for data providers and funding agencies
- Collaboration with the Global Carbon Project
- Measuring the success of SOCAT
- Plans for additional parameters in SOCAT version 4 and/or later

Acknowledgements and credits are essential for data gatherers, funding agencies and future SOCAT releases. The SOCAT data policy states that data providers should be consulted and considered for co-authorship, if SOCAT is used for a regional study.

The Global Carbon Project used one data product based on SOCAT version 2 in its 2013 Global Carbon Budget and will use four such products for the 2014 Budget (Le Quéré et al., 2014) and beyond.

One measure of success is that SOCAT has been cited or named in more than 100 peer-reviewed scientific publications, 7 international reports, 5 book chapters, 2 PhD theses and 10 other "soft" publications. SOCAT data products are used for a variety of scientific studies, notably process studies, quantification of the ocean carbon sink, its seasonal, year-to-year and decadal variation and the initialisation and validation of ocean carbon cycle models. An example is the Surface Ocean pCO_2 Mapping Intercomparison (SOCOM). The OceanGHG Flux project (http://www.oceanflux-ghg.org), a European Space Agency project, heavily relies on SOCAT.

Frequent requests are made to add extra parameters to SOCAT, for example, surface water nutrients, oxygen, dissolved inorganic carbon (DIC), alkalinity, methane and nitrous oxide and isotope data. At present additional parameters submitted to SOCAT, alongside surface water xCO_2, pCO_2 or fCO_2, are archived, but they are not quality controlled and not included in the SOCAT data products. Extra parameters are needed for understanding mechanisms of fCO_2 changes. An increase in fCO_2 may be related to enhanced remineralisation or variable upwelling, as shown by numerous studies. Such research requires nutrient data. An analysis of fCO_2 growth rates and causes thereof in 14 regions in relation to SST, salinity, DIC and alkalinity, shows that in several regions the loss of alkalinity increases fCO_2, suggesting that the uptake of anthropogenic carbon is smaller than expected based on analysis of fCO_2 alone. There is an increasing necessity for understanding climate-carbon feedbacks and for more information on regional uptake rates of anthropogenic carbon. All this has relevance for ocean acidification, which partly explains why the Global Ocean Observing System (GOOS) wants measurements of the full carbonate system, rather than just fCO_2 (Framework for Ocean Observing (FOO), 2012), describing carbonate parameters as 'essential variables'.

The Global Ocean Acidification Observing Network (GOA-ON)

The GOA-ON-related efforts are the main IOCCP contribution to our understanding of this multidisciplinary, multi-scale, global phenomenon. The marine biogeochemistry community strongly influences GOA-ON strategies and implementation solutions through active participation of four current and former IOCCP SSG members in the GOA-ON Executive Council. The backbone of GOA-ON efforts to develop the optimal observing system to detect OA impacts on various ecosystem relies heavily on IOCCP coordination of global ocean carbon observing networks such as repeat hydrographic surveys, time-series stations, floats and glider observations, and volunteer observing ships.

Two major GOA-ON activities developed with IOCCP leadership over the past 12 months are (i) the Ocean Acidification Data Portal and (ii) ocean acidification data synthesis products.

A small technical working group lead by Benjamin Pfeil (IOCCP Data Manager) was established to investigate possibilities to create a dedicated portal for ocean acidification observing data. A work plan and initial goals of this group were turned into an agenda for a small workshop held in Monaco in June 2015 (details in the meeting section below). The group's report will incorporate the recommendations made by the OA-ICC Advisory Board, the GOA-ON Executive Council and workshop participants. This document will be distributed to the community for comments and will serve as a baseline for a data portal implementation plan, which will be hopefully developed before May 2016.

The second GOA-ON-related item of strong interest to IOCCP are OA data synthesis products, and how their development—for example, on a regional basis using open ocean and coastal data—could be taken forward as pilot projects. As a global approach similar to SOCAT was deemed not feasible for such a fragmented and mostly coastal community, it was suggested that effort might initially be directed at a regional synthesis for the western Pacific (primarily involving China,

Taiwan, Japan and Korea), and for the Northeast Atlantic/European seas (expanding on a UK/North Sea synthesis that is expected to be carried out in the next 6 months by NERC/Defra and ICE).

More detailed discussions on this topic are planned to be held during the next GOA-ON Executive Council meeting, tentatively planned for November 2016.

The Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP)

Updated GO-SHIP cruise plans are available at http://www.go-ship.org/CruisePlans.html. In 2014, 9 cruises (4 in the Atlantic, 3 in the Pacific, and 2 in the Southern Ocean) were completed. In 2015, 7 cruises (2 in the Atlantic; 2 in the Pacific, and 1 in the Southern, 1 in the Indian, and 1 in the Arctic) have been funded. This year is marked by the implementation of GO-SHIP cruises in the Indian Ocean and in the Arctic. For 2016, 8 cruises have been planned or funded. The GO-SHIP Executive Group approved the Central Med cruises in the Mediterranean and JOIS cruises in the Beaufort Sea as GO-SHIP cruises.

A technical decision was made to divide measurements made on GO-SHIP cruises into three levels in order of priority. This is in concert with U.S. Repeat Hydrography Program and substitutes "core variables" in IOC Technical Series 89.

Level 1 measurements are mandatory on all decadal survey cruises to fulfill the GO-SHIP scientific objectives of directly quantifying change in ocean carbon inventory; estimating anthropogenic CO_2 empirically; characterizing large-scale water mass ventilation rates; constraining horizontal heat, freshwater, carbon, nitrogen, and oxygen transports and/or net divergence; and providing an on-going basis for model evaluation. A subset of decadal survey lines occupied at higher frequencies (yearly, biennial), mainly to understand changes in natural carbon cycle, do not need to undertake all level 1 measurement on all re-occupations. The level 1 measurements include physical parameters as well as Essential Ocean Variables for biogeochemistry (BGC EOVs) such as DIC, T_{Alk}, pH, CTD oxygen, nutrients by standard auto analyzer, dissolved oxygen, CFC-11, CFC-12, CFC-113, and SF_6.

Level 2 measurements are highly desirable as augmentation and addition for the science objectives executed on GO-SHIP cruises. They include such BGC EOVs as discrete pCO_2, ^{14}C by AMS, ^{13}C of DIC, DOC, DON, and surface underway system for nutrients, O_2, Chl and skin temperature. All BGC EOVs except suspended particulates, particulate matter export and N_2O are included in either level 1 or level 2 measurements.

Level 3 measurements are mainly ancillary measurements often taken in conjunction with the core measurements in order to address a scientific question unique to the region of investigation.

While the integrity of GO-SHIP hydrographic sections seems temporarily secured, there are growing demands to add high-quality hydrographic sections, which do not meet GO-SHIP spatial and/or temporal requirements, to national plans. These sections, possibly labeled GO-SHIP "-

light", "-like" or "-partner", are requested in many locations from Argo Steering Team and are a requirement for the Atlantic Ocean Observing System in the EU AtlanOS Project. Other regions and programs will likely follow suit.

High-quality ocean biogeochemistry data, including BGC EOVs from these sections, are hoped to fill the large data gaps in time-space domain between time-series stations and GO-SHIP decadal surveys. They should help understand the biogeochemical processes/phenomena in societally important regions and in key regions for ocean (anthropogenic) CO_2 uptake and climate variability in the seasonal to interannual time scales. These sections will also provide substantial opportunities for sensor deployment/recovery and validating/calibrating autonomous sensors, thereby producing synergy with other ocean-observation programs such as Bio Argo and SOOP.

In addition to the GO-SHIP reference and high-frequency cruises, non-GO-SHIP cruises will be an important component of the GOOS Framework for Ocean Observing. GO-SHIP "light" is to be further discussed during the GAIC-2015 in September 2015.

Pilot project for evaluation of biogeochemical sensors on drifting buoys

Global oceans are relatively well monitored on a sustained routine basis in terms of physical properties such as sea level pressure and sea surface temperature (SST). This is the result of the global effort to populate the oceans with autonomous platforms capable of reporting these variables in support of Numerical Weather Prediction, climate change monitoring and oceanographic research. Platforms include the Argo array, the OceanSITES reference moorings, volunteer observing ships and the global drifter fleet. One consequence is that daily global SST and other products are now available that merge satellite and *in situ* observations. The same is not true for any of the biogeochemical variables such as pCO_2, oxygen, nutrients or pH, despite general recognition that monitoring of these is important for the understanding and prediction of climate variability and long-term change. In part, this gap is due to the lack of suitable remote sensing capability; in part, due to the inadequacy of the *in situ* network, in particular the absence of routine biogeochemical measurements by the global drifter, glider and profiling float fleets. The marine biogeochemistry community, in collaboration with the Argo programme, is moving to address this deficiency in terms of profiling floats (e.g. SOCCOM Project), as are many of the glider operators, but to date drifter operators have been slow to respond.

OceanObs'09 called for the rollout of biogeochemical observations, and the resulting Framework for Ocean Observing called for IOCCP to lead the effort of enhancing existing observing networks by ensuring close collaboration between the existing operators and marine biogeochemistry community. This was noted by the WMO-IOC Data Buoy Cooperation Panel (DBCP) and in 2011, Dr Maciej Telszewski (IOCCP) addressed the DBCP at its session in Geneva and requested the DBCP to respond. At that stage, the sensor technology was insufficiently advanced in terms of robustness and cost for it to be realistic for the DBCP to consider the implementation of biogeochemical sensors within the global drifter fleet, but the DBCP did request to be updated on a regular basis.

Over the last four years major advances have been made in sensor technology to the extent that it is now timely for the DBCP to consider the evaluation of biogeochemical sensors as possible candidates for incorporation within the global drifter fleet. The results of such an evaluation would form a valuable input to OceanObs'19 and other assessments of ocean observing capability. Most recently, the GOOS Steering Committee session in May 2015 asked the IOCCP and DBCP to consider launching a biogeochemistry drifter pilot project as a matter of priority. The DBCP has established a significant reputation in the evaluation of new sensors and technologies and their eventual transition to operational use through the mechanism of time-limited pilot projects. Successful projects in recent years have covered the Iridium and Argos-3 satellite communications systems, wave-buoy intercomparisons and High Resolution SST for satellite algorithm validation. DBCP and IOCCP agreed to work on this activity, furthermore DBCP asked IOCCP to form a relevant task team and submit a proposal (in October 2015) for a 4-year pilot project with an annual budget ceiling within US$30,000 – US$50,000 brackets

In May-August 2015 the IOCCP worked with the relevant subset of biogeochemistry community to develop the most efficient and realistic approach. It was agreed that oxygen and pH will be the first two parameters to be implemented, mainly for technical reasons and also due to certain cost effectiveness of such approach which is extremely important with a very limited budget.

Prof. Anders Tengberg of the University of Gothenburg, Sweden and Dr Matt Mowlem of the National Oceanography Centre, Southampton, UK agreed to act as co-chairs of the so-far informal task team. They are both world leaders in biogeochemical sensor development, deployment and data analysis. Remaining task team members (3-5) will be approached in fall 2015. Additionally, IOCCP has successfully approached 2 industrial partners (oxygen and pH sensor technology) and their support and input will be crucial in terms of cost-efficiency and technical logistics.

The IOCCP has prepared a proposal for the DBCP to consider implementing a 4-year pilot project for biogeochemical observations from drifters. The objectives of the project would be four-fold:

i) To demonstrate the feasibility or otherwise of adding biogeochemical sensors to standard SVP-B drifters already being procured by many agencies;

ii) To evaluate the quality of the ensuing data and its usefulness in describing the state of the global oceans in biogeochemical terms;

iii) To elaborate a cost model for the financial implications of adding biogeochemical sensors to drifters on a sustained basis;

iv) To present the results on behalf of DBCP and IOCCP to OceanObs'19 in 2019.

At DBCP-31 Plenary (19-23 Oct 2015) the IOCCP (through Tengberg and/or Mowlem) will present the science case and seek the general approval for the pilot project concept, likely budget ceiling and proposed composition of the task team.

In the next 12 months following a positive response by the DBCP-31 plenary, IOCCP (through the extended task team) plans to focus on the following tasks:

- Achieve consensus as to development and deployment strategy within known constraints (financial, technical, logistical)
- Further engage with biogeochemistry community, drifter manufacturers and operators to agree first steps regarding sensor choice and fit
- Seek incremental costings for sensor fit
- Procure and lab-test prototype
- Prepare report and recommendations for submission to DBCP-32 in October 2016

This pilot project will provide an initial assessment of feasibility of enhancing the global drifter array with biogeochemical sensors. Data quality protocols, data archival scheme and planning for data synthesis product(s) will have to follow in the coming years. Hopefully this activity will trigger the major stakeholders in biogeochemical observing research to add the global drifter array with biogeochemical sensors to their agenda.

Biogeochemical Observations in Global Climate Observing System (GCOS) Status Report 2015 and Implementation Plan 2016

During the last 12 months the IOCCP significantly contributed to the Status Report on the Global Observing System for Climate (draft version for public review available at http://www.wmo.int/gcos). Several SSG members took the responsibility to lead individual sections of the Report. IOCCP's input is most significant in sections describing oceanic essential climate variables related to biogeochemistry (nutrients, ocean acidity, carbon dioxide partial pressure, oxygen and tracers) and sections dealing with the observing networks that carry out biogeochemical observations (volunteer observing ships, GO-SHIP, biogeochemical floats, mooring arrays and ship-based time series). Additionally IOCCP made important contributions to an overall ocean observing section introduction and summary.

This Report tries to provide a full account of how well climate is currently being observed in support of IPCC and UNFCCC. It provides a basis for identifying the actions required to reduce gaps in knowledge (expression of which will be published as a GCOS Implementation Plan in 2016), and allows to assess where progress is being made, and where progress is lacking (progress against 2010 GCOS Implementation Plan is assessed). Since 2012, when the Framework for Ocean Observing identified the need for a more integrated marine biogeochemistry observations, IOCCP was asked to lend its expertize and community-wide network to contribute to this multi-domain effort. This year was when the actual report writing took place and the final product is going to be presented during the COP 21 in Paris in December 2015.

Specific details on individual parameters and networks can be found in the report currently available in its draft form from the GCOS website (http://www.wmo.int/gcos) but the very general conclusion is that observation of the ocean has progressed substantially through deployment of buoy networks, autonomous sub□surface measurement systems and space□based remote sensing,

which complement longer-established and still-essential ship-based programmes. It is now taking place under revised arrangements for scientific guidance and advice, provided by GOOS and its three panels, including one for biogeochemistry (led by IOCCP). The last few years have seen rapid development of chemical and bio-optical sensors, with increasing levels of readiness for deployment on Argo floats, gliders and moorings. Currently 7% of floats are equipped with oxygen sensors and a smaller number of floats sense nitrate and pH.

Progress in recent years has also been made on data collection and support, for example through establishment of SOCAT. Organisation of observing activities has taken place through formation of the Global Ocean Acidification Observing Network. The considerable progress made in establishing observational capabilities and systems such as these provides a basis for reconsidering the specification of the related ECVs during preparation of the 2016 Implementation Plan (IP16).

And the IP16 is where the importance of this activity lies, for biogeochemistry community. This Status Report lays the foundations on which the Implementation Plan for Global Observing Systems for Climate in Support of the UNFCCC will be built. The Implementation Plan (IP) will be published in 2016 and it is already clear that much stronger emphasis will be placed on marine biogeochemical observations for the system to be able to truly observe climate variability globally.

Optimizing and Enhancing the Integrated Atlantic Ocean Observing System – AtlantOS

Searching for diversification of funding to bring the Project Office back to 2 FTEs, in 2013 IOCCP became involved in a proposal answering to the EU Horizon-2020 call BG-8-2014: *Developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources*.

The proposal was successful and the project called AtlantOS started on 1 April 2015. IOCCP is one of the 62 project beneficiaries that include research institutes, universities, marine service providers, multi-institutional organisations, international partners and the private sector from 18 countries.

With the EU funding secured through AtlantOS, IOCCP will employ a Project Officer for 36 months staring some time between November 2015 and January 2016.

The new project officer will be primarily responsible for delivering tasks listed below. Although the tasks have to be initially regionally focused, their scope is by all means global and the idea is to apply newly developed procedures and ideas to the global coordination efforts and vice-versa. Also the new Project Officer is expected to share some of the workload related to the core IOCCP mission.

The IOCCP committed to delivering results in four tasks:

Task 1.1 : Identification of major scientific and societal challenges that require sustained ocean biogeochemistry variable observations in the Atlantic Ocean region.

We will facilitate a formal and coordinated international dialogue between the observing community, the societal stakeholder community (representatives of policy-making entities across European administration with interest vested in marine environment) and the funders as to what ocean observing requirements for marine biogeochemistry exist in the Atlantic. The IOCCP will compile the available information on societal and scientific requirements for long-term observations assuring the sustained development of the human population within the region. The observing system based on selected requirements has to provide information allowing to ensure sustained ocean services and improve our response capabilities to issues impacting human health and security. These requirements will also have to reflect the needs of policy-making community so that information collected through observations will generate a strong evidence base for decision-making.

Task 1.2 : Identification of biogeochemical Essential Ocean Variables (EOVs) for the Atlantic Ocean observing system and multidimensional feasibility assessment of the observing system capabilities based on proposed EOV's and available infrastructure.

Through consultation and negotiation with scientific and societal stakeholders we will establish a set of biogeochemical Essential Ocean Variables (EOVs) needed to address the current scientific and societal ocean/climate-related issues highlighted for the Atlantic Ocean.

In the process we will consult with programmatic and institutional partners as well as representatives of all observing networks across the AtlantOS on their requirements for the spatial, temporal and resolution requirements. We will also gather information on national capabilities, aspirations and impediments within the EU and throughout other coastal states of the Atlantic region to identify gaps and opportunities.

Each observational network supports measurements of a range of variables with varying time and space sampling resolution and accuracy, and intrinsic trade-offs based on strategy and capacity. We will perform a multidimensional feasibility assessment of the proposed EOVs with observing, modeling and sensor/instrument developing communities involved. Such assessment, built on the FOO recommendations, will reveal the current state of the Atlantic Ocean observing system for biogeochemistry and it's fitness-for-purpose by highlighting duplications, gaps, cross-fertilization opportunities and more.

Task 6.2 : Coordination of technological improvements in the observing system elements and end-user training on the usage of new observing technologies

We propose to aid the development and full integration of new technologies into the Atlantic Ocean observing system in two ways: first by coordinating the development of standards, best practices guides and data quality protocols for new observing technologies for biogeochemistry and second by hands-on training of the European and Pan-Atlantic end-users to provide capability enhancement into the future.

Task 6.4 : Support for system optimization at the data and information flow level and the information production and delivery-to-user level.

As the outputs of AtlantOS, data and information products will be the interface between our work and it's users. Many modeling, data assimilation, synthesis, and assessment activities that will provide added value to observations have to meet specific user requirements for information. Ocean information products will have to support both research and decision-making in diverse areas such as climate studies and adaptation, disaster warning and mitigation, commerce, and ecosystem-based management.

There is a need to quantify and optimize how clearly and completely all biogeochemical EOV data sets compiled under AtlantOS are identified, described, and documented. In addition, we propose to develop data usage metrics to reflect the level of demand for and breadth of uses for different data and information types. Such quantification will allow for improvements in data access, quality, and products. Such metrics, tested within AtlantOS, could then be promoted globally and become an integral part of the continuing cycle of assessing and updating the requirements, the measurement approaches and the data and information products themselves.

Nutrients Inter-comparison Experiment

Nutrients and total inorganic carbon have been the major observational variables in various international global ocean observation expeditions, such as the Geochemical Ocean Sections Study (GEOSECS) in the 1970s, the World Ocean Circulation Experiment (WOCE) in the 1990s, and the on-going Climate Variability and Predictability (CLIVAR). The comparability and traceability of nutrient data in the world's oceans are fundamental issues in marine science, particularly for studies of global climate change and it has been IOCCP's goal for many years to establish solid foundations for global comparability of the nutrients data.

In 2003, 2006, 2008 and 2012, inter-laboratory comparison studies of Reference Material of Nutrients in Seawater, RMNS, were conducted, led by Meteorological Research Institute (MRI), Japan and collaborators. Results obtained in these inter-laboratory comparison studies indicated that variability in in-house standards of the participating laboratories and handling of non-linearity of the instruments of the participating laboratories are the primary sources of inter-laboratory discrepancy. Therefore it became apparent that the use of a certified reference material for nutrients in seawater, CRMs, and the common use of the methodology of nutrients measurements are essential to improve and establish global comparability and traceability of nutrient data in the world ocean.

In 2014, IOCCP and JAMSTEC co-organized an inter-laboratory comparison study of nutrients in seawater using: four lots of recently certified reference materials (CRMs) prepared by KANSO, Japan; three CRMs by National Metrology Institute of Japan; one recently developed reference material (RM) from the Korean Institute of Standards (KIOST), and the silicate stock solution provided by the Royal Netherlands Institute for Sea Research (NIOZ).

A set of samples was distributed to all 71 participating laboratories from 28 countries. Results from 54 participating laboratories were collected as of 30 June 2015 deadline. A few more participants informed the organizers about short delays in data analysis. Detailed results will be made available by the end of 2015.

Workshops and Meetings

23rd Annual Meeting of the North Pacific Marine Science Organization (PICES), Yeosu, Korea, 18-24 October 2014.

Responding positively to annually reoccurring invitation from PICES Executive Secretary, the IOCCP took this opportunity to present various aspects of IOCCP activity to selected panels and committees of PICES. Several terms of references of both coordinating bodies overlap and both PICES and IOCCP confirmed their willingness to strengthen inter-programmatic coordination to increase the cost-effectiveness and longevity of selected activities.

Specific discussions with PICES panels are summarized below:

A. PICES Section on Carbon and Climate (S-CC)

Inter-programmatic discussions were focused on the review of the existing information on carbon cycling in the (North) Pacific, including anthropogenic carbon, the biological pump, impacts of ocean acidification on marine biota, and possible feedbacks to atmospheric greenhouse gases. Major gaps in our knowledge were identified, and prioritized recommendations for future research were listed. These included general data gap in the south Pacific and the need for a homogenous ocean acidification synthesis data product. The scope of the former exceeds the PICES geographic "coverage", nevertheless it was decided that PICES would increase its interest in basic observations in this region. As for the latter, IOCCP was asked to lead the global effort and PICES agreed to act as a regional champion triggering follow-up actions in other ocean regions.

B. PICES Technical Committee on Data Exchange (T-CODE)

Data management requirements for PICES countries and region were discussed against the needs expressed in the Framework for Ocean Observing. Strategic plan set to update those requirements was discussed and will be proposed at the PICES Executive Council meeting. No major changes are required, however subtle additions especially in the metadata forms will enable easier data archival in the world data system.

C. PICES Technical Committee on Monitoring (MONITOR)

Principal monitoring needs for the PICES region were identified and several actions were proposed to develop approaches to meet these needs. Once again IOCCP's strong advocacy for a GOOS-borne Essential Ocean Variables approach resulted in PICES agreeing to promote the EOV-based monitoring system in their region. PICES MONITOR agreed to help facilitate method development and inter-comparison workshops to promote calibration, standardization and harmonization of data sets.

EU FP7 CARBOCHANGE Final Project Meeting
Bergen, Norway, 19-22 January 2015.

The IOCCP served as the International Advisory Board throughout the lifetime of CARBOCHANGE (March 2011 - February 2015). During this Final Meeting, Maciej Telszewski presented the compiled IOCCP's Scientific Steering Group's assessment of the scientific and structural input that CARBOCHANGE gave to the global marine biogeochemistry research.

During the four years, scientists from 30 research institutes across Europe worked on better quantification of the incorganic carbon uptake by the Atlantic Ocean. Their somewhat unique approach included combining observational and modelling research allowing for creation of a system that on one side includes observational research infrastructure measuring parameters at frequencies and resolutions best fitted for the modelling research, and on the other side fit-for-purpose models that can utilize in-situ information in order to most efficiently infer on our ocean's future.

All this work is now being transferred into the pan-European Integrated Carbon Observing System Research Infrastructure (https://www.icos-ri.eu/icos-research-infrastructure/icos-central-facilities/icos-ocean-thematic-centre) with hopes for nationally funded ICOS nodes taking over the challenge.

Meeting of Ocean-Related Global Science Projects in conjunction with the Ocean Sustainability Science Symposium, Kiel, Germany, 3-6 March 2015

This meeting was convened by SCOR, GEOMAR and Consortium for Ocean Leadership as an open information exchange and strategy development arena for global marine science projects/programmes. The purpose of the meeting was to strengthen existing cooperation among international marine science activities and to foster new collaborations. The meeting resulted in two major achievements (1) a set of themes that could guide future interactions among the topics and programs and (2) an idea for an Integrated Marine Science Network that would serve as a mechanism for the interactions among the projects. This network would be managed by the projects involved, independent of the organizations that sponsor the projects. The Integrated Marine Science Network would be an open network of international research coordination entities (currently including CLIVAR, IMBER, IOCCP, LOICZ, PAGES, SOLAS) established to enhance their activities.

6th Session of the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM)'s Observation Coordination Group (OCG), Cape Town, South Africa, 27-30 April 2015

Representatives of most monitoring and operational observing networks (Argo, DBCP, GLOSS, GO-SHIP, OceanSITES, VOS, EGO) and IOCCP as a hub for biogeochemistry observations report on the status, issues and challenges for their particular network. This bi-annual meeting provides a platform for cross-fertilization as well as drawing interdisciplinary, multiplatform strategies. Particular issues discussed included but were not limited to:

- Need for development of better ways to routinely expressing the state of each observing network, including the risk assessment, potential mitigation strategy and "early warning system"
- Urgent need for development of consistent standards and practices for data management **amongst the observing networks** to facilitate discoverability and accessibility of integrated data for the research, forecast, and end□user communities as well as for product development.

IOCCP continues to advocate the needs of biogeochemical measurements being implemented throughout the system. Progress is being made in this regard and biogeochemistry becomes an important part of each observing network. All the meeting information including background documents and Power Point presentations can be downloaded from the meeting website: http://www.jcomm.info/index.php?option=com_oe&task=viewEventRecord&eventID=1601

4th Session of the Global Ocean Observing System (GOOS) Steering Committee, Townsville, Australia, 24-26 May 2015

GOOS is a permanent global collaborative coordination body for observations, modeling and analysis of marine and ocean variables to support operational ocean services worldwide. GOOS decision-making processes are centered around its Steering Committee meetings which involve representatives of all IOC member states, three expert panels (IOCCP leads the GOOS Biogeochemistry Panel) and invited experts in disciplines of importance to global observing.

These processes are designed to promote strategic investment by governments of IOC member states, through the identification of what is essential to measure in the ocean, while avoiding duplication and addressing key gaps. Therefore explicit presence of the marine biogeochemistry community (through IOCCP and invited experts) is essential during the GOOS SC and GOOS EC meetings where creating ever-increasing levels of interoperability within an integrated, multidisciplinary global ocean observing system takes place.

Detailed information related to this meeting, including background documents, presentations and final report can be accessed from the GOOS website: http://www.ioc-goos.org/index.php?option=com_oe&task=viewEventRecord&eventID=1629

Global Ocean Acidification Observing Network – Data Portal Planning Workshop, Monaco, 1-2 June 2015

This small expert workshop was organized to investigate possibilities to create a portal for ocean acidification observing data as part of GOA-ON. The workshop was organized in response to recommendations by the OA-ICC Advisory Board and the GOA-ON Executive Council.

The main goals of the workshop were to:

- Discuss the development of a web data portal allowing optimal data discovery, access, integration, and data visualization from collection- to granular- level OA data and data products using common inter-operable web data services. This web portal would build on current capacity and capabilities, accept data streams from relevant data centers, provide visual and data link capabilities, and synthesis data products for the ocean scale.
- Explore options for providing coordinated scientific data management and data flow framework that builds on existing infrastructure and scientific requirements over the long-term.
- Develop requirements for best practice metadata procedures/protocols following international standards (e.g., ISO) to facilitate data discovery, use of DOIs or similar identifiers to provide clear data provenance and attribution.
- Investigate how to best coordinate with international ocean-carbon long-term archival centers for OA observational, biological, model data, and data products. These centers would provide data integration where possible using interoperable online data services consistent with the proposed web data portal.

Several data centers were represented and gave voice to their vision for such an endeavor. One of the main aspects discussed was IP rights of data providers. It was deemed absolutely essential that the Data Portal will give clear and explicit recognition to data providers and only in the second instance to data archives. Use of existing infrastructure with potential adjustments to serve the specific needs of the portal was also decided for cost efficiency reasons. As data from many data providers will feed into the GOA-ON Data Portal.

The implementation of common vocabulary lists amongst these providers was also agreed upon as a first worldwide implementation step. Common vocabulary lists consist of lists of standardized terms that cover a broad spectrum of disciplines of relevance to the oceanographic and wider community. Using standardized sets of terms solves the problem of ambiguities associated with data markup and also enables records to be interpreted by computers.

A more comprehensive report led by Benjamin Pfeil is expected later this fall.

EU Horizon 2020 AtlantOS Project Kick-Off Meeting, Brussels, Belgium, 10-12 June 2015.

AtlantOS, one of the largest and according to some accounts, most ambitious marine research projects of recent decades has started on 1 April 2015 and held its kick-off meeting on 10-12 June 2015 in Brussels.

More than 130 participants, representing 62 project partners from 18 countries met in the Royal Library of Belgium (KBR) to formally initiate the process of enhancing the Atlantic Ocean observing system. During this kick-off meeting the details of the work program were presented and the overarching goals discussed. The first day included a plenary session which discussed expectations and concerns about sustained ocean observations and what support the AtlantOS project can provide to European and particularly non-European partners.

The second and third days were devoted to parallel meetings within work packages and tasks. With such a large number of partners with backgrounds from variety of disciplines, it was during this meeting when on many occasions collaborators met for the first time. In order to assure effective coordination of this large project, the inter-sessional period will be filled with videoconferences and small technical workshops.

Summer Course on Best Practices for Selected Biogeochemical Sensors Kristineberg, Sweden, 21 June -1 July 2015

Details were given on page 3 of this report. Agenda and participants list are attached to this report. More background information can be found at:
http://www.ioccp.org/index.php/sensorscourse.

Project Office

IOCCP Scientific Steering Group Meeting

The Tenth IOCCP Scientific Steering Group meeting was held on 14-16 April 2015 in parallel with the Ocean Observations Panel for Climate (OOPC) at Tohoku University, Sendai, Japan and was hosted by OOPC Co-Chair, Toshio Suga. The two panels were joined by Dean of Science at Tohoku University, the Vice President of the Intergovernmental Oceanographic Commision (IOC), the co-chair of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Observations Coordination Group, the Chair of the Global Climate Observing System (GCOS) and the Director and Co-Chair of the Global Ocean Observing System (GOOS). Toste Tanhua (Chair) was joined by seven members of the SSG, the Project Director and two guests representing GOOS Biogeochemistry Panel. Two SSG members could not attend the meeting; one joined by Skype. Updates on activities in nine themes coordinated by IOCCP were followed by discussion of short- to medium-term future outlook within each theme.

Although the agenda was structured around the IOCCP core themes, progress and priorities were considered in the context of coordination with OOPC, GOOS and GCOS. There was also a strong focus on the development of homogeneous essential ocean variable and observing networks specifications for combined biogeochemistry-physics-biology observing system, and how to coordinate the development of the ocean component of the 2016 GCOS Implementation Plan. Full meeting report with specific action items will be soon available from IOCCP website.

Employment of IOCCP Project Officer

Thanks to funding from AtlantOS, the IOCCP is in the process of employing a Project Officer. Following a selection process, the new Project Officer is expected to start some time between 1 November and 1 January. On 11 August 2015 the following opening (with 15 September application deadline) was distributed through IOCCP, OCB, IMBER and IO PAN distribution channels:

The **International Ocean Carbon Coordination Project (IOCCP)** invites applications for a Project Officer position. This is a full time, fixed term (36 months) appointment, based in the Institute of Oceanology of Polish Academy of Sciences in Sopot, Poland, with possibility of extension dependent on ongoing funding. Net monthly salary (after all obligatory and other deductions) will be within the 2,400-2,600 EUR range.

Project Officer: We seek a motivated, broad-thinking scientist-coordinator with interest in observational marine biogeochemistry on a global scale to contribute to existing expertise in the Project Office. The position requires a PhD degree in a relevant field and a competitive record of publication as well as evidence of the ability to provide a coordination and communication services within a global marine biogeochemistry community. As part of the Project Office, the successful candidate will be directly involved in, and responsible for implementation of specific tasks developed annually by the IOCCP Scientific Steering Group. These tasks are dictated by ever-changing challenges and needs of the marine biogeochemistry community but in general are built around the IOCCP mission as stated below:

- Develop and implement targeted workshops to promote the development of a global network of ocean carbon and biogeochemistry observations, including workshops to reach agreement on global strategies, data sharing practices, and best practices and standards, and to ensure that data from individual programs are comparable globally,
- Facilitate data collection, management, data product development, and archival of ocean carbon and related data, by assisting regional and global data syntheses such as SOCAT or GLODAP; and through collaboration with the University of Bergen and the Carbon Dioxide Information Analysis Center (CDIAC) facilitate the development of historical data bases for ocean carbon and biogeochemistry ensuring long-term data availability through archival of data sets beyond the lifetime of individual research projects,
- Maintain an international directory on ocean carbon and biogeochemistry activities through the development and maintenance of web-based compilations and syntheses of ocean carbon observation and research activities (www.ioccp.org) and through e-mail and web-based newsletters as well as peer-reviewed publications.
- Work with global research and observation organizations, programmes and projects (for example: SCOR, IOC, GOOS, GCOS, Argo and more) to promote and document the development and status of a sustained ocean carbon and biogeochemistry observing system in the framework of the Global Ocean Observing System.
- Liaise with atmospheric and terrestrial carbon and biogeochemistry programs to promote the integration of ocean carbon and biogeochemistry into earth system studies and globally-integrated observations.

- Provide regular reports and updates on IOCCP activities to sponsors and the international research community and produce outreach material for the research community and public stakeholders including workshop reports, scientific summaries for policymakers, guides and manuals on best practices, and a quarterly newsletter.

Selection Criteria

- A PhD in marine science, with strong background in marine biogeochemistry.
- Background in project management, including the writing/development of strategic and project planning documents.
- Well-developed negotiating skills encompassing different science areas and cultural backgrounds.
- Well-developed networking and communication skills (fluent oral and written English) and experience in development and writing of technical and public documentation suitable for both science community and public consumption.
- Experience in development of funding proposals to government and non-government organizations.
- Proven ability to work under limited direction, and across culturally diverse working environments.
- Experience in the development and maintenance of web-sites and fluency in use of web-based communication and coordination tools.

To apply by 15 September 2015 deadline send your CV (including contact details for 3 referees) and cover letter to Maciej Telszewski (IOCCP Project Director) at m.telszewski@ioccp.org

Publications (IOCCP SSG members in blue)

1. Study co-funded by IOCCP with IOCCP, NSF and SCOR prominently acknowledged:

Orr, J. C., Epitalon, J.-M., and Gattuso, J.-P. **2015**. Comparison of ten packages that compute ocean carbonate chemistry, Biogeosciences, 12, 1483-1510, doi:10.5194/bg-12-1483-2015, freely available at http://www.biogeosciences.net/12/1483/2015/bg-12-1483-2015.html

2. WMO GHG Bulletin Vol 64(1) – 2015 (http://www.wmo.int/bulletin/en/volumes/vol-64-1-2015) was co-authored by Toste Tanhua, Laura Lorenzoni and Masao Ishii, and IOCCP and SCOR are acknowledged in the document. The WMO *Bulletin* (http://www.wmo.int/bulletin/en) is the official journal of WMO issued twice yearly and produced in English, French, Russian and Spanish.

Future Directions

IOCCP will execute specific actions developed during the Tenth Session of the Scientific Steering Group (14-16 April 2015, Sendai, Japan). In addition, more general actions will be taken to meet new challenges dictated by changing needs of marine biogeochemistry community. During the course of the next year IOCCP priorities will include:

Underway CO_2 observations
A more efficient and better-coordinated network of surface ocean carbon and biogeochemistry observation platforms, including ships of opportunity and research vessels, remains one of the key objectives for IOCCP. To achieve a sustained, scientifically robust and cost efficient ocean carbon and biogeochemistry observing system, stronger implementation ties with the Global Ocean Observing System (GOOS), Global Climate Observing System (GCOS), and WMO-IOC Joint Commission on Oceanography and Marine Meteorology Observations Coordination Group (JCOMM-OCG) will be developed. GOOS and GCOS implementation plans include a strong biogeochemistry component after several years (if not decades) of being focused almost entirely on physical parameters. Marine biogeochemistry is now explicitly included in all phases of observing system improvement plans: requirement setting, observing system distribution, data quality assurance, data archival and distribution of synthetic information. Both programs rely on IOCCP's coordination and leadership, which will allow drawing on biogeochemistry community's expertise and energy during the implementation process.

To increase the success rate of VOS recruitment for underway observations a web-searchable data-base of VOS information for non-scientist will be developed. The aim will be to promote the global VOS network, specifically in the shipping industry, which we collaborate with. Currently, the information is publically available, but unfortunately provided by different organisation and institutes, hence it is difficult for a non-specialist to get a comprehensive view. IOCCP is ideally suited to provide a one-point where relevant information is available and searchable.

The information to be provided includes (but is not restricted to):

- the shipping companies involved (showing the huge range of different companies),
- the type of ships involved (showing the huge range of different types of ships),
- the national identities of the scientific institution (showing the global aspect of our work/collaboration),
- the port calls of the ships and where/when maintenance is carried out (where scientists can most likely be met),
- the parameters being measured and their relevance in a wider scientific context

Data Synthesis Activities: Surface Ocean
Appreciable advances have been made over the past 8 years in assembling and serving surface pCO_2 data and data products, in particular through activities organized by IOCCP and the Surface Ocean CO_2 Atlas (SOCAT) group. Much of the advances in standardization and improvements in data reduction, and assembly have been accomplished through an effective "top-down" approach

by the SOCAT global ocean group but it is time to facilitate for a coordinated, community-wide input on future progress.

The final products would be:

- a series of short citable implementation white papers (1-3 pagers) on procedures and best practices and/or updates of current documentation on the topics above that would be posted on the IOCCP website
- a description of implementation of procedures and best practices
- a description and delivery time of products

An important component of the effort would include setting up a series a quantifiable metrics to gauge progress and improvement in data quality and procedures. While a working group primarily composed of data submitters and data managers would determine the topics that would be acted on in this activity, it will likely include the following:

A. Data submission and metadata
SOCAT is instituting an automated data and metadata submission procedure and this is an opportune time for initial assessment. Not all underway pCO_2 data is reaching SOCAT. The reasons why will be determined and approaches to increase submission will be outlined. Discussions will include better means of acknowledgement and tagging data to the submitter

B. Improvements in data reduction
This will include discussion and description of data reduction and uniform quality control procedures, including robust accuracy estimates of individual data points.

C. Improvement characterization of instruments
A recommended comparison scheme of new sensors with established ones will be provided including robust accuracy estimates of instruments.

D. Data-product development
Currently SOCAT provides a limited number of products. Additional products that can be produced from the SOCAT database will be determined and how these products would be produced on a regulate basis.

The SOCAT Automation Team is currently working on a data submission system which allows upload of data and metadata, 1st level data quality control and visualization and finally automated data submission to SOCAT and CDIAC. A technical workshop bringing together all involved in the development of the automation process will be required early in 2016. Finally, a dedicated team is being formed to extend the portfolio of SOCAT-based gridded data products to fully utilize the wide range of information that can be deducted from surface observations (mainly auxiliary biogeochemical parameters).

Ocean Interior Observations

A combined GO-SHIP/Argo/IOCCP conference on physical and biogeochemical measurements of the water column will be held in Galway, Ireland on 14-18 September 2015. The three sponsoring programs for this conference promote and coordinate sustained observations of the water column to reveal the changing physics, chemistry and biology of the ocean. Argo began with a focus on physical properties of the upper 2000 metres of the ocean. GO-SHIP covers the full water column, with repeat physical and biogeochemical measurements from research ships. The focus of IOCCP is on coordination of ocean carbon and marine biogeochemistry observations, including data from research ships and other platforms. Each program has established maturity in its own field. Studies combining data from these programs are addressing new research questions and adding value to the individual programs. New technology means there is growing overlap in the research questions that each program can now address. It also presents challenges for how to implement and utilize new technology.

This conference will bring together these programs that make sustained observations of the water column on global scales, showcasing the individual programs as well as the synergies among them. An additional focus of the conference will be the future opportunities presented by these programs: in particular the technological development of Argo into the realms of Deep and Bio-Argo. Deep and Bio Argo measurements will supplement GO-SHIP and other IOCCP-coordinated observations in new ways. In turn, these new measurements will depend on ship-borne programs for calibration and data quality assurance of the new float data. It is timely to bring together scientists from the communities that will enact the next phase of this technological evolution.

Data Synthesis Activities: Ocean Interior

The IOCCP activity on Interior Ocean Synthesis will continue to be focused on the coordination of the Global Ocean Data Analysis Project version 2 (GLODAPv2). GLODAPv2 merges the data included in the past synthesis products GLODAPv1, CARINA, PACIFICA and data from 169 new cruises into a consistent global data product. The data for the core parameters: salinity, oxygen, phosphate, nitrate, silicate, dissolved inorganic carbon, total alkalinity, pH and freons have been analysed for consistency among cruises and bias-corrected whenever required during several technical workshops co-sponsored by IOCCP and attended by approximately 15 scientists each, over the last 3 years.

GLODAPv2 will be distributed in the form of a merged and bias corrected synthesis file for the global ocean, regional synthesis files for the Arctic, Atlantic, Indian and Pacific Oceans, and in the form of a set of WOCE exchange formatted files containing the original, uncorrected, data for each cruise. All data will be made accessible through a dedicated web page at CDIAC, accompanied by an extensive technical report and publications in Earth System Science Data.

GLODAPv2 is expected to be released by the end of 2015, and the work will then shift to GLODAPv3 and gradual automation of the process for further releases. Also additional parameters (SF_6, $\delta^{13}C$, C-14, tritium, helium, He-3, neon, $\delta^{18}O$, total and dissolved organic carbon, total and dissolved organic nitrogen and chlorophyll *a*) will be analyzed for consistency to form an integral part of this data set. It has been proposed that at that point the key members of the international

repeat hydrography community will form a GLODAP Panel, which will oversee timely data submission, schedule and perform data quality control and coordinate GLODAPv* releases (2-3 years frequency is discussed at the moment). Forming this panel and getting the activity off the ground will be an important IOCCP task for the next year and beyond. The first meeting of the Panel is tentatively scheduled to take place in February 2016 during the Ocean Sciences Meeting in New Orleans, USA.

Ship-based Time Series Efforts

A current effort led by IOCCP, IOC and the U.S. Ocean Carbon and Biogeochemistry Program (OCB) has identified >160 ship-based, biogeochemical time series throughout the globe. The International Group for Marine Ecological Time Series (IGMETS, http://igmets.net/) seeks to integrate a suite of in situ biogeochemical variables from time-series stations, together with satellite-derived information, to look at holistic changes within different ocean regions, explore plausible reasons and connections at a global level, and highlight any locations of especially large changes that may be of special importance.

Over the next 12-18 months a better integration of ship based biogeochemical time series is envisaged to be achieved through compiling a "Biogeochemical Time-Series Compilation Report" (sponsored by IOC and IOCCP). The first "writing team" meeting was held in St. Petersburg, FL. March 4-6, 2014 and the second meeting was held in Paris, France, December 2-4, 2014. This report seeks to integrate selected variables measured at ship-based biogeochemical time-series to look at holistic changes within different ocean regions, explore plausible reasons and connections at a global level, and highlight any regions of especially large changes that may be at greater risk. The third and final writing team meeting is planned for late 2015 and publication of the report is planned before the end of 2015.

Ocean Acidification

A 3rd international GOA-ON science workshop is provisionally scheduled for 8-9 May 2016 in conjunction with the 4th Symposium on the Ocean in a High CO_2 World to be held in Hobart, Australia 3-6 May 2016; http://www.highco2-iv.org/.

An internal meeting organizing committee was established to take forward planning for the GOA-ON workshop (Members: Bronte Tilbrook (Chair), Fei Chai, Minhan Dai, Sam Dupont, Richard Feely, Libby Jewett, Jan Newton, Phil Williamson and Maciej Telszewski). The workshop agenda, aims and outcomes are the first priority, however several tasks need taking care in a very near future.

Basic logistics information:

- The GOA-ON workshop is expected to be held in the CSIRO auditorium with maximum capacity of 150 (and 80-100 considered more manageable)
- Consideration needs to be given as to whether participation is 'first come, first served' or selective: whilst priority could be given to existing GOA-ON network members, there is also need to encourage new involvement

- The multi-stressors and pteropod workshops are expected to be in the IMAS building (next door), the FOCE workshop is some distance away (transport to be arranged)
- Financial support is being sought; needs for travel and accommodation assistance relating to the Workshop need to be identified and prioritised

Nutrients

Over the last decade it became obvious that it is necessary to develop accurate observations of trends in dissolved nutrients in both upper and deep ocean waters. For these observations, it is critical that results from different laboratories can be reliably compared. To get a global consensus for nutrient data, a series of inter-comparison experiments have been held, supported by IOCCP, IOC-UNESCO, JAMSTEC and recently SCOR. Results from each of these experiments provide quantitative assessment of the accuracies achieved by participating laboratories but they lack a synthetic view of change over time. IOCCP, SCOR WG 147 and JAMSTEC plan to hold a workshop focusing solely on this synthetic view, so that conclusions can be drawn from various developments reported after each of the inter-comparison experiment.

Results from so far performed inter-comparison experiments suggest that in many cases relatively easy to eliminate errors in analytical protocols followed by individual laboratories lead to large discrepancies in reported experiment results. And again, IOCCP, SCOR WG 147 and JAMSTEC plan to hold a technical training workshop aimed at eliminating analytical errors in nutrients analysis performed in laboratories around the world. An update to best practices guide included in the GO-SHIP Manual is planned as an outcome from this workshop.

Biogeochemistry Essential Ocean and Climate Variables

During the last 3 years the IOCCP lead the efforts of the Biogeochemistry Panel of GOOS. Great progress was made towards developing a community vetted set of Essential Ocean Variables and Essential Climate Variables. Several international experts gave support to the work of the Panel and a wide range of ocean users is being currently consulted for their input into the final list.

In 2016 IOCCP will lead the effort focused on enhancing the accuracy and relevance of biogeochemistry elements of the Global Climate Observing System Implementation Plan. This will be achieved through a series of small technical workshops funded by GOOS and GCOS that will seek input from the 3 disciplinary communities in order to present a comprehensive Implementation Plan during the 22 COP to UNFCCC to be held in November 2016.

In the following year (2017) IOCCP plans to engage in developing a set of targets and metrics for the biogeochemistry observing system. Such a set is badly needed from the funding perspective as funding agencies often require qualitative justification for supporting sustained observation. Physical oceanographers centered around several observing networks (Argo, XBT, SOOP, VOS) were very successful in securing funding for their sustained observations to a large extent thanks to clear requirement for meeting quantifiable targets. This work is planned to be done through a series of joint workshops bringing together physical and biogeochemical oceanographers and is going to be funded by GOOS/IOC-UNESCO and EU AtlantOS Project.

Instruments and Sensors
The first summer course "Instrumenting our oceans for better observation: a training course on biogeochemical sensors" was held in June 2015 in Kristineberg, Sweden (page 3 of this report). The primary goal of the course was to generate a "Best Practices" guide, which provides easy-to-follow steps on usage (including preparation, deployment, recovery and basic data reporting, processing and quality) of autonomous biogeochemical sensors.

The first draft of the Best Practices report is expected to be completed by the end of 2015 and the final document to be available to the community in early 2016. IOCCP plans to use this Best Practices Guide to train the next generation of sensors users during the second Summer Course on Biogeochemical Sensors, tentatively planned for May-July 2017.

Data and Information Management
In addition to the many data and information management activities that are part of most of IOCCP plans listed above there are a couple of planned activities related strictly to data management.

First is an effort to bridge the gap between SOCAT and GLODAP data sets over the next 2-3 years. There is a lot of data that is not captured by either of the data synthesis efforts due to technical differences in measurement techniques. For example surface data from discreet samples taken during repeat hydrography cruises are not captured by SOCAT and they are taken on every single station during GO-SHIP cruises. This results in hundreds of thousands of data points often collected in unique locations not making it to SOCAT. Such activity would also be very useful for ocean acidification observing needs (e.g. GOA-ON).

The second effort which IOCCP plans to engage in will be focused on international sample naming standards for ocean carbon and biogeochemistry community, similar to what IGSN (International Geo Sampling Number http://www.geosamples.org/igsnabout and http://www.geosamples.org/whyigsn) is trying to achieve. The need for such an activity stems from the fact that due to regional requirements, ocean carbon and biogeochemistry data are being submitted to multiple data archives and hence multiple versions of the same data exist. The IGSN would be the same for data points stored in various data archives enabling data users to easily identify repetitive data.

4.2 Southern Ocean Observing System (SOOS)

THE SOUTHERN OCEAN OBSERVING SYSTEM

ANNUAL REPORT

TO THE SCOR EXECUTIVE COMMITTEE

2015

The Southern Ocean Observing System (SOOS) is a joint initiative of SCAR and SCOR, and facilitates the collection and delivery of essential observations on dynamics and change of Southern Ocean systems to international stakeholders, through design, advocacy, and implementation of cost-effective observing and data delivery systems.

This report provides an update on SOOS activities from May 2014 to August 2015. SOOS welcomes all comments and suggestions on activities and products. A more detailed report on SOOS activities and products can be found in the SOOS 3-Year Progress Report at http://soos.aq/resources/reports?view=product&pid=29

SOOS Activities and Milestones from May 2014 – August 2015

1) SOOS Strategic and Implementation Activities

In 2014, SOOS clarified its mission and objectives, and developed new *Implementation Structures* to support implementation activities (e.g., Working Groups, Task Teams). This was articulated in the SOOS 5-year Strategic Plan, which is currently in internal review, and will soon be disseminated for external comments. This plan restructured SOOS Objectives into a logical sequence of implementation. All Implementation Milestones will be reported herein against the newly defined Objectives.

Objective 1: DESIGN

Facilitate the design and implementation of a comprehensive and multi-disciplinary observing system for the Southern Ocean

Activities / Milestones

Physical Oceanographic Essential Ocean Variables (EOVs) Task Team

OBJECTIVE: Develop a list of candidate EOVs for Southern Ocean physical oceanography

PRODUCT: A list of candidate EOVs for the Southern Ocean

Ecosystem Essential Ocean Variables Task Team
OBJECTIVE: Organise an international workshop on identification of ecosystem Essential Ocean Variables (eEOVs)
SPONSORS: ICSU, SCOR, Rutgers University
PRODUCT: Workshop on identification of eEOVs (report); Defined process for identification of eEOVs; SCOR Working Group proposal (unsuccessful); List of candidate eEOVs for the Southern Ocean; paper submitted to a peer-reviewed journal

Sea-Ice EOVs Task Team
OBJECTIVE: Develop a list of candidate EOVs for Southern Ocean sea ice
PRODUCT: A list of candidate sea-ice EOVs for the Southern Ocean

Ocean-Ice EOVs Task Team
OBJECTIVE: Develop a list of candidate EOVs for Southern Ocean Ocean-Ice interface
PRODUCT: A list of candidate ocean-ice EOVs for the Southern Ocean

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Objective 2: CAPABILITIES
Advocate and guide the development of new observation technologies

Activities / Milestones

- SOOS endorsed 5 successful international funding proposals that have a focus on advancing technological capabilities.
- SOOS is developing a new Endorsement Category, which will focus specifically on endorsement of ventures that support the development, testing and operation of new technologies.
- A SOOS Capability Working Group on facilitating observation technology development has been suggested and will be developed.
- Stemming directly from the 2014 SOOS SSC and FRISP meetings, Australia and Sweden will collaborate on the purchase, maintenance and use of Autonomous Underwater Vehicles (AUVs) for research under Antarctic ice shelves.

Objective 3: FACILITATING OBSERVATIONS
Compile and encourage use of existing international standards and methodologies, and facilitate the development of new standards where required

Activities / Milestones

- Support has been secured from SCOR for development of an online database of international standards and protocols.

Objective 4: REGIONAL IMPLEMENTATION
Unify and enhance current observation efforts and leverage further resources across disciplines, and between nations and programmes

Activities / Milestones
SOOS has identified 3 implementation structures required to facilitate and drive activities against all objectives: Regional Working Groups, Capability Working Groups, and Task Teams

SOOS will be implemented regionally, the natural areas of focus by nations involved in Southern Ocean activities, although some activities will be coordinated at a circumpolar scale, such as Argo. SOOS is therefore developing *Regional Working Groups* that will coordinate and implement the observing system in their defined region, including facilitating improved readiness of particularly measurements and an ability to measure them where needed. Regional Working Group membership will be open, and will have representation from all nations working in the region, and expertise across all disciplines.

Capability Working Groups will be used to develop important capabilities for SOOS generally, including (i) developing and implementing technologies, (ii) improving observational design, efficiency and coverage, and (iii) developing methods for managing and disseminating information. The existing national and international projects and programs that contribute to SOOS will be identified and recognised as contributing regionally and/or to enhancing capabilities.

Task Teams are very short-term (weeks to months) groups developed with the purpose of producing a specific product or organizing an activity. Whilst the Working Group categories have only recently been defined and are not yet active, SOOS Task Teams have been active for nearly 2 years. Recent Task Team activities are listed below:

Ross Sea Task Team
OBJECTIVE: Identify current and planned activities and key observation gaps in the Ross Sea, to ensure that activities of nations new to the Ross Sea complement the international effort.
PRODUCT: "Observations in the Ross Sea" – SOOS Report Series, Issue 1.

Air-Sea Fluxes Task Team
OBJECTIVE: Organise a workshop that will bring together the Southern Ocean flux community, identify priorities, define EOVs, and develop a strategy for enhancing observations
SPONSORS: ESRIN, WCRP, SOOS, US-CLIVAR
PRODUCT: The SOOS Air-Sea Flux Workshop, 21-23 September 2015, Frascati, Italy

Joint SOOS-CliC-SCAR Southern Ocean Satellite Data Requirements Task Team
OBJECTIVE: Develop a community report that articulates Southern Ocean satellite data requirements for inclusion in future mission planning.

SPONSORS: SOOS, CliC, SCAR
PRODUCT: A report of community needs for Southern Ocean Satellite Data

National Capabilities Product
OBJECTIVE: Central repository of information on National Capabilities for Southern Ocean nations, including routine shipping routes and routine operational or project-based observations.
SPONSORS: SCOR
PRODUCT: In development - National webpages for all Southern Ocean nations; A web-based map of national infrastructures and activities.

Southern Ocean Field Activities Database
OBJECTIVE: Database of existing and planned field activities,
SPONSORS: ARC Antarctic Gateway Partnership, NSF-CCHDO
PRODUCT: In development - Database of information on existing and planned (funded) national and programmatic field activities, visualised in a dynamic, web-based mapping tool.

Objective 5: DATA DELIVERY
Facilitate linking of sustained long-term observations to provide a system of enhanced data discovery and delivery, utilising existing data centres and programmatic efforts combined with, as needed, purpose-built data management and storage systems.

The SOOS data effort thus far has been limited by a lack of dedicated resources. In 2014, SOOS gained support through the Australian Research Council's Special Research Initiative for Antarctic Gateway Partnership (Project ID SR140300001) and has hired a Data Officer for 2 years. This will greatly enhance DMSC activities and capabilities towards achieving Objective 5.

The SOOS Data Management Sub-Committee (DMSC)
New members on the DMSC include Alicia Aleman (NASA GCMD), James Cusick (AAD, AU), Jenny Thomas (SONA, UK) and Joana Beja (BODC, UK).

Activities / Milestones

- SOOS has hired Dr Phillippa Bricher as the inaugural SOOS Data Officer.
- 3rd Annual SOOS DMSC meeting was held in Hobart, Australia (June 2015), hosted by IMAS-UTAS. Two open data activity days and a joint DMSC-SSC session were also held.
- The SOOS metadata portal (hosted by NASA GCMD) had stagnated due to a lack of resources to dedicate to its full development. A significant overhaul of the portal was carried out during the open data activity days by the DMSC. The search term that draws in metadata records on the GCMD to this portal was reworked to explicitly draw in any datasets that spatially overlap with the Southern Ocean and which are related to any of the candidate Essential Ocean Variables, so as to better target the portal on datasets of

interest to SOOS's stakeholders. The group also identified key datasets and established processes for converting metadata records from other formats into GCMD's native DIF format. The metadata portal is available through http://gcmd.nasa.gov/portals/soos/.

- In the immediate term, SOOS is working with the following groups:
    - OceanSITES (http://www.oceansites.org/) to find a home for identified orphan mooring datasets that can be made discoverable through the metadata portal.
    - The Swedish Polar Research Secretariat to make Bellingshausen, Amundsen and Ross Sea data discoverable through the SOOS metadata portal.
    - The Coastal Ocean Observation Lab at Rutgers University to make U.S. glider data discoverable through the metadata portal
    - The University of Cape Town's Marine Research Institute to house South African glider data and make it discoverable through the metadata portal.

These groups represent the initial steps of a much wider program to make Southern Ocean data public and discoverable, using existing data repositories and the metadata portal

- A data policy has been adopted and will soon be available on the SOOS website
- An interim field-project planning tool has been designed to help researchers share details of upcoming voyages and deployments. Ultimately, this will have a web interface with a live web-map, but currently consists of a web-form that feeds data to a spreadsheet that will soon be publicly available.

Objective 6: SUPPORT ACTIVITIES
Provide services to communicate, coordinate, advocate and facilitate SOOS objectives and activities

Community and Advocacy Activities / Milestones

- The importance of connecting with SOOS has been articulated in the strategic and implementation plans of 2 international programs (WMO Year of Polar Prediction, CLIVAR-CliC-SCAR Southern Ocean Region Panel), and 1 national observing effort (Australia's Integrated Marine Observing System).
- Australia and the USA submitted a joint working paper to the Committee for Environmental Protection (CEP) at the 2015 Antarctic Treaty meeting. Titled "Shared science priorities and cooperation: systematic observations and modelling in the Southern Ocean", this report highlighted the importance of international contributions to SOOS. CEP nations agreed unanimously on the importance of SOOS and supported all recommendations from the paper.
- SOOS has 40 Affiliated Institutes, Organisations, Programmes and Field Initiatives across 16 nations.
- Since March 2014, SOOS has endorsed 18 individual research projects.

Communication Activities / Milestones

- The SOOS website (www.soos.aq) was maintained; however, it needs updating, which will take place in September 2015.

- Two issues of the online SOOS newsletter were produced and disseminated www.soos.aq/index.php/resources/newsletters?view=newsletters
- SOOS has developed an online Report Series for all grey literature and reports. These reports are published through the SOOS Collection on Zenodo (https://zenodo.org/collection/user-southern-ocean-observing-system)
- Between March 2014 and April 2015, SOOS was represented or presented at 26 international conferences, and has provided reports to the Antarctic Treaty and SCOR.
- SOOS has Twitter and Facebook accounts, providing updates to more than 1,000 people, across 45 countries.
- SOOS Town hall at SCAR OSM (New Zealand, August 2014) to enhance understanding and knowledge of the status of ecosystem Essential Ocean Variable activities for the Southern Ocean
- SOOS Scientific Session at SCAR OSM (New Zealand, August 2014) to support SOOS-relevant science, build community, and highlight the breadth of SOOS science.
- SOOS International Workshop "Implementation of a Southern Ocean Observing System" (11-12 June 2015, IMAS-UTas, Australia) attended by 70 international participants
- SOOS International Workshop "Assessing the State of the Climate of the Southern Ocean" (10 June 2015, IMAS-UTas, Australia) attended by 60 international participants

Publications and Reports Activities/Milestones

- Williams, M. et al., (2015). Observation Activities in the Ross Sea: Current and future national contributions to the Southern Ocean Observing System. Zenodo. 10.5281/zenodo.21169
- Wåhlin, A. et al., (2015). Towards an integrated Southern Ocean Observing System. CLIVAR Exchanges, in press
- Meredith, M.P. et al., (2015). Southern Ocean [in "State of the Climate in 2014"]. Bulletin of the American Meteorological Society, 96(7).
- Newman, L., et al., (2015). Southern Ocean Community response to the Year of Polar Prediction Implementation Plan. Zenodo, 10.5281/zenodo.27261
- Newman, L., et al., (2015). SOOS 3-Year Progress Report. Zenodo, 10.5281/zenodo.21419
- Constable, A., et al., (2015). Report on 2015 Activities of the Southern Ocean Observing System relevant to the work of CCAMLR. Zenodo, 10.5281/zenodo.28227

Governance and Management Activities / Milestones

- From an international call for nominations, SOOS appointed four new members for the 2015 Scientific Steering Committee: Matthew Mazloff (SIO, USA), Mike Williams (NIWA, NZ), Jean-Baptiste Sallee (LOCEAN, FR), SangHoon Lee (KOPRI, Korea). Two SSC members rotated off the committee in 2014: Bronte Tilbrook (CSIRO, AU) and Steve Rintoul (CSIRO, AU).
- Maciej Telszewski became the IOCCP ex-officio on the SOOS SSC
- Giorgio Budillon became the Italian National Representative for SOOS
- Takeshi Tamura became the Japanese National Representative for SOOS

- 4th SOOS Scientific Steering Committee Meeting (Australia, June 2015), hosted by the Institute for Marine and Antarctic Studies, University of Tasmania.

Sponsorship and Endorsement Activities / Milestones

- SCAR and SCOR both continued their support of the annual SOOS SSC meeting (2014 and 2015)
- IMAS-UTas continued to host the SOOS IPO and will do so until Aug 2016.
- The Australian Research Council's Special Research Initiative for Antarctic Gateway Partnership (Project ID SR140300001) sponsored the SOOS IPO with 100,000 AUD over 3 years towards supporting new SOOS initiatives, and a further 300,000 AUD over 3 years to support the salary of the SOOS Data Officer (2015- Aug 2016), and then the SOOS Executive Officer (Aug 2016 – Aug 2017) when the existing IMAS hosting contract finishes.
- The Australian Antarctic Division continued to provide financial support to the SOOS IPO for both the 2014-2015 and 2015-2016 financial years.
- The Australian Integrated Marine Observing System (IMOS) continued their in-kind support of the SOOS IPO in 2014 and onwards into 2015. This support was extended to include support of Finance and Administration duties for the SOOS IPO.
- The New Zealand Antarctic Research Institute (NZARI) provides support for SOOS in 2015 through sponsorship of NZ SSC Member Mike Williams to attend SOOS activities.
- Antarctica New Zealand have sponsored SOOS since 2012. ANZ and SOOS are in the process of developing an official MoU to better articulate and define ANZ sponsorship and involvement in SOOS for 2015 onwards. In the meantime, Antarctica NZ have agreed to continue the sponsorship of the IPO for 2015 calendar year.
- The Tasmania Partnership for Advanced Computing (TPAC) continued its in-kind sponsorship of SOOS by providing web-programming support.
- NSF-CCHDO are new sponsors in 2014, through their in-kind support of 1-month web-programming activities per year.
- The University of Gothenburg, Sweden, are also new sponsors for 2014/2015, through their in-kind support of Anna Wåhlin's (SOOS Co-Chair) involvement in SOOS and provision of computer hardware for the IPO.

SOOS thanks all of its sponsors for their support over the last few years, and for their continued assistance into 2015.

SOOS Planned Activities for April 2015 - onwards

Implementation activities in 2015-2016 will focus on achieving the objectives and deliverables outlined in the interim SOOS 5-year Strategic Plan.

Specific activities already planned for this period are listed below:

- International review, finalisation and publishing of the SOOS 5-year Strategic Plan

- Submission of the SOOS Community Report on Satellite Data Requirements
- Air-Sea Flux Workshop (21-23 September, Frascati, Italy), sponsored by ESA, WCRP-CLIVAR and SOOS
- Development and delivery of online Southern Ocean portal of existing and planned field activities of relevance to SOOS
- Release of SOOS Metadata Portal and regular population with new records.
- Update of SOOS website
- Development of Regional and Capability Working Groups
- Solidification of long-term funding of the SOOS Executive Officer salary

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5. IMPORTANCE OF SCOR SUPPORT

SCOR has continued to provide significant support for SOOS, financially and through guidance, advice and input provided by the SCOR Executive Director. SOOS would like to acknowledge and thank SCOR for this continued support. It is fundamental to our success.

SOOS also acknowledges the support provided by SCOR for the annual Scientific Steering Committee meeting, and requests that this support is continued for 2016. Continuation of the support for the SSC meeting will ensure participation by all SSC members, which is imperative for planning and implementation of SOOS objectives. SCAR also provides support for the annual SOOS SSC meeting and continuation of this support for 2016 is being requested at the SCAR EXCOM meeting in August 2015.

The SOOS 2016 SSC meeting will be hosted by the Scripps Institution of Oceanography, USA, on 12-14 May 2016, and will be held in conjunction with the annual meeting of Southern Ocean Carbon and Climate Observations and Modeling project (SOCCOM) and the SOOS Data Management Sub-Committee. The week of parallel meetings will include joint sessions and a Southern Ocean workshop. SCOR support for this meeting will ensure broad international involvement.

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

Report to SCOR and IAPSO on JCS Activities July 2014-June 2015

Membership

Executive

Rich Pawlowicz (Chair)	Canada
Rainer Feistel (Vice-chair)	Germany
Trevor J. McDougall (Vice-chair)	Australia

Salinity/Density Subgroup

Frank J. Millero	USA
(Rich Pawlowicz)	Canada
Steffen Seitz	Germany
Hiroshi Uchida	Japan
Stefan Weinreben	Germany
Youngchao Pang	China-Beijing
Henning Wolf	Germany

pH Subgroup

Maria Filomena Camoes	Portugal
Andrew Dickson	USA
Daniela Stoica	France

Relative Humidity Subgroup

Olaf Hellmuth	Germany
Jeremy Lovell-Smith	New Zealand

Thermodynamics

(Rainer Feistel)

Numerical Modelling and Applications

(Trevor J. McDougall)

Software

Paul Barker	Australia

Industry Representatives

Paul Ridout (OSIL)	UK
Barbara Laky (Anton Paar)	Austria

NB: Former member Petra Spitzer has retired.

Meetings

JCS did not meet as a full group in 2014-2015. However, 7 JCS members did attend the 2015 IAPWS Annual Meeting in Stockholm, Sweden, including Y. Pang (and two of his colleagues). Detailed updates were provided on "other progress" items listed below, and on the JCS tasks agreed on at the Salinity and pH workshops held during the 2013 International Conference on the Properties of Water and Steam (Greenwich, UK). Significant progress was also made on some of these tasks during discussions in the IAPWS Subcommittee on Seawater workshop at this meeting and in a separate (closed) JCS meeting.

Rainer Feistel attended the 4th JCOMM Marine Instrument Workshop for ASIA-PACIFIC, in Weihai, China, 21-23 Oct. 2014 as a JCS representative, at the invitation of the GOOS Project Office (IOC/UNESCO). Feistel provided information on TEOS-10 to this group.

Web site

JCS maintains a web site at www.teos-10.org. This site gets 1,500-2,000 visitors per month, with 34,136 "unique views" since Oct 2010. Annual downloads in the past year are increasing over past years.

Web site Item	**Unique downloads June 2011-June 2013**	**Unique downloads June 2013-June 2014**	**Unique downloads June 2014-June 2015**
Manual	920	360	535
Getting Started	879	362	558
Slides	704	284	374
Primer	584	197	289
GSW_MATLAB_v3_0	1920	1102	1485
GSW_FORTRAN_v3_	366	222	171
GSW_C_v3_0	202	84	133
GSW_PHP	-	55	61
SIA_VB_V3_0	72	100	46
SIA_FORTRAN_V3_0	59	118	58

Other Progress

1. Trevor McDougall is working with several modelling groups (MOM, NEMO) to add TEOS-10 support.
2. Rich Pawlowicz and Frank Millero carried out density anomaly measurements in N. Pacific (Line-P program, Feb. 2014).
3. Rich Pawlowicz and Hiroshi Uchida carried out density anomaly measurements in N. Pacific (Salish Sea, Oct 2014).
4. Hiroshi Uchida carried out density anomaly measurements in N. Pacific (WHP P01) and Arctic (Mirai MR14-05).
5. Hiroshi Uchida, Frank Millero, and Henning Wolf are continuing measurements of density in SSW batches; this information will be collated in a planned publication.
6. Maria Filomena Camoes is working towards a Pitzer equation for seawater pH.
7. Henning Wolf, Hiroshi Uchida, Stefan Weinreben, Rich Pawlowicz are still writing the 'Best Practices Guide for seawater Density Measurements' (now at version 13).
8. Steffen Seitz is still investigating instrument effects on conductance measurements.
9. Rainer Feistel is working on uncertainty budgets for correlation equations.
10. Trevor McDougall and Paul Barker released version 3.05 of GSW software.
11. Andrew Dickson continues to provide seawater buffers for pH, and is also a member of SCOR WG145 on speciation (discussing a seawater Pitzer model).

Papers published

1. Feistel, R., Lovell-Smith, J.W., Hellmuth, O. 2015. Virial Equation for the Fugacity of Water in Humid Air. *International Journal of Thermophysics* 36(1):44-68.
2. Feistel, R., Lovell-Smith, J.W., Hellmuth O. 2015. Erratum to: Virial Approximation of the TEOS-10 Equation for the Fugacity of Water in Humid Air. *International Journal of Thermophysics* 36(1):204.
3. Feistel, R., Lovell-Smith, J.W., Hellmuth, O. (Proposers): Guideline on a Virial Equation for the Fugacity of H_2O in Humid Air. The International Association for the Properties of Water and Steam. Stockholm, Sweden, July 2015
4. Hellmuth, O., R. Feistel, J. Lovell-Smith and J. Kalova, 2015: Metrological Aspects of Humidity: State of Discussion on Common Positions, Challenges, and Needs. Technical Report of the Joint BIPM, CCT-WG6/CCQM and JCS Workshop on Hygrometry, held during the 16th International Conference on the Properties of Water and Steam 2013 (ICPWS 2013), Greenwich, UK. Online available: http://www.teos-10.org/pubs/ICPWS2013_WS_TechnicalReport_Humidity_20150211primo.pdf
5. Hellmuth, O., Shchekin, A. K. 2015. Determination of interfacial parameters of a soluble particle in a nonideal solution from measured deliquescence and efflorescence humidities. *Atmos. Chem. Phys.* 15:3851-3871
6. Kretzschmar, H.-J., Feistel, R., Wagner, W., Miyagawa, K., Harvey, A.H., Cooper, J.R., Hiegemann, M., Blangetti, F.L., Orlov, K.A., Weber, I., Singh, A. Herrmann, S. 2015. The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater. Desalination

and Water Treatment 55:177-1199, doi: 10.1080/19443994.2014.925838
7. McDougall, T.J., Barker, P., Feistel, R., Galton-Fenzi B. K. 2014. Melting of Ice and Sea Ice into Seawater and Frazil Ice Formation. *J. Phys. Oceanog.* 44:1751-1775
8. Pawlowicz, R. 2015. The Absolute Salinity of seawater diluted by riverwater. *Deep-Sea Research I* 101:71-79.
9. Woosley, R., Huang, F., Millero, F. 2014. Estimating absolute salinity (S_A) in the worlds oceans using density and composition. *Deep Sea Research I* 92:14-20.

Papers Submitted

1. R. Feistel, J.W. Lovell-Smith, P. Saunders and S. Seitz: Uncertainty of Empirical Correlation Equations. Submitted to *Metrologia*, 26 May 2015
2. R. Feistel, R. Wielgosz, S.A. Bell, M.F. Camões, J.R. Cooper, P. Dexter, A.G. Dickson, P. Fisicaro, A.H. Harvey, M. Heinonen, O. Hellmuth, H.-J. Kretzschmar, J.W. Lovell-Smith, T. J. McDougall, R. Pawlowicz, P. Ridout, S. Seitz, P. Spitzer, D. Stoica and H. Wolf: Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH, and atmospheric humidity. Part 1: Overview. REVIEW PAPER. Submitted to *Metrologia*, in press
3. R. Pawlowicz, R. Feistel, T.J. McDougall, P. Ridout, S. Seitz, H. Wolf: Metrological challenges for measurements of key climatological observables, Part 2: Oceanic salinity. Submitted to *Metrologia*, 26 May 2015
4. A.G. Dickson, M.F. Camões, P. Spitzer, P. Fisicaro, D. Stoica, R, Pawlowicz and R. Feistel: Metrological challenges for measurements of key climatological observables, Part 3: Seawater pH. Submitted to *Metrologia*, 28 May 2015
5. J.W. Lovell-Smith, R. Feistel, A.H. Harvey, O. Hellmuth, S.A. Bell, M. Heinonen, J.R. Cooper: Metrological challenges for measurements of key climatological observables, Part 4: Atmospheric relative humidity. Submitted to *Metrologia*, in press
6. Feistel, R. 2015: Salinity and relative humidity: climatological relevance and metrological needs, *Acta Imeko*, in press
7. H.-J. Kretzschmar, Herrmann, S., Feistel, R., Wagner, W.: The International IAPWS Formulation for the Thermodynamic Properties of Seawater for Desalination Processes. The International Desalination Association World Congress on Desalination and Water Reuse 2015/San Diego, CA, USA. Submitted 15 Febr. 2015

R. Pawlowicz
JCS chair, Aug 1, 2015

4.4 GlobalHAB *Enevoldsen, Urban*

The GEOHAB report is given in Tab 3. GEOHAB was an international project to coordinate national research on harmful algal blooms. GEOHAB also conducted a variety of infrastructural activities to help scientists in the field. GlobalHAB will continue infrastructural activities similar to those pursued by GEOHAB, but will not function as an international research project.

Workshops

As reported last year, three activities were prioritized at the Synthesis OSM in Paris as part of the transition from GEOHAB to GlobalHAB, and the GEOHAB SSC recommended providing partial funding to the first two:

1. Linkages between HABs and Hypoxia (proposed by Grant Pitcher, South Africa)
2. Quantifying HAB resting stage emergence and deposition fluxes: A comparative workshop and training program (proposed by Don Anderson, USA)
3. Linkage between HABs and caged fish activity; it was recommended as a submission to SCOR as a Working Group, but it has not yet been submitted.

These activities have not been conducted yet. The new GlobalHAB SSC will assume the task of contacting the researchers that suggested the activities and re-evaluate their eventual implementation.

Transition towards GlobalHAB

The Mission and Terms of Reference of the new program GlobalHAB, elaborated by the GEOHAB SSC, were already presented in the 2014 Report to SCOR. Raphe Kudela and Elisa Berdalet have served as executives of the new GlobalHAB SSC, and in coordination with Henrik Enevoldsen and Ed Urban (representing IOC and SCOR, respectively) have been working on the list of potential members of the new SSC covering the different expertise required for the implementation of the program, and taking into account gender and geographic representation. The list will be given to SCOR and IOC for approval before the SCOR Annual Meeting. Following nomination, the SSC members will have the first meeting to start working on the implementation of GlobalHAB.

The main tasks and activities of the SSC for 2016 include the following:

- First SSC meeting (tentatively, February 2016)
- Finalize Terms of Reference
- Establish the procedure for updating Science Plan and developing Implementation Plan
- Implement transition projects
- Presentation of the new program at the International Conference on Harmful Algae (Brazil, November 2016). This venue will allow formal launch of GlobalHAB and invite the international community to actively participate in the program.

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

Urban

Processes that occur at, immediately above, and just below the seafloor play an important role in global biogeochemical cycles, from coastal areas to the deep ocean. SCOR supported a workshop convened by several seafloor ecologists (Paul Snelgrove, Simon Thrush, and Alf Norkko) to consider seabed ecosystem functioning on a global scale. The workshop brought together the interdisciplinary expertise necessary to address this issue and identify priority research topics. Twelve experts in seabed biology, chemistry, and geology from North America, Europe, Asia and New Zealand met for 2.5 days, hosted by Roberto Danovaro at the historic Stazione Zoologica in Naples, Italy. The group began to develop a set of priority research questions on the role of seafloor processes in ocean functioning. Discussions began with short presentations on modelling ecosystem functions how to go about it, processes and key functions, available data and gaps, scaling functions, approaches to generating large-scale metrics of biological activity, and model systems that have been well sampled. Workshop participants then discussed links between seabed processes, functions, and services and quickly zeroed in to ask how we can evaluate and predict seafloor ecosystem functions in the global ocean, to the extent that this assessment can inform debate on the consequences of environmental change. The group focused primarily on carbon cycling and nutrient regeneration, and the role that sedimentary organisms from microbes to megafauna play in those key processes. Next, they considered how to build maps—or at least define testable functional relationships—that might allow extrapolation of a sparsely sampled seabed to regional and global scales. The goal of the workshop was to produce an article for a peer-reviewed journal that could form the basis for a more inclusive discussion by interested scientists, and the workshop places the group in an excellent position to do just that.

A detailed outline has been developed for the group's paper and a rough draft is being planned by the end of 2015.

5.0 CAPACITY-BUILDING ACTIVITIES

5.1 SCOR Committee on Capacity Building, p. 5-1 ***Ittekkot***

5.2 SCOR Visiting Scholars, p. 5-1 ***Ittekkot***

5.3 POGO-SCOR Visiting Fellowships for Oceanographic Observations, p. 5-8 ***Urban***

5.4 NSF Travel Support for Developing Country Scientists, p. 5-14 ***Urban***

5.0 CAPACITY-BUILDING ACTIVITIES

5.1 SCOR Committee on Capacity Building *Ittekkot*

The 2006 SCOR meeting approved terms of reference for a SCOR Committee on Capacity Building, whose primary purposes are to oversee all of SCOR's capacity-building activities and to help the SCOR Secretariat manage these activities. The approved terms of reference follow:

- Provide direction for all of SCOR's existing capacity-building activities: participation of scientists from developing countries and countries with economies in transition in SCOR activities, POGO-SCOR Fellowship Program, travel grants, and provision of reports to libraries in developing countries.
- Guide and assist SCOR Executive Director in development of new capacity-building activities, particularly the Regional Graduate Schools of Oceanography activity.
- Assist SCOR-sponsored projects in developing their capacity-building activities.
- Help SCOR arrange funding for existing and new capacity-building activities.
- Assist SCOR in interacting with regional and international groups related to capacity building in ocean sciences, such as the ICSU regional centers, START, IOC regional programs, etc.

Chair:
Venu Ittekkot (Germany)

Other Members:
Hal Batchelder (PICES)
Sükrü Besiktepe (Turkey)
Missy Feeley (USA and SCOR Executive Committee)
Mike Lucas (South Africa)
Wajih Naqvi (India)
Ilana Wainer (Brazil)
Jing Zhang (China and IMBER)

The membership of the committee is designed to create a tight linkage with the SCOR Executive Committee. A subgroup of the committee can now meet in conjunction with annual SCOR meetings at little extra cost to SCOR, making it possible for any committee recommendations to SCOR to be acted on immediately. The committee will not meet at the SCOR meeting in Goa, to reserve funding for capacity building activities at the International Symposium on the Indian Ocean in Goa.

5.2 SCOR Visiting Scholars *Ittekkot*

SCOR began a program in 2009 to enlist the services of ocean scientists from the SCOR community, from both developed countries and developing countries, both recently retired and active, to teach short courses and to provide more extended on-site education and mentorship at developing country institutions. Some countries and/or individual institutions have requirements for their scientists to retire at a given age, sometimes as early as 60 years of age. Many retired

ocean scientists are still interested in teaching and mentoring, and are supported by pensions after their retirement, so do not need salary support. Some active scientists can also use some of their already-supported work time to work in a developing country.

Hosting visiting scientists, whether retired or active, can have many benefits to host institutions also, such as inspiring, motivating, and informing students and faculty, and leading to future collaborations between the visiting scientist and the host institution.

The idea of this program is to regularly send ocean scientists interested in short-term visits to developing countries. The program is a partnership, with the host institution providing local accommodation and SCOR finding resources to pay for airfares and other local expenses, as necessary. The participating scientists donate their time. SCOR Visiting Scholars might be onsite for as little as two weeks to as long as visa requirements would allow. Applicants may already have selected a host institution or SCOR will help identify hosts. Information about the program is available at http://www.scor-int.org/SCOR_Visiting_Scholars.pdf. The call for applications for 2016 Visiting Scholars has already been issued and the deadline for applications is 4 December 2015. Five applications have already been received. The SCOR Visiting Scholars who are making their visits in 2015 are shown below and some written reports follow.

2015 SCOR Visiting Scholars

Year	Name	Home Country	Host Country	Dates	Purpose
2015	Nagappa Ramaiah	India	Bangladesh	June 2015	Teach biological oceanography
2015	Kunio Takahashi	Japan	India	To be scheduled	Training course on the Continuous Plankton Recorder
2015	Tony Koslow	USA	Peru	11 April–1 May 2015	seminars/lectures on the development of ocean observation systems for sustainable management of marine ecosystems
2015	Bill Burnett	USA	Brazil	27 July-7 August 2015	short course on “Applications of Isotopic Techniques for Coastal Studies”

Applications of Radioisotopes in Coastal and Environmental Sciences

Report to SCOR
William C. Burnett (Florida State University) and Vanessa Hatje (Universidade Federal da Bahia)

INTRODUCTION

The Scientific Committee on Oceanic Research (SCOR) awarded US$2500 towards sponsoring a visit by W. Burnett to Salvador, Brazil in order to teach a course on uses of radioisotopes in coastal and environmental sciences. Additional funding for accommodation, hiring boats, equipment needs, etc. was met by funds from the Todos os Santos Bay Project (FAPESB) and the Brazilian Institute of Science and Technology (INCT). It was agreed that Burnett would work closely with V. Hatje to coordinate the course and collaborate with her and her students on a preliminary assessment of Baia Todos os Santos, a large bay in Salvador.

Burnett and Hatje agreed to run the course in two main parts: (1) a week-long series of classroom lectures, assigned readings and problem-solving exercises; followed by (2) a series of practical demonstrations and hands-on experience in the field. The 2nd portion of the course covered two full weeks and included 4 days in a hired boat on the bay, several days sampling groundwater wells on land and one full day making measurements of radon, radium and metals from a mooring at a marina near the famous church of Bonfim.

ACTIVITIES

Approximately 25 students from several different areas in Brazil attended the course. During the 1st week of the course we met each morning in a classroom in the Institute of Geosciences at the Federal University of Bahia and Burnett presented a wide range of applications of natural radioisotopes for coastal studies. We also went over basic laws of radioactivity and radioactive decay equations. After lunch each day, we reconvened and worked on problem sets representative of the types of calculations necessary for environmental applications. The students were also asked to read a series of 10 papers that covered the topics discussed in class.

During the 2nd week of the course, we rotated smaller groups of students through a series of hands-on training that included demonstrations of use of the equipment in the laboratory followed by field radon surveys along the shore of Todos os Santos Bay from a boat. In addition, another group of students deployed on land and sampled groundwater wells and analyzed the samples for radon concentration.

We emphasized radium sampling during the 3rd week using a boat to sample throughout the Paraguacu Estuary and throughout the bay. While all the radon measurements were completed on site, the “Mn fibers” used for preconcentration of Ra isotopes will be analyzed by two separate laboratories in Brazil. We have plans to hold a Skype teleconference with all major players in approximately 4-5 weeks after the radium isotopes have been measured.

All participants agreed that the course was worthwhile and will stimulate increased activity concerning applications of radioisotopes for coastal studies.

Applications of Radioisotopes in Coastal and Environmental Sciences

Course Overview

Instructors: William ('Bill') C. Burnett, SCOR Visiting Scientist, Professor (Emeritus) of Oceanography, Florida State University, wburnett@fsu.edu and Vanessa Hatje, Centro Interdisciplinar de Energia e Ambiente, Universidade Federal da Bahia, vanessahatje@gmail.com

Abstract: A short course that will serve as an introduction to the theory, measurement, and especially the application of natural uranium and thorium decay-series (^{210}Pb, ^{226}Ra, ^{222}Rn, etc.), cosmogenic isotopes (^{14}C, ^{10}Be, ^{7}Be, etc.) and artificial radionuclides (^{137}Cs, ^{239}Pu, etc.) to address problems in the earth, marine and environmental sciences. The use of ^{222}Rn ('radon') and ^{220}Rn ('thoron') for studies concerning groundwater discharge into surface water bodies will be emphasized. The course is directed towards advanced undergraduate and graduate students as well as interested faculty and researchers in Oceanography, Hydrology, Environmental Science and Geology.

Textbook: None, a list of recommended readings from the literature will be made available.

Schedule: Mornings: 2 lecture periods of about 1.5 hours separated by a break.
Afternoons: homework sets, reading references, preparation

Week-1/Day	Topics
1	1. Radioactivity in the Environment 2. Basics of radioactivity; 3. Principles of radioactivity ingrowth and decay, U/Th-series equilibrium, disequilibrium (reading #1, problem set #1)
2	4. Radioactive isotopes for geochronology 5. U/Th disequilibrium dating; U/Th-series dating: carbonates, other minerals (readings #2, #3; problem set #2)
3	6. Geochronology via Pb-210 dating (reading #4, problem set #3) 7. Coastal mixing rates, ages via radium isotopes (readings #5, #6)
4	8. Use of Ra isotopes to assess groundwater discharge (reading #7) 9. Use of Rn-222 to assess groundwater discharges (problem set #4)
5	10. Case studies of groundwater assessment via Rn and Ra isotopes Radon and thoron as groundwater tracers (readings #8, #9; problem set #5)

Weeks-2, -3: Practical experience, sampling and analysis of radon and radium isotopes from groundwaters and coastal waters. Complete preliminary Ra/Rn survey of Todos os Santos Bay.

Example of course certificate:

This is to certify that

GABRIEL COTRIM

Participated in and completed the

Applications of Radioisotopes in Coastal and Environmental Sciences

held in

Salvador, Brazil
July 27th to August 7th 2015

The training course was organized by the Todos os Santos Bay Project (FAPESB) and Brazilian National Institute of Science and Technology (INCT) Energy & Environment, in cooperation with the Scientific Committee on Oceanic Research (SCOR). The programme of the training course consisted of lectures and practical exercises (40h) and field work at Todos os Santos Bay, Bahia (40h). The course covered the following topics:

- Radioactivity in the Environment
- Principles of radioactivity ingrowth and decay, U/Th-series equilibrium, disequilibrium concepts
- U/Th isotopes for geochronology
- U/Th disequilibrium dating; U/Th-series dating: carbonates, other minerals
- Geochronology of sediments via Pb-210 dating
- Coastal mixing rates, residence times, ages via radium isotopes
- Use of Ra isotopes to assess submarine groundwater discharge
- Use of Rn-222 to assess groundwater discharges
- Case studies of groundwater assessment via Rn and Ra isotopes
- Radon and Thoron as groundwater tracers

Vanessa Hatje
Centro Interdisciplinar de Energia e Ambiente
Universidade Federal da Bahia

Instructor William C. Burnet
Professor (Emeritus) of Oceanography
Florida State University

5-6

Class photo, Salvador, Brazil:

Equipment and supplies used for the practical portion of the course were coordinated between FSU and 3 Brazilian universities.

REPORT: SCOR Visiting Fellowship to Peru, April 11 – May 1, 2015

Julian Anthony (Tony) Koslow, Scripps Institution of Oceanography, University of California, SD, La Jolla, CA 92093

I undertook a SCOR Visiting Fellowship with the Instituto del Mar del Peru (IMARPE) in Callao, Lima (Peru) from April 11 to May 1, 2015. Overall, the fellowship was highly successful. During these three weeks, I delivered a series of three lectures to Dr. Dimitri Gutierrez's Biological Oceanography course at Universidad Peruana Cayetano Heredia in Lima. Dr Gutierrez is Director of Oceanography at IMARPE and Research professor and coordinator of the Master's program in Marine Science at UPCH. My lectures covered:

- Ocean observation systems: our window on a changing global ocean
- The meso- and bathypelagic: Ecology and biogeochemistry
- Seamount ecosystems and deepwater fisheries

At IMARPE, I provided a seminar on ocean observation programs and my own research based on the CalCOFI ichthyoplankton time series. This seminar covered some of the same ground as my first lecture at UPCH, but focused more on current research and in particular on the use of ichthyoplankton data to assess the impacts of changing ocean conditions on marine communities, the subject of my collaboration with IMARPE scientists.

The major focus of my visit was my collaboration with Ms Patricia Ayon, head of IMARPE's zooplankton and ichthyoplankton laboratory, to prepare her laboratory's data set on larval fishes for multivariate community time-series analysis. This would enable us to examine the response of the fish community in the Humboldt Current to ocean variability and change. Her laboratory, following the practice of CalCOFI and other ichthyoplankton laboratories around the world, identifies and enumerates a number of ichthyoplankton taxa besides those used directly in current stock assessments (e.g., for anchovetta). Mean annual larval abundance can serve as a proxy for adult stock biomass, so the IMARPE time series potentially provide a window onto broad fish community changes in the Humboldt Current over decadal time scales, much as the CalCOFI time series point to major changes in fish communities in the California Current (Koslow et al. 2011, 2013, 2014).

The IMARPE time series is characterized by greater spatial and temporal sampling variability than the CalCOFI surveys, which for many years have followed a fixed survey pattern at monthly or seasonal intervals. Identification of less-common taxa has also evolved over the period of IMARPE plankton surveys. As a result, the fellowship period primarily entailed assembling the ichthyoplankton data set and evaluating the spatial and temporal sampling variability and level of taxonomic identifications over time. This has now been achieved for the data up to 2004; over the coming months, Ms Ayon will update her database for the last 10 years (2005-2014), at which time we plan to initiate further analyses in relation to community responses to climate. Given the complexity of the Peruvian ichthyoplankton data set and the changes it has encountered over the years, we believe the fellowship period was highly productive, insofar as the groundwork was laid for further teaching and collaborative research to carry the project forward. Dr Gutierrez has invited me to participate in future teaching at UPCH,

and Ms Ayon and I have discussed future visits either by her to Scripps or me to IMARPE to build on the work initiated in during this fellowship period.

I should add that Ms Ayon, Dr Gutierrez, members of the zooplankton and ichthyoplankton laboratory and other scientists at IMARPE were wonderfully hospitable. I always felt most welcome and truly enjoyed my stay. My accommodation in Miraflores, provided by IMARPE, was quite suitable, and because the accommodation was a considerable distance from the IMARPE laboratory in Callao, they provided a driver and transport to and from the lab each day. Peru is an interesting country with warm and friendly people, a wonderful cuisine and a deep and fascinating history. All these factors contributed to a marvelous stay.

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

SCOR and the Partnership for Observation of the Global Oceans (POGO) have been co-funding a program of Visiting Fellowships for Oceanographic Observations since 2001. In 2013, four individuals were funded through the program.

pogo Partnership for Observation of the Global Oceans

www.ocean-partners.org

International Council for Science SCOR Scientific Committee on Oceanic Research

Report on the 2015 POGO-SCOR Fellowship Programme

This year saw the fifteenth fellowship programme implemented using POGO funds with supplementary financial support from SCOR. As the POGO Members had to be consulted on this year's budget expenditure at POGO's annual meeting at the end of January, the announcement was posted on 2 February 2015, with a closing date of 31 March 2015.

This year saw a total of 50 applications, which was slightly greater than the previous year. This was possibly a result of a wide distribution of the announcement for applications as the POGO network widens. Applications were received from 21 countries.

Since the budget from POGO was reduced this year, four candidates were selected, from Chile, China, Ivory Coast and India. This year's host institutions included Georgia Institute of Technology (USA), Colorado Center for Astrodynamics Research (CCAR) - University of Colorado at Boulder (USA), NorthWest Research Associates (NWRA) in collaboration with NOAA/Pacific Marine Environmental Laboratory (PMEL) (USA) and Plymouth Marine Laboratory (UK).

The applications were screened independently by a committee of six, with representation from SCOR, POGO and partners of POGO. In making their selection, the committee considered the following factors:

- quality of the application;
- relevance of the application to the priority areas identified in the fellowship announcement;
- evidence that the training will lead to improved sustained observations in the region, or improved applications of such data;
- evidence that the training would lead to capacity-building with potential lasting impact on regional observations, and
- the need to maximise regional distribution of the awards.

POGO and SCOR commend the efforts from all the supervisors and colleagues at the various host institutions, who agreed to devote time and energy required for the training. The programme would not have been viable without such efforts from prominent scientists and their teams.

All the people involved in each fellowship (the fellowship holder, the supervisor at the parent institute and the supervisor at the host institute) have been requested to submit short reports at the end of the training period. Many of the fellowships are currently in progress or yet to be completed and their reports are expected to be received by the end of the year. From previous fellowships, both host and parents supervisors as well as the fellows themselves have indicated that these exchanges should lead to effective capacity building at the host institute and facilitate longer term collaborations between the institutes concerned. All have concluded that the programme serves a useful purpose.

There is tremendous interest in the fellowship programme at all levels, both in the oceanographic institutions of the developing nations, as well as among leading scientists who are eager to contribute to this initiative. It is seen to be filling a niche in capacity building through specialised training that is not filled by intensive courses or by participation in scientific meetings. It helps improve the *esprit de corps* among oceanographic institutions around the world, and serves as a stepping stone to building collaborations.

Furthermore, the POGO-SCOR fellowship scheme is increasingly seen by other organisations as a model in capacity building, and similar schemes have been set up by other programmes based on the success of the POGO-SCOR model (e.g. EU projects, the Europe-Africa Marine Network, EAMNet; and the EUROMARINE consortium of European Networks of Excellence). The POGO Secretariat is often approached for help/advice on setting up similar fellowship schemes, or proposals to partner up with other organisations.

Demography of Fellowships

Parent Institutions of Successful Candidates:

Chile	University of Concepcion
China	South China Sea Institute of Oceanology (SCSIO), Chinese Academic of Sciences (CAS)
Ivory Coast	Centre Universitaire de Recherche et d'Application en Télédétection (CURAT) / Université Félix Houphouët-Boigny (Côte d'Ivoire)
India	Inter University Centre for Development of Marine Biotechnology, School of Marine Sciences, Cochin University of Science and Technology

Host Institutions:

USA	Georgia Institute of Technology
USA	Colorado Center for Astrodynamics Research (CCAR) - University of Colorado at Boulder
USA	NorthWest Research Associates (NWRA) in collaboration with NOAA/Pacific Marine Environmental Laboratory (PMEL)
UK	Plymouth Marine Laboratory

Gender distribution
Male: 4

2015 Fellows

Jose David Donoso – Chile
Parent supervisor and institution: Prof. Ali Belmadani – Department of Geophysics, University of Concepcion.
Host supervisor and institution: Prof. Emanuele Di Lorenzo – Georgia Institute of Technology.
Fellowship period: 22 August-20 November 2015 (3 months)
Topic: Advanced numerical ocean modeling by means of high-performance computing.

David Donoso is currently working as a research assistant on the project “Dynamics of striations and eddies off central Chile” (www.chilejets.com) lead by Dr. Ali Belmadani, assistant professor at the Department of Geophysics (DGEO), University of Concepcion (UDEC), Chile. His duties are to process and analyze atmospheric and oceanographic data from the Eastern South Pacific (ESP) in order to get the forcing and initial conditions for a series of high-resolution numerical simulations using the Regional Ocean Modeling System (ROMS). While the control simulation that has been developed is comparable to the real ocean, future sensitivity experiments will reveal the contributions of various generation mechanisms for a new kind of oceanic currents called striations. The large number of sensitivity runs to be carried out requires an extensive

computational resource. Thus, the training requirements are to acquire the necessary skills to configure, use and take advantage of high-performance computing (HPC) applied to ROMS. The training will be on data assimilation and the advanced use of ROMS in the framework of Partnership for an Advanced Computing Environment (PACE), which is a HPC environment located at the Georgia Institute of Technology (GATech), Atlanta, USA. It will benefit the current research by using the central Chile ROMS model configuration as a benchmark to run and contrast the sensitivity experiments on the PACE cluster at GATech. In the medium-term future, the acquired skills would allow the fellow to implement data assimilation of ESP regional observations in ROMS at the National Laboratory for High Performance Computing (NLHPC), located at the Center for Mathematical Modeling (CMM), Universidad de Chile, Santiago, Chile. In addition to the benefits of this visit for the long-term research partnership between Dr. Di Lorenzo and Dr. Belmadani, it will also reinforce the institutional collaboration between GATech and UDEC.

Qingyang Sun – China
Parent supervisor and institution: Prof. Danling Tang – South China Sea Institute of Oceanology, Chinese Academic of Sciences.
Host supervisor and institution: Dr. Gad Levy – NorthWest Research Associates (NWRA) in collaboration with NOAA/Pacific Marine Environmental Laboratory (PMEL) (POC Dr. Nicholas Bond).
Fellowship period: 8 July to 24 September 2015 (2.5 months)
Topic: Data analysis, assimilation, and integration of Fixed-Point Time-Series Observations (floats, moorings and buoys) with new satellite ocean observations.

Qingyang Sun's current work focuses on air-sea carbon dioxide (CO_2) interaction in response to typhoons and on the variability of the aerosol optical thickness (AOT) over the ocean due to monsoon evolution using ship-collected and satellite data. Basing his research on ship-collected and satellite datasets poses some problems, especially for typhoon research as the ship data can only be collected after the typhoon passage and the satellite data are then not available (due to cloud cover and precipitation). To extend this work beyond case studies to climate applications, globally, to model implementation, and for comparing oceanic changes between pre- and post-typhoon passage, sustained, long time-series ocean observations are needed and their integration with ship-collected and satellite data is required. Training in data analysis, assimilation, and integration of long time-series observations with ship-collected and with new satellite ocean observations is required for the fellow's current work and future research.

The fellow will receive training in data acquisition, requirements and management of long time series of fixed-point observations (floats, moorings and buoys), including their analysis, assimilation and integration with new satellite ocean observations, as well as the data management and model implementation aspects of such observations. The training would provide a good opportunity to discuss these topics and learn from the expert scientists and engineers at NWRA and PMEL, and to gain experience and develop Qingyang's understanding of the global observational data process and model implementation, which would both the fellow and the parent institution tremendously in future work. The training would lead to more cooperation between SCSIO and NWRA/PMEL on (1) applying of the technology (especially for the pCO_2 mooring)

in the observing system in SCSIO, (2) developing the oceanic CO_2 products in SCS through cooperation and integration of datasets with the Global Ocean Observing System.

Abaka Brice Hervé Mobio – Ivory Coast
Parent supervisor and institution: Prof. Kouadio Affian – Centre Universitaire de Recherche et d'Application en Télédétection (CURAT) / Université Félix Houphouët-Boigny (Côte d'Ivoire).
Host supervisor and institution: Prof. William J. Emery – Colorado Center for Astrodynamics Research (CCAR) - University of Colorado at Boulder.
Fellowship period: 1 September 2015 – 29 November 2015 (3 months)
Topic: Spatial and temporal monitoring of the Ivorian continental shelf surface current fronts: Maximum Cross-Correlation (MCC) technique application

Brice Mobio is currently a researcher and lecturer in remote sensing and oceanography at CURAT at Université Félix Houphouët-Boigny (Cote d'Ivoire). Brice is a member of the oceanography staff of CURAT. Since his thesis, he has dealt with estimation and mapping of ocean surface currents (Ivorian continental shelf). The Maximum Cross-Correlation (MCC) technique used to estimate ocean surface current has provided interesting results. However, better understanding and control of the Maximum Cross-Correlation (MCC) technique is needed to efficiently understand the Ivorian continental shelf surface current system. Training at the Colorado Center for Astrodynamics Research (CCAR) will allow the fellow and his parent institute to reach that goal. W. Emery at CCAR originated this method and has considerable experience applying MCC to different types of satellite data (Sea Surface Temperature, Ocean Color, Synthetic Aperture Radar) to estimate sea surface currents, thus building capacity in that field.

During training, the fellow will perform MCC program with better understanding in order to estimate more precisely the two currents of the Ivorian continental shelf and locate more accurately the area where the two currents meet. He will monitor those convergence areas spatially and temporarily, and carry out an analysis of temperature, chlorophyll, salinity and wind data on this area. This training will allow Brice to develop skills to conduct studies on variability of oceanic parameters, especially in areas where the eastward current meets the westward current. This study will then be extended to the entire Gulf of Guinea to allow regional study. At CCAR, skills will be developed for modelling surface currents to predict and assist economic activities such as fisheries. CURAT and CCAR will establish collaboration with common research programmes. They will involve students and researchers exchange along with experience in ocean surface currents monitoring.

Deepulal Parenkat Mony – India

Parent supervisor and institution: Prof. Chandramohanakumar N.– Inter University Centre for Development of Marine Biotechnology, School of Marine Sciences, Cochin University of Science and Technology.

Host supervisor and institution: Dr. Mingxi Yang, Plymouth Marine Laboratory, UK.

Fellowship period: 15 September to 15 December 2015 (3 months)

Topic: How variability in atmospheric CO_2 and CH_4 concentrations impact the air-sea fluxes of these Greenhouse Gases in a coastal region.

Deepulal Parenkat Mony is currently working on the carbon sequestration potential and methane fluxes in the mangrove ecosystem and adjacent coast zones. The proposed work at PML focuses on the atmospheric variability of CO_2 and CH_4, and their impact on the air-sea fluxes in coastal regions. So the data validation and interpretation will help to develop skills and give hands-on experience with latest instruments installed at host institute.

Observations of CO_2 and CH_4 in the ocean and in the overlying atmosphere are important for understanding the carbon cycle. Globally, the open ocean is a net sink of atmospheric CO_2 and a small source of CH_4. Coastal regions are often influenced by estuarine inputs (which carry elevated dissolved CH_4 concentrations) and demonstrate large seasonality in biological productivity. CO_2 and CH_4 in the coastal atmosphere are influenced by terrestrial emissions and uptake as well as meteorology and dynamics of the marine boundary layer. These factors are expected to cause rapid changes in air-sea CO_2 and CH_4 fluxes in the coastal region. The proposed study will focus on the atmospheric variability of these two greenhouse gases and its impact on the air-sea fluxes. The main aims of study are as follows: 1) Evaluating of the performance of two state-of-the-art CO_2/CH_4 analysers installed at the field station of Penlee Point Atmospheric Observatory (PPAO); 2) Explaining the atmospheric variability of CO_2 and CH_4 with co-collected environmental parameters; 3) Estimating the air-sea fluxes of CO_2 and CH_4 in this coastal environment based on dissolved concentration measurements at the nearby L4 station. This training will help the fellow to understand the rapid changes in the air-sea fluxes of CO_2 and CH_4. After successful completion of training, with the help of Plymouth Marine Laboratory, the fellow would like to do more research on the air-sea fluxes of CO_2 and CH_4, which have not been studied in the south west coast of India.

FINANCIAL SUMMARY

Surname	First Name	Country of origin	Flight paid by SCOR (US$)	Stipend paid by SCOR (US $)
Ammamkuzhiyil	Smitha	India	888.61	99.14*
Cozzolino	Ezequiel	Argentina	1289.42	2271.00
Liu	Zhiyu	China	2065.51	3386.32
		Subtotals	**4243.54**	**5756.46**
		Total contribution		**10,000.00**

*This was a contribution towards the total stipend of 1245.19 USD.

5.4 NSF Travel Support for Developing Country Scientists

SCOR has received support from the U.S. National Science Foundation (NSF) since 1984 to provide funding for SCOR capacity building activities. Most of the funds are used for travel grants for scientific meetings, although a portion are used for SCOR's contribution to the POGO-SCOR Fellowship Program and the SCOR Visiting Scholars program. Travel grants are awarded to ocean scientists from developing countries and the former Soviet Union, Eastern Europe, and other countries with economies in transition, to enable them to attend international scientific meetings. The current three-year grant runs from 1 July 2014 to 30 June 2017.

The amount of the award from NSF is $75,000 per year. Recipients of SCOR travel awards are always chosen in consultation with the organizers of meetings that SCOR has agreed to cosponsor; direct applications from individuals are not accepted by the SCOR Secretariat. Priority is given to applicants who are presenting a paper or poster at the meeting or to those who have some special expertise or regional knowledge to bring to a workshop or working group. Preference is also given to younger scientists. In general, care is taken to ensure that the recipients of SCOR/NSF funds are *active* scientists, and that they have not received similar support from SCOR in the previous two years. All travel grant recipients are informed that their support comes from SCOR and that it is made possible through NSF funding.

INTERNATIONAL OCEAN INSTITUTE

REPORT ON SCOR FUNDING FOR 2015 IOI TRAINING PROGRAMME

1. INTRODUCTION

This report provides an account of the use of the SCOR funds which were awarded to IOI-Canada for its 2015 training programme on *Ocean Governance: Policy, Law and Management*. The course was conducted at Dalhousie University, Halifax, Nova Scotia from 20 May to 17 July, and SCOR's financial support of US$4,900 helped enable two marine professionals in their 30s to attend by contributing towards their expenses. The grant-holders were: **Ms Dysi Polite Dyspriani**, Coastal Community Empowerment Analyst, Directorate of Coastal Community Empowerment and Business Development, Ministry of Marine Affairs and Fisheries, Jakarta, Indonesia and **Ms Cheryl Rita Kaur Dalbir Singh,** Senior Researcher, Centre for Coastal and Marine Environment, Maritime Institute of Malaysia, Kuala Lumpur, Malaysia.

IOI-Canada, Dalhousie University, Halifax

2. IOI-CANADA

IOI-Canada (www.dal.ca/ioihfx) is a leading member of the International Ocean Institute's network of centres and focal points (www.ioinst.org) operating worldwide in over 30 countries. Based at Dalhousie University, IOI-Canada is a not-for-profit organisation, federally incorporated under the Canada Corporations Act. Its mission is to promote responsible ocean governance and the stewardship and sustainable use of coastal and ocean resources in Canada and around the world. In pursuit of this, IOI-Canada aims to encourage and develop the potential and capacity of individuals, institutions and communities to foster:

- a network of individuals dedicated to effective coastal and ocean governance;
- management, education, training, research and outreach; and,
- sustainable and prosperous coastal communities.

Interdisciplinary training is its major focus, and an IOI course has been held at Dalhousie each summer since 1981. Through this flagship programme, nearly 670 individuals from over 100 countries have been trained (www.internationaloceaninstitute.dal.ca/alumni/index.php).

3. TRAINING PROGRAMME ON OCEAN GOVERNANCE: POLICY, LAW & MANAGEMENT

The 2015 programme was attended by 12 participants from Africa, Asia, the Caribbean, Europe and South America. They were drawn from a range of disciplines and backgrounds,

and emphasis was placed on having strong female representation among the group, with equal numbers of women and men in the class.

During two months of interactive studies, the participants were challenged to:

- deepen their understanding of the complexity and role of ocean-related issues in sustainable development;
- strengthen and update their academic knowledge, while also being exposed to practical lessons drawn from actual experience in integrated coastal and ocean management;
- develop relevant skills and networks to help them apply their new knowledge on their return home; and
- assist their countries towards maximising benefits to be derived from the UN Convention on the Law of the Sea, through the proper integration of coastal and ocean management into national and international development strategies.

The course consisted of approximately 200 hours of intensive learning. While it was primarily lecture-based, it also included lively discussions, participant presentations, exercises and simulations involving both individual and group work, several field trips and an international round table. Content was organised thematically as follows, with the detailed syllabus available online (www.internationaloceaninstitute.dal.ca/2015Syllabus.pdf).

Module 1: Orientation and Introduction to the Training Programme
Module 2: Ocean Sciences
Module 3: Integrated Coastal and Ocean Management
Module 4: Fisheries and Aquaculture
Module 5: Law of the Sea and Principled Ocean Governance
Module 6: Communication and Negotiation
Module 7: Maritime Security
Module 8: Marine Transportation
Module 9: Energy
Module 10: International Round Table and Conclusion of Training Programme

Lectures and presentations were delivered by about 90 speakers, and included local and international experts and practitioners. Details are available online at: www.internationaloceaninstitute.dal.ca/lecturers.htm.

4. BENEFITS AND OUTPUTS

At the individual level, these SCOR-funded professionals benefited as follows.

Dysi P. Dyspriani: *my institution will have a good human resource in applying the knowledge and skills acquired, formulating ocean strategy, law, policy and management, creating good ocean governance*

Attendance at lectures and presentations led to:

- Enhanced understanding of integrated coastal and ocean management issues;
- greater knowledge of relevant legislation, policy and experience;
- the development of practical skills in areas such as information management, project cycle management, performance management, and communication (including presentations and media interviews);
- valuable networking potential with lecturers and presenters in Canada and internationally.

Making presentations and participating in group exercises, including the course-long simulation, helped:

- facilitate the assimilation of the subject matter;
- strengthen the participants' ability to work co-operatively in groups;
- develop their confidence while providing an opportunity to practice new skills.

Taking part in field trips:

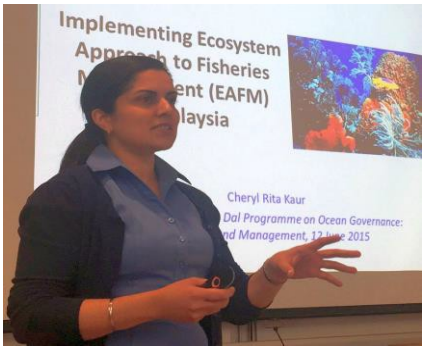
- provided them with increased exposure to a range of oceans-related activities within coastal communities;
- offered opportunities for them to meet practitioners at the grass-roots level, and compare theory with reality.

Studying and living with the other international participants provided:

- a unique experience of being part of a group from diverse cultures and backgrounds, sharing different perspectives and examining issues from different viewpoints.

Focusing on how to use their new knowledge and skills on their return home encouraged them to maximise the impact and multiplier effect of the training.

The immediate beneficiaries of this training were therefore the two grant-holders themselves who would not have been able to attend the course without



Cheryl Dalbir Singh: *I am already applying some of the experiences that were obtained from the course into my current role especially in coming up with feasible action plans and strategies to influence environmental and conservation policies in Malaysia.*

financial support, and the immediate outcomes were increased knowledge, skills, networks and confidence. The grant-holders' organisations and countries also benefited by gaining newly trained professionals aware of, and capable of dealing with, complex ocean issues. Since this training has proved over the last 35 years to give increased potential for alumni advancement, it is hoped that the participants will rise to significant positions of responsibility in their countries and thus be able to influence future policy and management decisions.

5. GRANT EXPENSES

As outlined in the original invoice, the SCOR funds were used to help cover the expenses incurred by Ms Dyspriani and Ms Dalbir Singh. Details are as follows:

Item	***COST (USD)***
Living Allowance x 2 participants	1,602
Lunch Allowance x 2 participants	513
Group Lunch x 2 participants	179
Dinners, first week x 2 participants	122
Accommodation x 2 participants	2,268
Ground transportation x 2 participants	216
TOTAL RECEIVED AND DISBURSED	**$4,900**

6. CONCLUSION

Both the SCOR grant-holders were intelligent, hard-working and committed professionals who made very good use of this unique training opportunity. They participated well in the course and were excellent members of the group. They were keen to learn, contributed to discussions, put in long hours, and co-operated collaboratively with others from a range of backgrounds, countries and cultures. As indicated above, they benefited from their experiences here in a range of ways, and IOI will be following up with them six months after the end of the course to see how they have continued to use and share their new knowledge and skills. Given the importance of creating a multiplier effect with this kind of training, we hope and expect to hear that not only they but also their colleagues and organisations are continuing to benefit from SCOR's generous support. We therefore join Ms Dyspriani and Ms Dalbir Singh in expressing our sincere thanks for helping make their participation possible.

Requests come in throughout the year and the SCOR Committee on Capacity Building considers new requests between meetings. The following requests have been approved since the 2014 SCOR annual meeting:

Activity Name	Dates	Location	Amount granted
SCOR Visiting Scholars	Various	various	$7500
Polar GRC	15-20 March 2015	Italy	$4900
International Ocean Colour Science meeting	16-18 June 2015	San Francisco	$4,900
SOLAS Open Science Conference	7-11 Sept. 2015	Kiel, Germany	$7,500
SCOR-related workshops at 2015 PICES meeting	16-26 Oct. 2015	Qingdao, China	$4,900
IMBER Imbizo	26-30 October 2015	Trieste, Italy	$7,500
Fisheries meeting in Senegal	November 2015	Dakar, Senegal	$3,000
IIOE-2 Symposium in Goa	30 Nov.-4 Dec. 2015	Goa, India	$10,000
WG 146 training	9-11 June 2016	Xiamen, China	$5,000
41st COSPAR Scientific Assembly	30 July-7 August 2016	Istanbul, Turkey	$3,000

Additional requests will be approved by the SCOR Committee on Capacity Building before the SCOR annual meeting and will be reported on at the meeting.

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1 Intergovernmental Oceanographic Commission (IOC), p. 6-1 ***Burkill***

6.2 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), p. 6-8 ***Urban***

6.3 North Pacific Marine Science Organization (PICES), p. 6-13 ***Batchelder***

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

6.1 Intergovernmental Oceanographic Commission (IOC) *Enevoldsen, Burkill*

IOC report for SCOR, 2015

Ocean acidification

Ocean acidification (OA) is an emerging global concern and is a risk to marine biodiversity, ecosystems and human society. In terms of new research and networking, the IOC is co-leading the Global Ocean Acidification Observing Network (GOA-ON) which is aimed to coordinate and improve ocean observation to detect the impacts of ocean acidification. The GOA-ON roadmap was published in September 2014 and the most recent development was the establishment of a biological working group, co-chaired and coordinated by IOC-UNESCO, in order to improve measurements detecting the impact of increasing CO_2 levels on marine life. Furthermore, together with the support of the Ocean Acidification International Coordination Center of the IAEA, a session focusing on OA during the Third International Symposium on the Effects of Climate Change on the World's Oceans in March 2015 in Santos, Brazil. COP20, was organized. To enhance the awareness among policymakers, IOC contributed to a side event in Lima during the COP20 and currently prepares OA workshops and side events towards the COP21. Regarding communication with the general public and permanent delegations at UNESCO, IOC celebrated the World Oceans Day, which included one session on ocean acidification. The TV corner, which was produced for the Second International Ocean Research Conference in November 2014, received a lot of positive feedback and was used again during other occasions.

Blue Carbon

The Blue Carbon Initiative, established in 2011 by the IOC, the International Union for the Conservation of Nature (IUCN) and Conservation International (CI) works to develop management approaches, financial incentives and policy mechanisms for ensuring the conservation, restoration and sustainable use of coastal blue carbon ecosystems. The IOC is highly involved in the Blue Carbon Scientific Working Group, which provides the scientific foundation for the Blue Carbon Initiative by synthesizing current and emerging science on blue carbon and by providing a robust scientific basis for coastal carbon conservation, management and assessment. Priority research of the Scientific Working Group functions in close partnership with the Initiative's Policy Working Group. Internationally applicable standards for quantifying and monitoring carbon storage, sequestration, and emissions in coastal ecosystems on regional and local scales were identified and the manual "Coastal Blue Carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows" was published and launched at the last meeting of the Scientific working group of the Blue Carbon Initiative in Rio Grande, Brazil, in October 2014. The distribution via internet in its pdf format is ongoing.

De-oxygenation

De-oxygenation is a global problem in coastal and open regions of the ocean, and has led to expanding areas of oxygen minimum zones and coastal hypoxia. In the coastal ocean, the

number of reported dead zones has increased exponentially since the 1960s, with more than 479 systems now. The recent expansion of hypoxia in coastal ecosystems has been primarily attributed to global warming and enhanced nutrient input from land and atmosphere. The global extent and threat to human health and marine ecosystem services of ocean deoxygenation are just beginning to be appreciated; the social and economic consequences have yet to be determined, but are likely to be significant. Therefore the IOC supports a group of scientists trying to create awareness among policymakers and the general public, e.g. via publishing a scientific fact sheet via the 'Ocean and Climate' platform on deoxygenation, as well as via assisting in the establishment of a global network of experts within this field.

Time Series

In a growing effort to distinguish between natural and human-induced Earth system variability, the IOC is paying attention to sustained ocean time-series measurements. Shipboard biogeochemical time-series programmes provide the oceanographic community with the multi-year, high-quality data needed for characterizing ocean biogeochemistry and ecosystem variability and have taken a renewed importance as they represent one of the most valuable tools that scientists have to characterize and quantify ocean fluxes and their associated links to ecosystem functioning in a changing ocean. Under the auspices of the IOC, the International Group for Marine Ecological Time Series (IGMETS), compiled data from more than 400 time-series sites worldwide. It is envisaged that the analysis of these data sets, to be published in November 2015, will serve to disentangle natural and human-induced change in marine ecosystems. The initiative shows that the assessment of present data is critical to improve the information delivered to decision makers so that they understand marine ecosystem responses to a changing climate and plan accordingly.

IOC Joint action with ICES and IMO on Ballast and other Ship Vectors

The ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) critically reviews and reports on the status of shipping vector research, with an emphasis on new developments in ballast water treatment technology, risk assessment, ballast water sampling devices, and selection of ballast water exchange zones. The WG also discusses and evaluates the sampling strategies to ensure that international guidelines are based on accurate scientific information, thereby helping to achieve consensus on difficult technical issues.

In 2015, the WG continued to critically review and report on the status of shipping vector research, with an emphasis on studies of shipping transport vectors, shipping vector management activities and risk assessment. WGBOSW discussed and evaluated sampling and analysis strategies for type approval and compliance testing of ballast water treatment technologies under consideration at IMO or by other regulators (e.g. U.S. Environmental Protection Agency). WGBOSV further discussed and evaluated available information on the effects of treated or exchanged ballast water on the aquatic environment and provided input on strategies which could be used to increase confidence surrounding environmental safety of treated ballast water being discharged. Other terms of reference were to provide input to WGITMO in connection with OSPAR 1/2015 request, to review a draft OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition, and to investigate and report on new developments in non-native species issues in the Arctic, as a result of climate change and resource development. Finally, WGBOSV investigated and reported (incl. via AquaNIS) on new molecular tools for

identification, early detection and monitoring of non-native species, in collaboration with the ICES Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT). The Full report is available at http://www.ices.dk/community/groups/Pages/WGBOSV.aspx.

Nutrient's coastal Impacts research

Nutrient over-enrichment of coastal ecosystems is a major environmental problem globally, contributing to problems such as harmful algal blooms, dead zone formation, and fishery decline. Yet, quantitative relationships between nutrient loading and ecosystem effects are not well defined. The IOC Nutrients and Coastal Impacts Research Programme (N-CIRP) is focussing on integrated coastal research and coastal eutrophication, and linking nutrient sources to coastal ecosystem effects and management in particular. A key component in the implementation strategy is a four-year Joint UNEP-IOC Global Environment Facility (GEF) Project 'Global foundations for reducing nutrient enrichment and oxygen depletion from land-based pollution' which was launched in March 2012. The IOC is leading the Project research component, which delivers global and local models for impact of nutrient loading. As part of the implementation strategy for N-CIRP, IOC also actively participates in a UNEP-led ´Global Partnership on Nutrient Management' (GPNM) with intergovernmental organizations, non-governmental organizations and governments. GPNM has an online information portal to enable GPNM partners to monitor progress on implementing activities related to the sustainable use of nutrients. The platform provides a knowledge hub, networking opportunities and promotes global discussions on sustainable nutrient management.

Microplastics

The Group of Experts on the Scientific Aspects of Marine environmental Protection (GESAMP) WG 40 'Sources, fate and effects of micro-plastics in the marine environment: a global assessment' has completed its work under the leadership of the IOC-UNESCO. It has started a second phase with a joint co-sponsorship shared by the IOC, UNEP and FAO. The new TORs were agreed by the three organizations, plus GESAMP, and the kick-off meeting was held in Rome on 21-23 April 2015. The most immediate milestone for this group is to present a report on the impact of microplastics on fish by May 2016. The IOC is also acting as an advisory body on potential plastics projects funded by the European Union Joint Programming Initiative on Oceans (EU JPI Oceans).

Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socio-Economic Aspects – World Ocean Assessment

IOC continued to follow closely the preparation of the World Ocean Assessment (WOA) report under the UN Regular Process, providing technical comments to the chapters related to its expertise. IOC also contributed financial resources to assist the UN Division for Ocean Affairs and the Law of the Sea (DOALOS) with the editorial process of the report. In December 2014, the Secretariat of the Regular Process (Division of Ocean Affairs and Law of the Sea) informed the Commission that the draft of the first global integrated marine assessment of the Regular Process was completed and ready to be reviewed by Member States and relevant intergovernmental organizations. Through IOC Circular letter 2564, IOC Member States were invited to take part in the review process that concluded on 15 March 2015. In parallel, the IOC secretariat also provided a technical review for the chapters particularly relevant to the IOC field

of expertise.

The WOA report is now being finalized by the Group of Experts and will be ready in September 2015 for consideration by the UN Ad Hoc Working Group of the Whole. In the context of the WOA consideration by UN Member States, an evaluation of the 1st cycle of the Regular Process implementation may be conducted, reviewing the effectiveness of the arrangements and drawing lessons for improving the next cycle of the Regular Process.

In 2009, the Group of Experts leading the Assessment of Assessments (preliminary phase of the Regular Process) recommended that the Regular Process be serviced by an inter-agency secretariat co-located in one single intergovernmental organization. However, when the General Assembly decided to set up the Regular Process and its arrangements, it was decided to establish the Secretariat within the Division on Ocean Affairs and the Law of the Sea (DOALOS) in New York. The impact of this decision has resulted in a limited engagement of relevant intergovernmental bodies and programmes such as FAO, UNEP, IMO and IOC, or of scientific advisory groups such as GESAMP, in the operations of the Regular Process. The adequate provision of supporting resources is critical to facilitate the work of the Group of Experts as well as the inclusion of the state-of-the-art scientific knowledge. The next cycle of the Regular Process may consider the use of indicators and reference points to compare status and trends over time. This would require a heavy investment in the development of an indicator-based methodology. This is an area where IOC, building on its experience with the Transboundary Water Assessment Programme (TWAP), is well placed to contribute to.

TWAP

IOC is leading the implementation of the marine components of the Transboundary Water Assessment Programme (TWAP) funded by GEF. The project will provide a number of core ecological, socio-economic and governance indicators for the marine environment (64 Large Marine Ecosystems and Open Ocean areas) using globally available datasets. From the IOC perspective, TWAP is the first integrated and global marine assessment that the Commission is leading, and the results produced have the potential to inform a number of ocean governance mechanisms; these include the GEF, other UN agencies with an ocean mandate, other global assessment processes such as WOA and Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES), regional seas organizations, and LME commissions, as well as Member States. In order to conduct this assessment, IOC established a consortium of institutional partners and experts for the current Open Ocean and LMEs assessments (these include for e.g. NOAA, IGBP, GESAMP, UNEP-WCMC, University of British Colombia, National Center for Ecological Analysis and Synthesis (NCEAS), amongst others). This consortium is crucial for the conduct of the assessments, as the members provide the necessary expertise, tools and data that underpin the assessments. The final TWAP deliverables will be released in September 2015, there will be two technical assessment reports (IOC Technical Series, 119, vol. 1: LME and Vol.2: Open Ocean; IOC/2015/TS/119) and a joint web portal displaying the indicators globally and providing access to the underpinning data. (see http://www.geftwap.org)

OBIS

OBIS continuous to grow, with about 3 million species observations per year. It currently holds 45 million records, integrated from over 1,800 datasets.

The financial situation of the OBIS secretariat is now looking much better, with the project coordinator's position being covered by UNESCO's regular programme budget. This position is combined (50/50) with GOOS, to support the newly established Biology and Ecosystems Panel of GOOS.

The mission of GOOS Biology is: "By OceanObs'19, identify at least one (set of) GOOS variable providing a change indicator, globally coordinated with a clear pathway to global coverage, including open access data, and reporting to support international reporting needs (including SDGs, CBD reporting needs, a future World Ocean Assessment, etc.) – i.e. a mature GOOS programme. A further 3 (sets of) GOOS variables have been identified as pilot eEOVs with a clear pathway to progress them to mature variables." More information can be found on http://www.ioc-goos.org/biology.

OBIS and GOOS Biology are heavily involved in the developments of GEO MBON (a marine Biodiversity Observation Network as part of the Group on Earth Observation), in collaboration with GEO Blue Planet.

OBIS has received funding from the Flanders Government (Flanders UNESCO Science Trust Fund) to develop information products and services to support major ocean assessments, such as the World Ocean Assessment of the UN regular process and those of the new IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services). Within this project, OBIS is currently developing customized information portals on particular geographic or thematic issues.

OBIS continues to be an important information source for the identification of Ecologically or Biologically Significant Areas (EBSAs) of the Convention on Biological Diversity (CBD).
A new pilot project has been approved by the IODE Committee (March 2015) to expand OBIS with additional data beyond species occurrence records (e.g. biological measurements, environmental measurements, water, sediment, etc.). The purpose is to ensure that mixed datasets (holding all measurements taken during a sampling event) are kept together; multiplying the value of these data for a multitude of science applications and ensuring that published results/analysis are reproducible.

IOC Capacity Development Strategy

During 2014-15 the Intersessional Working Group for the Development of the IOC Capacity Development discussed the proposal for the new IOC Capacity Development Strategy, to be implemented in the period 2015-2021.

The vision of IOC's Capacity Development Strategy is derived from the IOC Vision and High-Level Objectives for 2014-2021 (Resolution XXVII-2, 27th Session of the IOC Assembly) and also from risks and opportunities related to ocean and coasts.

The vision statement of IOC's Capacity Development Strategy is: *"Through international cooperation, IOC assists its Member States to collectively achieve the IOC'S high-level objectives (HLOs), with particular attention to ensuring that all Member States have the capacity to meet them.*" Furthermore, the mission statement of IOC's Capacity Development Strategy states that "*The IOC will undertake relevant actions to assist Member States with developing and sustaining the necessary capacity to undertake activities necessary to achieve the IOC vision at the national level as well as at the international cooperation leve*l."

The IOC CD Strategy defines 6 main outputs, each output including a number of activities to be developed towards pursuing IOC's CD vision. The outputs are: 1) Human resources developed; 2) Access to physical infrastructure established or improved; 3) Global, regional and subregional mechanisms strengthened; 4) Development of ocean research policies in support of sustainable development objectives promoted; 5) Visibility and awareness increased; and 6) Sustained (long-term) resource mobilization reinforced.

One key element towards the implementation of this CD Strategy is the development of sustained partnerships, where SCOR can play an important role. Such partnership(s) can involve, inter alia, joint fellowships and grant/travel awards as well as sharing/exchange of experts contributing lectures/contents to training courses and programmes, etc.

The new IOC Capacity Development Strategy, to be implemented in the period 2015-2021, was approved by the Member States in June 2015 during the IOC 28th Assembly.

OceanTeacher and OceanTeacher Global Academy
In 2014-15 OceanTeacher – IODE's Capacity Development (CD) tool – started the implementation of a new phase in Capacity Development. The new OceanTeacher Global Academy (OTGA), funded by the Government of Flanders (Belgium), aims at creating a network of Regional Training Centres (RTCs), thus moving from a centralized model to a distributed model for its CD activities.

The OTGA Project (2014-18) will:

- promote the establishment and assist with the start-up of Regional Training Centres that will plan, organize and implement training courses that are of relevance and serve the needs of the target region;
- promote the use of local experts as lecturers/training assistants by the RTCs;
- promote the collaboration between the RTCs by enabling (through advanced information technology) lecturers from multiple regions to contribute lectures; and
- further develop the use of the OceanTeacher Learning Platform.

During 2014, all candidate RTCs were visited and assessed for their adequacy to become part of the OTGA network of RTCs. The candidate RTCs spread across the globe, including Colombia, USA, Senegal, South Africa, Mozambique, Kenya, India, Malaysia, China and the already existing one in Belgium. In late 2014, a proposal from Samoa was also received.
In January 2015, the OTGA Steering Group (SG) met for the first time. During this meeting the

partners had the opportunity to meet and discuss some of the challenges of the project, including that the number of RTCs is twice as many as expected (the project expected 5 RTCs, while 10 applications were received). The OTGA SG agreed on the following main activities for 2015:

- Each RTC to organise at least one training course on an IODE-related topic;
- Definition of an 'OTGA Global and Regional Communication and Outreach Strategy' (implementation to start early 2016);
- Launch the regional training needs surveys.

The OTGA SG will meet again during the first quarter of 2016.

During the 2014-2015 the OceanTeacher Learning Platform has been improved and expanded to include courses from other IOC Programmes, and it now includes specific sections for the Harmful Algal Bloom (HAB), Coastal and Marine Management and Planning (MPR/ICAM), Tsunami and JCOMM, besides IODE. Altogether, over 20 new courses were added in 2014-15. In December 2014, during its 69th General Assembly, the UN Member States expressed their appreciation for IOC contribution towards CD through OT.

The OTGA SG calls for members from the SCOR community to contribute to OceanTeacher as lecturers.

IIOC-2

The IIOE-2 continues to be co-championed by SCOR, IOC and IOGOOS. This report does not repeat SCOR's input on IIOE-2, but mentions a few salient IOC specific points as a supplement. IOC Assembly 28, June 2015, considered the Report on IIOE-2 submitted to it by the IOC IIOE-2 Interim Planning Committee (Group of Experts): *IOC/INF-1324, 26 May 2015: Strategic Framework for Implementation of the Second International Indian Ocean Expedition (Report of the IOC Second International Indian Ocean Expedition (IIOE-2) Interim Planning Committee*. That report is available via IOC websites (including www.iocperth.org). The Assembly consideration on IIOE-2 led to the adoption of a Resolution establishing, for IOC, the IIOE-2 as a new IOC project with a dedicated allocated budget and to run in conjunction with SCOR and the Indian Ocean Global Ocean Observing System Regional Alliance. IOC also endorsed the SCOR IIOE-2 Science Plan Development Committee's Science Plan (Version 1, May 2015) as the adopted underpinning science framework for IIOE-2. In terms of secretariat support for IIOE-2, Australia (via the IOC Perth Programme Office) and India (via a resourced IIOE-2 International Project Office) combined to provide formative contributions and support for collaborative International Project Office Framework (IPO) model.

The IOC also agreed to extend the tenure of the IPC in order to facilitate it preparing an IIOE-2 Implementation Plan complementary to the Science Plan. The elements of the Implementation Plan, in terms of its structure and themes, will align with the recommendations of the IPC's Report to Assembly 28, referring to a Steering Committee and an integrated set of Working Groups. The Implementation Plan is being prepared to be ready for the 4 Dec 29015 launch of IIOE-2 in Goa, India at the end of the II50 conference and it will be submitted to the Executive Council of the IOC at its 49th meeting in June 2016.

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

GESAMP WG 38
ATMOSPHERIC INPUT OF CHEMICALS TO THE OCEANS

2015 Report to SCOR from the Co-Chairs of Working Group 38

History of WG 38

Recognition continues to grow concerning the impact of the atmospheric input of both natural and anthropogenic substances on ocean chemistry, biology, and biogeochemistry as well as climate. In the 1980s, GESAMP formed a working group sponsored by WMO, UNESCO/IOC, and UNEP that developed a comprehensive review of the input of atmospheric trace species to the global ocean (GESAMP, 1989). That benchmark effort led to a scientific publication in *Global Biogeochemical Cycles* in 1991 that for more than 15 years was the state-of-the-art reference in this area, leading to over 1,300 citations in the literature. That paper is now 25 years old, and a new overall look at this issue was needed.

For this reason, Working Group 38 was formed during 2008 and it held its first meeting at the University of Arizona, Tucson, Arizona (USA), in December, 2008. Subsequent meetings were held at IMO in London in 2010, and Malta in 2011. Sponsors of those WG 38 efforts have included WMO, IMO, SCOR, SIDA, the European Commission Joint Research Centre, the University of Arizona, and the International Environment Institute at the University of Malta.

Following the initial terms of reference, as a result of the first working group meetings, five scientific papers have been published in the scientific literature. These include the following:

1) Okin, G., A. R. Baker, I. Tegen, N. M. Mahowald, F. J. Dentener, R A. Duce, J. N. Galloway, K. Hunter, M. Kanakidou, N. Kubilay, J. M. Prospero, M. Sarin, V. Surapipith, M. Uematsu, T. Zhu, "Impacts of atmospheric nutrient deposition on marine productivity: roles of nitrogen, phosphorus, and iron", Global Biogeochemical Cycles, 25, GB2022, doi:10.1029/2010GB003858, (2011).

2) Hunter, K.A., P. S. Liss, V. Surapipith, F. Dentener, R. A. Duce, M. Kanakidou, N. Kubilay,, N. Mahowald,, G. Okin,, M. Sarin,, I. Tegen, M. Uematsu, and T. Zhu, "Impacts of anthropogenic SO_x, NO_x and NH_3 on acidification of coastal waters and shipping lanes", Geophysical Research Letters, 38, L13602, doi:10.1029/2011GL047720 (2011).

3) Kanakidou, M., R. Duce, J. Prospero, A. Baker, C. Benitez-Nelson F. J. Dentener, K.A. Hunter, N. Kubilay, P. S. Liss , N. Mahowald, , G. Okin, M. Sarin, K. Tsigaridis, M. Uematsu, L.M. Zamora, and T. Zhu, "Atmospheric fluxes of organic N and P to the ocean", Global Biogeochemical Cycles, 26, GB3026,doi:10.1029/2011GB004277, (2012).

4) Schulz, M., J. M. Prospero, A. R. Baker, F. Dentener, L. Ickes, P. S. Liss, N. M. Mahowald, S. Nickovic, C. Pérez García-Pando, S. Rodríguez, M. Sarin, I. Tegen, R.A. Duce, "The atmospheric transport and deposition of mineral dust to the ocean - Implications for research needs", Environmental Science and Technology, 46, 10,390-10,404 (2012).

5) Hagens, M., K.A. Hunter, P.S. Liss, and J.L. Middelburg, "Biogeochemical context impacts seawater pH changes resulting from atmospheric sulfur and nitrogen deposition", Geophysical Research Letters, 41, doi:10.1002/2013GL058796 (2014).

More Recent Activities of WG 38

Additional terms of reference for continued work of GESAMP WG 38 were approved in 2012 to address issues related to the impact of the atmospheric deposition of anthropogenic nitrogen to the ocean. The additional tasks added were as follows:

A. Update the geographical estimates of anthropogenic nitrogen deposition to the global ocean made in the 2008 paper in *Science* (Duce, R.A., et al., "Impacts of atmospheric anthropogenic nitrogen on the open ocean", *Science*, *320*, 893-897, 2008), which were based on data from 2005 and earlier. This would utilize newer and more geographically distributed data on anthropogenic atmospheric nitrogen concentrations and deposition over the global ocean, as well as improved models of these processes and impacts;

B. Considering issues related to Task 1 above, re-evaluate the impact of atmospheric nitrogen deposition on marine biogeochemistry, including re-estimating the amount of CO_2 that could be drawn down from the atmosphere into the ocean as a result of the increased productivity in the ocean derived from the additional anthropogenic nutrient nitrogen deposited. This would allow an update on the impact of the atmospheric nitrogen deposition on atmospheric radiative properties outlined in the 2008 *Science* paper;

C. Provide a more reliable estimate of the impact of atmospheric anthropogenic nitrogen deposition on the production of additional nitrous oxide in the ocean and its subsequent emission to the atmosphere. This was one of the greatest uncertainties in the 2008 *Science* paper;

D. Evaluate the extent to which anthropogenic nitrogen delivered to the coastal zone via rivers, atmospheric deposition, etc. is transported to the open ocean, in which regions this may happen, and what its impact is there. In the 2008 *Science* paper, it was assumed that all nitrogen delivered to the coastal zone was sequestered there and did not reach the open ocean, but this may not be true in all locations; and

E. Make a more detailed estimate of the input and impact of anthropogenic nitrogen in the area of the Northern Indian Ocean (Arabian Sea, Bay of Bengal) and the South China Sea - the areas that are expected to show the greatest increase of anthropogenic nitrogen deposition over the next few decades.

To address these new terms of reference, a highly successful workshop on The Atmospheric Deposition of Nitrogen and Its Impact on Marine Biogeochemistry was held at the University of East Anglia in Norwich, United Kingdom, from 11 to 14 February 2013. Twenty-three scientists participated in the workshop. The first day of the workshop was devoted to discussions of the five tasks identified above as the foci of the workshop. Two participants were asked to summarize the issues in each of these task areas and to lead the discussions that followed. On the basis of the task area discussions above, the workshop participants broke up into sub-groups on the second through fourth days of the workshop. These sub-groups began the development of a number of different scientific papers, covering the task areas above. This newest work by WG 38 has been supported by WMO, IMO, SCOR, the University of East Anglia, and the US National Science Foundation.

Since the Norwich workshop one paper has been published:

6) Kim, T.-W., K. Lee, R.A. Duce and P.S. Liss, "Impact of atmospheric nitrogen deposition on phytoplankton productivity in the South China Sea", Geophys. Res. Lett., DOI: 10.1002/2014GL059665 (2014).

One additional paper has been submitted for publication:

7) Somes, C.J., A. Landolphi, W. Koeve, and A. Oschlies, "Ocean biogeochemical feedbacks limit the impact of atmospheric nitrogen deposition on marine productivity", Submitted to the Proceedings of the National Academy of Sciences (2015).

Five additional papers are in preparation, and all should be submitted before the end of 2015. This includes a major summary paper on our current understanding of the impact of atmospheric nitrogen deposition on marine biogeochemical cycling, led by Tim Jickells, and a paper comparing observation and model-based estimates of atmospheric nitrogen deposition to the ocean, led by Alex Baker.

Potential Future Activities of WG 38

Following its successful 2014 session at the European Geosciences Union (EGU) meeting, WG 38 again organized a session on atmospheric input of chemicals to the ocean for the 2015 EGU meeting, held in Vienna, Austria in April 2015. Papers at this session were presented by a combination of WG 38 members and other scientists. The co-chairs; several members of WG 38; and officials from the Atmospheric Environment Research Division, World Meteorological Organization, met at the 2015 EGU meeting and began to discuss possible additional tasks for WG 38. Since then, WG members have developed three possible proposals for future WG 38 activities and these (see summaries below) were presented at GESAMP 42 in Paris in September, 2015. GESAMP approved these new initiatives, assuming that appropriate funding could be obtained.

Workshop on the Impact of Ocean Acidification on Fluxes of Atmospheric non-CO_2 Climate-Active Species

Earlier investigations on the impact of ocean acidification (OA) have primarily focused on

changes in oceanic uptake of anthropogenic CO_2, the resulting shifts in carbonate chemical equilibria and the consequences for marine calcifying organisms. Very little attention has been paid to the direct impacts of OA on the ocean sources of a range of other gaseous and aerosol species (including N_2O, CH_4, DMS, and marine VOCs and halocarbons important in tropospheric chemistry and particle formation) that are influential in regulating radiative forcing, atmospheric oxidising capacity (via OH and O_3 cycling) and atmospheric chemistry. The oceanic processes governing emissions of these species are frequently sensitive to the changes in pH and ocean pCO_2 accompanying ocean acidification. The direct and indirect influences of these oceanic processes (e.g., microbial metabolic rates, levels of surface primary production, ecosystem composition, etc.) on ocean fluxes of non-CO_2 trace gases and aerosols, and the subsequent feedbacks to climate remain highly uncertain. The aim of this proposed project would be to review and synthesize the current science on the direct impact of OA on marine emissions of these other key species; identify the primary needs for new research to improve understanding of these processes and quantify the impact of OA on marine fluxes; publish the results in the open peer-reviewed scientific literature, and provide input to and interact with national and international research programs on OA (e.g., UKOA, NOAA-OAP) and with relevant WMO programmes.

Workshop on Changing Atmospheric Nutrient Solubility

Atmospheric deposition of nutrients to the ocean is known to play a significant role in regulating marine productivity and biogeochemistry, in turn potentially impacting the drawdown of CO_2 from surface seawater as well as the production of other climate-active gases (e.g., N_2O and DMS). The specific impact is dependent on the nutrient in question, the location of the deposition (more significant impact where a particular nutrient is in short supply), and the bioavailability of the deposited nutrient. Bioavailability is largely governed by the chemical speciation of a nutrient and, in general, insoluble species are not bioavailable. For Fe and P, solubility increases during transport through the atmosphere. The causes of this increase are complex, but interactions of aerosol particles with acids appear to play a significant role. Past and future changes in anthropogenic emissions of acidic (SO_2 and NO_x) and alkaline (NH_3) gases have had and likely will have an impact on the acidity of the atmosphere downwind of major urban/industrial sources, with potential consequences to the supply of soluble nutrients to the ocean. Concurrent with this change in acidity there are likely to be other changes which may also impact marine productivity rates and microbial species population composition. The aim of this proposed workshop would be to review and synthesize the current scientific information on solubility of key biogeochemical elements, their pH sensitivity and the biogeochemical controls on the pH sensitivity; identify the key future research needs that are necessary to reduce uncertainties in predictive capability in this area; publish the results in the open peer-reviewed scientific literature; and interact with and provide information to leading relevant international groups (e.g., SOLAS, IGAC, IMBER, SCOR) and WMO programmes such as GAW.

Possible Funding for These Two Workshops

Both the WMO and IMO have indicated that they will provide some financial support for these 2 workshops if they go ahead. Preliminary discussions have been held with personnel at the U.S. National Science Foundation and with Dr. Ed Urban at SCOR about the possibility of NSF once again providing partial finding for these workshops, through SCOR, as it did for the earlier Nitrogen Workshop. The discussions of this possibility will continue, and if it is decided that this is feasible, a proposal from SCOR to the National Science Foundation might be submitted sometime during the first half of 2016. At its annual meeting in Kiel, Germany in September, 2015 SOLAS indicated its support and willingness to collaborate on these two workshops if they go forward.

Possible Workshop for the Integrated Nitrogen Management System (INMS)

A third future activity proposed by WG 38 is the assessment of the impact of nitrogen on the marine environment as a contribution to the Integrated Nitrogen Management System (INMS). INMS is a global targeted research project with the aim to provide clear scientific evidence to inform future international nitrogen policy development. INMS's core funding comes from the Global Environment Facility (GEF) (the environment funding mechanism of the United Nations System) with the United Nations Environment Program (UNEP) as the Implementing Agency and the UK Natural Environment Research Council (Centre for Ecology and Hydrology) as the Executing Agency acting on behalf of the International Nitrogen Initiative (INI). WG 38 is in an excellent position to bring together observational scientists and atmospheric modeling groups to address these issues. Funding for this effort would come from the INMS. The expertise needed would be very different for the three activities, and thus it is likely that there would be very little overlap in participants at the planned workshops. WG 38 members would act as an overall executive committee and engage other experts for each of the projects.

New Co-Chair of WG 38

Prof. Peter Liss, who has served as an outstanding co-chair of WG 38 since its inception, has asked to step down from that position and Prof. Timothy Jickells, an internationally renowned atmospheric and marine chemist from the University of East Anglia, has agreed to become Co-chair of WG 38. Dr. Jickells has been involved with WG 38 activities for many years and is the lead author on the primary nitrogen paper that is coming out of the current WG 38 work on nitrogen deposition to the ocean and its impacts. At its Paris meeting, GESAMP approved this change in WG 38 leadership.

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

7.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

7.1 International Council for Science ***Burkill***

7.1.1 International Geosphere-Biosphere Program (IGBP), **p. 7-1** *Burkill*

7.1.2 World Climate Research Programme (WCRP), **p. 7-4** *Fennel*

7.1.3 Scientific Committee on Antarctic Research (SCAR), **p. 7-9** *Brussaard*

7.1.4 Future Earth Initiative, **p. 7-15** *Burkill*

7.2 Affiliated Organizations

7.2.1 International Association for Biological Oceanography (IABO), **p. 7-19** *Miloslavich*

7.2.2 International Association for Meteorology and Atmospheric Sciences (IAMAS), **p. 7-22** *Turner*

7.2.3 International Association for the Physical Sciences of the Oceans (IAPSO), **p. 7-24** *Smythe-Wright*

7.3 Affiliated Programs, p. 7-27

7.3.1 InterRidge - International, Interdisciplinary Ridge Studies, **p. 7-28** *Urban*

7.3.2 International Ocean Colour Coordinating Group (IOCCG), **p. 7-31** *Sun Song*

7.3.3 Global Alliance of CPR Surveys (GACS), **p. 7-35** *Burkill*

7.4 Other Organizations

7.4.1 Partnership for Observation of the Global Oceans (POGO), **p. 7-36** *Shapovalov*

7.1 International Council for Science (ICSU) *Burkill*

ICSU is reviewing SCOR and SCAR this year and next. The review panel includes the following members:

Peter Liss (Chair)
University of East Anglia
UNITED KINGDOM

Isabelle Ansorge
University of Cape Town
SOUTH AFRICA

Motoyoshi Ikeda
Hokkaido University
JAPAN

Nicholas Owens
Scottish Association of Marine Sciences
UNITED KINGDOM

Annelies Pierrot-Bults
University of Amsterdam
THE NETHERLANDS

Volker Rachold
International Arctic Science Committee
GERMANY

ICSU Committee on Scientific Planning and Review Ex- Officio: **Oyewale Tomori**
NIGERIA

ICSU Secretariat: **Lucilla Spini**
Head of Science Programmes, ICSU

The first meeting of the SCAR-SCOR Joint Review Panel was held on 14-15 September 2015 at the ICSU Secretariat in Paris. ICSU has informed SCOR that they would like the review panel to meet with the SCOR President and Executive Director during the review process, but no date has been set yet. A draft report is scheduled to be shared with SCOR and SCAR in February 2016 for comment.

7.1.1 International Geosphere-Biosphere Programme (IGBP) *Burkill*

IGBP Update
24 August 2015

27th IGBP SC Officers Meeting
The IGBP SC Officers meeting (20-21 October 2014) was held in Stockholm at the Royal Swedish Academy of Sciences (KVA). Members of the Future Earth interim secretariat from the five global hubs also attended portions of the meeting. The meeting focused on IGBP's final syntheses, including a Landmark Synthesis Event at the American Geophysical Union (AGU) Fall Meeting, 14-18 December 2015, in San Francisco.

30th IGBP Scientific Committee Meeting
The meeting (28-30 April 2015) was held in Austria at the International Institute for Applied Systems Analysis (IIASA). Over 40 participants met to discuss three main themes: IGBP's landmark synthesis, the program's transition to Future Earth, and a special event to be held at the American Geophysical Union Fall meeting at the end of 2015. An associated symposium, organized by IIASA, included an international symposium and public lecture around the theme of "Integrated Science for Sustainable Transitions."

The SC meeting was preceded by a one-day meeting of our core project international project offices (IPOs), with discussions on what makes a successful core project, and discussions with the newly appointed Future Earth Executive Director, Paul Shrivastava. Following the SC meeting, a one-day IGBP SC Officers meeting was held to further advance detailed discussions on the closing of IGBP as a program.

Interactions with the UNFCCC
As with previous years, the IGBP Secretariat worked closely with the UNFCCC's Subsidiary Body for Scientific and Technological Advice (SBSTA) to deliver policy-relevant findings on climate change. SBSTA meetings allow extensive and valuable dialogues between scientists and negotiators, and other policymakers. IGBP receives and acts on feedback from nations regarding current areas of policy interest. In advance of the June 2015 meeting, IGBP responded to guidance from SBSTA that this year's emphasis was to address data and information gaps, including from the AR5, such as in regards to climate change and desertification; to identify good practices for knowledge and research capacity building, in particular in developing countries; and to understand better how findings from the IPCC AR5 can be used at regional and local levels. IGBP Executive Director Sybil Seitzinger worked with WCRP Director David Carlson to bring together the presentation that was presented by Carlson. In preparation for the ending of IGBP, Seitzinger worked with WCRP and Future Earth to chart a path forward for continued engagement with SBSTA.

IGBP Landmark Synthesis Events at AGU
As part of the celebratory event to be held at the 2015 AGU Fall Meeting, IGBP is co-sponsoring over 60 scientific sessions covering a range of topics, as well as co-hosting an early-career scientists' event (in partnership with Future Earth); a booth; and an evening reception. The IGBP Secretariat has raised funds to support the participation of early-career scientists from the developing world and has worked actively to develop sessions as well as encourage abstract submission.

Other activities 2014-2015

Maintaining strong links with international research programs
The IGBP leadership attended the scientific committee meeting of the remaining global-change program, World Climate Research Program (WCRP).

IGBP worked closely with Future Earth's scientific and administrative leadership to develop a research agenda and negotiate a smooth transition of IGBP's projects to the new initiative. This included a meeting between the IGBP SC Officers and Secretariat with members of the Future Earth interim secretariat from the five global hubs. Discussions focused on practical needs of projects as they move towards Future Earth; organizational and operational aspects of the Future Earth secretariat; and other topics. The IGBP Secretariat staff contributed expertise throughout the year to several Future Earth taskforces, such as external communication and core project

operations/guidelines, and helped facilitate a connection between Future Earth and the European Space Agency.

Ocean Acidification Summary for Policymakers and website
In 2013, the Ocean Acidification Summary for Policymakers was published by IGBP, SCOR and UNESCO-IOC. In 2014, we published three translations of the summary, in French, German and Spanish. In addition we launched an Ocean Acidification website containing many policy-relevant resources, including the summaries (www.ocean-acidification.net).

Sustainable Development Goals
One of the key events in 2015 will be the UN General Assembly agreement of the Sustainable Development Goals. IGBP has supported ICSU and Future Earth to help ensure the targets underlying the goals are grounded in science and add up to long-term sustainability.

Synthesis
IGBP's focus last year was on its overarching synthesis. In early 2014, we cosponsored a workshop on the Anthropocene concept in Washington, D.C. The workshop brought together Earth-system experts and social-science leaders to develop fresh perspectives and a more nuanced understanding of the Anthropocene. A series of synthesis papers emerging from this workshop are under review with the journal *Global Environmental Change*.

Our second program synthesis effort is through IGBP's core projects, an effort coordinated by IGAC co-chair Paul Monks. A series of papers will appear in the journal *Anthropocene*. Our third program synthesis will highlight IGBP's leadership and development of the discipline of Earth-system science and IGBP's contributions over the last three decades.

IGBP has updated its "Great Acceleration" indicators, originally published in our first synthesis in 2004. The new suite of graphs, published in *The Anthropocene Review* journal (January 2015), charts the trajectory of the Anthropocene from 1750 to 2010. Similarly, we have also updated the Climate-Change Index, first produced in 2009. The index brings together four parameters: sea level, global average land-surface temperature, atmospheric carbon dioxide and Arctic sea-ice minimum. The Climate-Change Index helps us look beyond natural variability in these parameters and provides a snapshot of the planet's climate as human pressures mount. The latest edition continues to show an unequivocal increase, reflecting continued warming of Earth's systems. The underlying trend is clearly visible. So too is the annual extent of change. Members of the IGBP Secretariat are involved in writing the Anthropocene and Earth-system science papers and did an internal review of all core project papers before submission.

In December 2015, we will hold a series of science sessions as well as other events at the AGU Fall Meeting to discuss and celebrate IGBP's legacy. Many IGBP projects and close partners will hold sessions on topics relating to global environmental change.

7.1.2 World Climate Research Programme (WCRP) *Fennel*

The World Climate Research Programme (WCRP): a Short Update to SCOR-2015

General background
The Mission of the World Climate Research Programme (WCRP) is to facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society. The two overarching objectives of the WCRP are (1) to determine the predictability of climate; and (2) to determine the effect of human activities on climate.

WCRP is organized as a network of core and co-sponsored projects, working groups, modelling activities and cross-cutting initiatives (see http://wcrp-climate.org/about-wcrp/about-implementation). Those activities of most relevance to the work of SCOR are highlighted below.

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

The WCRP Grand Challenges
http://wcrp-climate.org/grand-challenges

The overarching WCRP Grand Challenges (GCs) represent major foci of scientific research, modelling, analysis and observations over the next decade or so. The WCRP intends to promote these GCs through community organized workshops, conferences and strategic planning meetings to identify high priority and exciting research that require international partnership and coordination, and that yield "actionable information" for decision makers. Currently, WCRP has five GCs, with a sixth with a focus on Decadal Climate Variability in the planning stages:

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

Of these, the GC on *Regional Sea-Level Change and Coastal Impacts* is of most relevant to SCOR. This Grand Challenge represents an integrated interdisciplinary program on sea level research reaching from the global to the regional and local scales to:

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

benefit for coastal zone management.

The effort will focus on all components of global to local sea level changes and will consider the necessary analyses on global and regional climate change data and simulations, extreme events and potential impacts, including the evaluation of sea level rise impacts for coastal zones. The program also aims to have close interaction with coastal communities to assure that results of the proposed scientific research are incorporated into practices of coastal zone management, and impacts and adaptation efforts. A WCRP-IOC Joint Sea Level Conference is being planned in commemoration of the ten years' anniversary of the WCRP Sea Level workshop held at IOC in Paris in 2006. The conference is tentatively scheduled for July 2017 in New York City, and 400 participants are anticipated.

The WCRP Core Projects

WCRP carries out a major part of its activities through its four core projects, CLIVAR (oceans and climate - www.clivar.org), CliC (cryosphere and climate - www.climate-cryosphere.org), GEWEX (water and climate www.gewex.org) and SPARC (upper atmosphere and climate - http://www.sparc-climate.org). Both CLIVAR and CliC are official endorsers of the SCAR/SCOR Southern Ocean Observing System (SOOS). Of these core projects, the work of CLIVAR is of particular relevance to SCOR.

The CLIVAR Project

CLIVAR is celebrating 20 years of progress since the publication of its first Science Plan in August 1995. The overarching goals of the project continue - to improve understanding and prediction of the ocean-atmosphere system and its influence on climate variability and change, to the benefit of society and the environment. However, CLIVAR's structure has evolved to meet the changing nature of the science and the community it serves. There are now four global Panels: the Ocean Model Development Panel, the Global Synthesis and Observations Panel, the Climate Dynamics Panel, and the joint CLIVAR-GEWEX Monsoons Panel. The regional ocean basin Panels (Atlantic, Pacific, Indian and Southern Ocean) promote and provide advice on the implementation of multi-national observational systems and process studies in support of research on climate and ocean variability and predictability. All Panels report to the CLIVAR Scientific Steering Group.

The regional ocean basin panels have developed through the years strong partnerships with groups that also work on the implementation of the ocean observing system, like the CLIVAR/IOC-GOOS Indian Ocean Region Panel links with IIOE-2 activities and the CLIVAR/CliC/SCAR Southern Ocean Region Panel's links with SOOS. More recently, the Atlantic Region Panel and the Pacific Region Panel are involved with AtlantOS and TPOS2020, respectively. The upcoming issue of the CLIVAR newsletter Exchanges provides an overview of CLIVAR's role in the development of a sustained ocean observing system, in terms of research and advances in understanding.

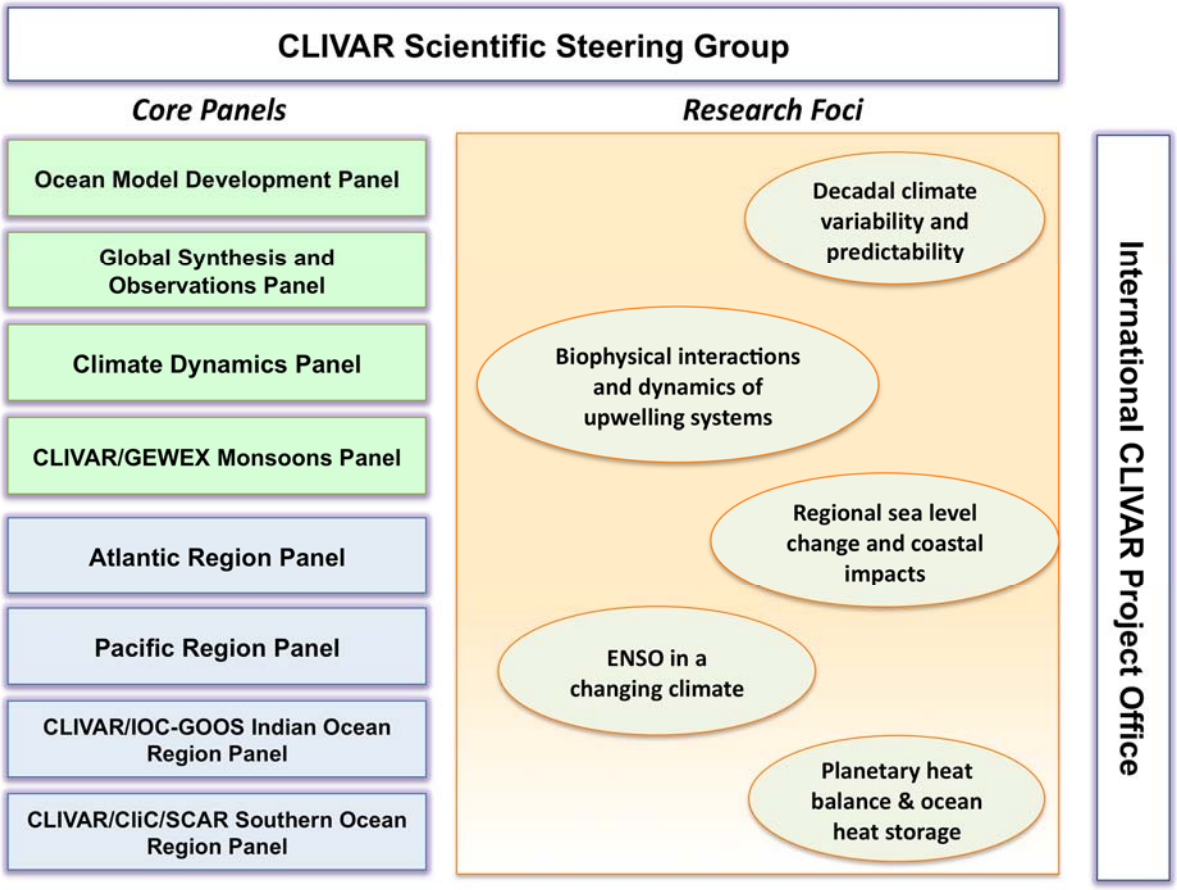
Recognizing the need for the CLIVAR project to be flexible and responsive to new ideas and challenges, the CLIVAR SSG has initiated the concept of *Research Foci* (RF, http://www.clivar.org/about/research-foci). These are focused research topics identified by members of the CLIVAR community as being ripe for progress in the next 5-10 years and that would significantly benefit from enhanced international coordination. The RF have already

demonstrated to be an effective means for CLIVAR to initiate activities and invigorate progress in areas that go beyond the traditional areas addressed by the Panels, fostering cross-panel, cross-community collaboration, and an opportunity to bring young scientists into CLIVAR. Four RF have presented their plans to the SSG and been endorsed to organize meetings and workshops this year to further define their science focus and implementation plans for the coming years: ENSO in a Changing Climate, Decadal Climate Variability and Predictability, Sea Level Rise and Regional Impacts (also a WCRP Grand Challenge) and Planetary Heat Balance and Ocean Heat Storage (CONCEPT HEAT). A fifth Research Focus on biophysical interactions and dynamics of upwelling systems is under development.

Panels highlights:

GSOP: The production of ocean reanalyses, or ocean state estimates, is now an established activity in several research and operational centres. A new generation of products has recently been produced and a coordinated community effort on the intercomparison of those ocean reanalyses has been undertaken addressing a variety of aspects. These include: i) quantifying uncertainty; ii) measuring progress in the quality of the reanalyses; and iii) defining indices for ocean monitoring. These are the motivations for the current Ocean Reanalyses Intercomparison Project (ORA-IP), which was jointly developed by GSOP and GODAE Ocean View (CLIVAR Exchanges, 2014; Balmaseda et al., 2015). A special issue of *Climate Dynamics* with results of the intercomparison is almost complete.

SORP: Members of the CLIVAR/CliC/SCAR Southern Ocean Region Panel, jointly with the Southern Ocean Observing System (SOOS) project, and representing the Southern Ocean community, have provided comprehensive comment on the Year of Polar Prediction (YOPP) Implementation Plan. These comments have been published and the document is now available online. This Working Paper is designed to highlight key Southern Ocean field and modelling capabilities of relevance to YOPP, identify key areas for collaborative efforts, and raise the imperative of the Southern Ocean's role in prediction capabilities.



ARP: The CLIVAR Atlantic Region Panel have been involved with the newly funded European project AtlantOS, that brings together scientists, stakeholders and industry from around the Atlantic to provide a multinational framework for more and better-coordinated efforts in observing, understanding and predicting the Atlantic Ocean. It will also continue to recognize the importance and urgency of resolving the tropical Atlantic bias issue, and will interact with the CLIVAR Upwelling Research Focus in a concerted effort within the CLIVAR Atlantic community to understand causes of the bias.

PRP: The CLIVAR Pacific Region Panel focuses on the process studies, ocean circulation and interannual to decadal climate variability and predictability in the region. Observation projects on understanding the Western Boundary Currents such as NPOCE and SPICE have been coordinated by the panel. The panel also supported the CLIVAR Indonesian Throughflow task team (ITF). Regional sea level and ENSO study have also been the research priorities of the panel. PRP is much involved in the TPOS-2020 planning via its task teams. Significant interactions between the Panel and the CLIVAR ENSO Research Focus have taken place.

IORP: The CLIVAR/IOC-GOOS Indian Ocean Region Panel is working to design and implement an integrated observing system for the Indian Ocean, IndOOS, including the RAMA array. The climate variability modes of different timescales from intraseasonal to decadal are the research priorities of the IORP. IORP interacts with the PRP on the research theme of Indo-Pacific climate interactions and Indonesian Throughflow. IORP is working on development of the YMC (Year of the Maritime Continent) project. The panel is also heavily involved in the planning of the IIOE-2 project as one of the four organizing groups.

OMDP: Fosters the development of ocean models for research in climate and related fields through the development of models and improved representation of ocean processes (parameterizations, resolution, numerics, addressing model biases) and the design and implementation of coordinated ocean-ice modelling studies and their analysis. The Coordinated Ocean-ice Reference Experiments (COREs) are a framework for performing global ocean – sea-ice coupled simulations forced with common atmospheric data sets. The second phase - CORE-II effort has gained unprecedented momentum over the past few years and attracted participation of over 20 ocean and climate modelling groups world-wide. These are hindcast simulations covering the period from 1948 to 2007 and are used to evaluate ocean and sea-ice model performance, to study mechanisms and their variability from seasonal to decadal time scales and to initialize climate, e.g., decadal, prediction experiments. The CORE-II protocol is the basis for the CMIP6 Ocean Model Intercomparison Project (OMIP). OMDP and collaborators have provided the ocean model diagnostics guidelines for the evaluation of ocean-ice model components of CMIP6 (ocean physics, ocean inert chemistry, ocean biogeochemistry).

The next OMDP 14-15 January in Yokohama, Japan, will focus on a detailed evaluation of the new reanalysis product, JRA-55. A 2-day workshop on the Kuroshio and its extension will precede the OMDP meeting. Scientists from various communities including ocean dynamics, modeling, and observation, as well as climate dynamics and marine ecosystems, are invited to attend.

Climate Dynamics Panel: The newly established panel held its first meeting in July 2015 and is in the process of preparing a science and implementation plan of its activities for the coming years. The panel will foster and coordinate international research efforts to increase understanding of the dynamical processes that control circulation variability and change in the atmosphere and ocean on synoptic to centennial time scales. The focus is on large-scale phenomena, processes, and mechanisms of coupled climate variability/modes, teleconnnections and change on seasonal to centennial time-scales, in particular i) storm tracks, jet streams and weather systems, ii) tropical-extratropical interactions, and iii) long-term coupled atmosphere-ocean circulation.

CLIVAR is organising a major Open Science Conference "Charting the course for future climate and ocean research" in Qingdao, China (www.clivar2016.org) on 19-23 September 2016, with an associated Early Career Scientist Symposium 18, 24-25 September and a Stakeholder Forum on 18 September.

WCRP and CLIVAR look forward to exploring possible collaborations in ocean-related activities in the future. Please contact Mike Sparrow msparrow@wmo.int or Valery Detemmerman valery.detemmerman@clivar.org to discuss this further.

7.1.3 Scientific Committee on Antarctic Research (SCAR) *Brussaard*

26 October 2015

SCAR activities of relevance to SCOR

SCAR and SCOR have a strong overlap of interest in the Southern Ocean region. In many cases the two organisations work together (e.g., with the SOOS) and in other cases there are SCAR activities that may be of interest to SCOR (as well as vice versa). Below are a few of those activities. Please see www.scar.org for further details.

(i) The Southern Ocean Observing System
Louise Newman <newman@soos.aq>

SCOR and SCAR jointly sponsor the Southern Ocean Observing System and provide funds for the meeting of the Steering Committee (see separate report to SCOR for details).

(ii) Ocean Acidification
Richard Bellerby <richard.bellerby@niva.no>

SCAR appointed an international ocean acidification Action Group to document the scientific understanding of ocean acidification. The Action Group consists of an international cross-disciplinary team of ocean acidification experts representing the fields of marine carbonate chemistry, global and regional modelling, marine ecology, ecotoxicology/physiology and paleoceanography. The Ocean Acidification Action Group is finalizing a report to:

- define our present understanding of the contemporary rates and future scenarios of Southern Ocean acidification;
- document ecosystem and organism responses from experimental perturbations and geological records;
- identify present and planned observational and experimental strategies;
- identify gaps in our understanding of the rates and regionality of ocean acidification; and
- define strategies for future Southern ocean acidification research.

The report will be completed by the end of 2015 and launched at the 4th International Symposium on the Ocean in a High-CO_2 World held from 3-6 May 2016 in Hobart, Australia.

(iii) The International Bathymetric Chart of the Southern Ocean
Jan Erik Arndt <Jan.Erik.Arndt@awi.de>

The International Bathymetric Chart of the Southern Ocean (IBCSO) project was initiated in 2006 with the objective to design and implement an enhanced digital database that contains bathymetric data available south of 60°S latitude. IBCSO is endorsed by international organizations such as the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the International Hydrographic Organization (IHO), and the Scientific Committee on Antarctic Research (SCAR).

In April 2013, IBCSO Version 1.0 was released by the Alfred-Wegener-Institute (AWI), in Germany. The map and data are now available: http://www.ibcso.org.

(iv) Antarctic Biodiversity Informatics
Bruno Danis <bdanis@ulb.ac.be>

Biodiversity Informatics is the application of informatics techniques to biodiversity information for improved management, presentation, discovery, exploration and analysis. The application of modern computer techniques can yield new ways to view and analyse existing information, as well as predictive models for information that does not yet exist. More specifically, the Expert Group and Antarctic Biodiversity Informatics plans to optimize ongoing developments in biodiversity informatics for the community. A series of relevant initiatives are ongoing, all aiming at offering free and open access to biodiversity information, but also at carrying out open-source technical developments, and promoting international standards.

(v) Continuous Plankton Recorder
Graham Hosie <graham.hosie@iinet.net.au>

The sensitivity of plankton to changes in the environment makes them useful early warning indicators of the health of ocean systems. The Southern Ocean Continuous Plankton Recorder Survey maintains a database on plankton abundance and distribution.

(vi) Birds and Marine Mammals
Mark Hindell <Mark.Hindell@utas.edu.au>

The Retrospective Analysis of Antarctic Tracking Data (RAATD) has also progressed significantly through the publication of a paper on multi-species tracking data over the last two decades [10]. This study developed global and regional habitat usage maps for key species based on physical and biological attributes of their "hot-spots" and overlaid species-specific maps to identify multi-species areas of ecological significance. This new approach identified regions that are important to multiple species, and therefore provides a much better understanding of the regions and processes that require monitoring and management in the future.

A workshop was held in Brussels in May 18-22, 2015, in conjunction with EG-ABI to process the datasets collected within the EG-BAMM community. The meeting assembled a team of around 12 specialists and produced a homogenised dataset of more than 2 million data points

from more than 2,000 individuals from 13 species. Modelling approaches were decided at this occasion and the first modelling steps were initiated (a full report is available on the EG-BAMM webpage).

(vii) Antarctic Climate in the 21st Century

Nancy Bertler <Nancy.Bertler@vuw.ac.nz>

The goals of the SCAR Scientific Research Programme Antarctic Climate in the 21st Century (AntClim21) are to deliver improved regional predictions of key elements of the Antarctic atmosphere, ocean and cryosphere for the next 20 to 200 years and to understand the responses of the physical and biological systems to natural and anthropogenic forcing factors. A primary form of data that we see being used by AntClim21 are the global coupled atmosphere-ocean model runs that form the basis of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Palaeo-reconstructions of selected time periods, recognised as past analogues for future climate predictions, will be used to validate model performances for the Antarctic region.

Mayewski, P.A., T. Bracegirdle, I. Goodwin, D. Schneider, N.A.N. Bertler, S. Birkel, A. Carleton, M. H. England, J-H. Kang, A. Khan, J. Russell, J. Turner and I. Veliconga, 2015: Potential for Southern Hemisphere climate surprises, Quaternary Science, DOI: 10.1002/jqs.2794.

Bracegirdle, T., N. Bertler, A. Carleton, Q. Ding, C. Fogwill, J. Fyfe, H. Hellmer, A.Karpechko, K. Kusahara, E. Larour, P. Mayewski, W. Meier, L. Polvani, J.Russell, S. Stevenson, J. Turner, J. van Wessem, W. van de Berg, and I. Wainer, 2015: A MULTI-DISCIPLINARY PERSPECTIVE ON CLIMATE MODEL EVALUATION FOR ANTARCTICA. Bull. Amer. Meteor. Soc. doi:10.1175/BAMSD-15-00108.1.

(viii) State of the Antarctic Ecosystem

Jan Strugnell <J.Strugnell@latrobe.edu.au> and Huw Griffiths <hjg@bas.ac.uk>

Biological diversity is the sum of all those organisms that are present in an ecosystem, that dictate how ecosystems function, and that underpin the life-support system of our planet. The State of the Antarctic Ecosystem (AntEco) Scientific Research Programme has been designed to focus on patterns of biodiversity across terrestrial, limnological, glacial and marine environments within the Antarctic, sub-Antarctic and Southern Ocean regions, and to provide the scientific knowledge on biodiversity that can be also used for conservation and management. In essence, we propose to explain what biodiversity is there, how it got there, what it does there, and what threatens it. A primary product of this programme would be recommendations for its management and conservation.

(ix) Antarctic Thresholds - Ecosystem Resilience and Adaptation

Julian Gutt <Julian.Gutt@awi.de>

Stresses on Antarctic ecosystems result from global climate change, including extreme events, and from other human impacts. Consequently, Antarctic ecosystems are changing, some at a rapid

pace, while others are relatively stable. A cascade of responses from molecular through organismic to the community level are expected. The differences in biological complexity and evolutionary histories between the polar regions and the rest of the planet suggest that stresses on polar ecosystem function may have fundamentally different outcomes from those at lower latitudes. Polar ecosystem processes are therefore key to informing wider ecological debate about the nature of stability and potential changes across the biosphere.

The main goal of the Scientific Research Programme Antarctic Thresholds - Ecosystem Resilience and Adaptation (AnT-ERA) is to facilitate the science required to examine changes in biological processes, from the molecular to the ecosystem level, in Antarctic and Sub- Antarctic marine, freshwater and terrestrial ecosystems. Tolerance limits as well as thresholds, resistance and resilience to environmental change, will be determined.

(x) The Biogeographic Atlas of the Southern Ocean
Claude deBroyer <claude.debroyer@naturalsciences.be>

Biogeographic information is of fundamental importance for discovering marine biodiversity hotspots, detecting and understanding impacts of environmental changes, predicting future distributions, monitoring biodiversity, or supporting conservation and sustainable management strategies. The recent extensive exploration and assessment of biodiversity by the Census of Antarctic Marine Life (CAML), and the intense compilation and validation efforts of Southern Ocean biogeographic data by the SCAR Marine Biodiversity Information Network (SCAR-MarBIN / OBIS) provided a unique opportunity to assess and synthesise the current knowledge on Southern Ocean biogeography.

The scope of the Biogeographic Atlas of the Southern Ocean is to present a concise synopsis of the present state of knowledge of the distributional patterns of the major benthic and pelagic taxa and of the key communities, in light of biotic and abiotic factors operating within an evolutionary framework. Each chapter has been written by the most pertinent experts in their field, relying on vastly improved occurrence datasets from recent decades, as well as on new insights provided by molecular and phylogeographic approaches, and new methods of analysis, visualisation, modelling and prediction of biogeographic distributions.

The Atlas was launched at the last SCAR Meeting and Open Science Conference (Auckland, New Zealand August 25-28, 2014) and is available online via http://atlas.biodiversity.aq, or to purchase at http://www.amazon.co.uk/gp/product/0948277289.

(xi) The SCAR Antarctic Science Horizon Scan
Chuck Kennicutt <mckennicutt@gmail.com>

The 1st SCAR Antarctic and Southern Ocean Science Horizon Scan assembled some of the world's leading Antarctic scientists, policy makers, leaders, and visionaries (including representatives from CCAMLR) to identify the most important scientific questions that will or should be addressed by research in and from the southern polar region over the next two decades. The Scan outcomes will assist in aligning international programmes, projects and resources to

effectively facilitate Antarctic and Southern Ocean science in the coming years. The outcomes have so far been published in the journals *Nature* and *Antarctic Science*.

Many national Antarctic programmes are now developing their own strategies on how they will deliver their science programmes in the future. Delivery of such a "roadmap" is not without its challenges. Therefore, with SCAR's assistance, COMNAP is leading a second stage in the process with the Antarctic Research Challenges (ARC) Project (www.comnap.aq) in order to assist national Antarctic programmes to understand, and develop ways to address the challenges, and share any innovation or access to such technology. The ARC project focuses on answering the question: "How will national Antarctic programmes meet the challenges of delivery of their Antarctic science in the next 20 years and beyond?"

(xii) ANTOS (Antarctic Nearshore Terrestrial Observing System)

This new Action Group aims to establish an integrated and coordinated trans-continental and trans-regional environmental surveillance system to identify and track environmental variability and change at biologically relevant scales, and to use this information to inform biological, physical, and earth science studies. www.scar.org/ssg/life-sciences/antos

(xiii) The Monaco Assessment
Aleks Terauds (Aleks Terauds@aad.gov.au)

A meeting of biodiversity and Antarctic experts, entitled '*Antarctica and the Strategic Plan for Biodiversity 2011-2020: The Monaco Assessment'*, was convened for three days in Monaco in June 2015, with the support of the Monaco government, the Centre Scientifique de Monaco, SCAR, and Monash University. The central purpose of the meeting was to examine the extent to which conservation of the biodiversity of Antarctica and the Southern Ocean is realizing the set of ambitions agreed for the world as part of the Strategic Plan for Biodiversity 2011-2020. The meeting also aimed to provide guidance for action that can effectively help deliver further conservation successes for Antarctica and the Southern Ocean.

One of its first outcomes is a statement by the participants, on Antarctic and Southern Ocean conservation in the context of the Strategic Plan for Biodiversity 2011-2020, based on an expert elicitation process, and entitled *The Monaco Assessment*. It is provided on the SCAR website at http://www.scar.org/monaco-assessment. Further outcomes and products of *Antarctica and the Strategic Plan for Biodiversity 2011-2020: The Monaco Assessment* will be made available over the next several months.

(xiv) Upcoming Conferences

- ***XXXIV SCAR Meetings and Open Science Conference***. 19-31 August 2016, Kuala Lumpur, Malaysia. The SCAR Open Science Conference will be held on 25-29 August. See *http://scar2016.com*

- ***The XXXV SCAR Meetings and Open Science Conference in 2018*** in Davos, Switzerland, will cover both polar regions, being organized jointly with the International Arctic Science Committee (IASC).

(xv) Staff Changes

In December 2014, Eoghan Griffin was appointed as SCAR Executive Officer, replacing Renuka Badhe, who became the new Executive Secretary of the European Polar Board. In May 2015, Mike Sparrow also left SCAR to take on a position with the Joint Planning Staff of the World Climate Research Programme. Jenny Baeseman replaced Mike in July 2016.

7.1.4 Future Earth Initiative

Burkill

The vision of Future Earth is for people to thrive in a sustainable and equitable world.

This requires contributions from a new type of science that links disciplines, knowledge systems and societal partners to support a more agile global innovation system.

Future Earth is a global research platform designed to provide the knowledge needed to support transformations towards sustainability. Future Earth seeks to build and connect knowledge to increase the impact of research, to explore new development paths, and to find new ways to accelerate transitions to sustainable development.

Future Earth will contribute to achieving goals on global sustainable development, as called for at the United Nations (UN) Conference on Sustainable Development (Rio+20) and subsequently articulated under the auspices of the UN General Assembly.

Future Earth will work with partners in society to co-develop the knowledge needed to support decision-makers and societal change at all scales and in diverse contexts, by focusing on three Research Themes – Dynamic Planet, Global Sustainable Development and Transformations towards Sustainability.

This document outlines what Future Earth needs to contribute to achieve its vision by 2025.

Why do we need Future Earth?

By 2025 Future Earth will have

Inspired and created ground-breaking interdisciplinary science relevant to major global sustainability challenges

Key focal challenges are to:

1. Deliver water, energy, and food for all, and manage the synergies and trade-offs among them, by understanding how these interactions are shaped by environmental, economic, social and political changes.
2. Decarbonise socio-economic systems to stabilise the climate by promoting the technological, economic, social, political and behavioural changes enabling transformations, while building knowledge about the impacts of climate change and adaptation responses for people and ecosystems.
3. Safeguard the terrestrial, freshwater and marine natural assets underpinning human well-being by understanding relationships between biodiversity, ecosystem functioning and services, and developing effective valuation and governance approaches.
4. Build healthy, resilient and productive cities by identifying and shaping innovations that combine better urban environments and lives with declining resource footprints, and provide efficient services and infrastructures that are robust to disasters.
5. Promote sustainable rural futures to feed rising and more affluent populations amidst changes in biodiversity, resources and climate by analysing alternative land uses, food systems and ecosystem options, and identifying institutional and governance needs.
6. Improve human health by elucidating, and finding responses to, the complex interactions amongst environmental change, pollution, pathogens, disease vectors, ecosystem services, and people's livelihoods, nutrition and well-being.
7. Encourage sustainable consumption and production patterns that are equitable by understanding the social and environmental impacts of consumption of all resources, opportunities for decoupling resource use from growth in well-being, and options for sustainable development pathways and related changes in human behaviour.
8. Increase social resilience to future threats by building adaptive governance systems, developing early warning of global and connected thresholds and risks, and testing effective, accountable and transparent institutions that promote transformations to sustainability.

What will Future Earth deliver?

By 2025 Future Earth will have

Delivered products and services that our societal partners need to meet these challenges

Key focal outputs are:

1. Open and inclusive platforms for observing and monitoring the status, trends and thresholds of the planet in a timely manner at different scales, including tracking fast-changing sentinel processes and systems.
2. Tailored metrics and evaluation tools for well-being and sustainable development.
3. A new generation of integrated Earth system models to deepen our understanding of complex Earth systems and human dynamics across different disciplines, and to underpin systems-based policies and strategies for sustainable development.
4. Science-based data, tools and resources to support improved resilience of people, communities and economics, including disaster risk reduction.
5. Scenarios for transformative development pathways that enable global sustainability, to help evaluate different strategies and options.
6. Critical contributions to key debates on global sustainability issues, including inputs to scientific assessments and decision-relevant syntheses.
7. Innovations in communicating, engaging and visualising global change and sustainability, fully exploiting the potential of new technologies and overcoming differential access to information across the world.

How will Future Earth work?

By 2025 Future Earth will have

Pioneered approaches to co-design and co-produce solutions-oriented science, knowledge and innovation for global sustainable development

Key approaches for focus are:

1. Conducting fundamental and applied research in ways that engage with diverse societal partners across all regions of the world to maximise impact and responsiveness to society's needs, and monitoring the effectiveness of these new approaches to research.
2. Establishing Future Earth as a globally recognised model for engagement and collaboration in research for global sustainable development, effective in all world regions.
3. Stimulating debate, illustrating good practice and mobilising capacities for solutions-oriented science, technology and innovation for sustainability.
4. Changing international research funding practices to better support interdisciplinary and transdisciplinary research and engagement across and within regions.
5. Fostering collaboration among national and international agencies' research programmes, to maximise resources for and impacts of research towards sustainability.
6. Contributing to improved modes of sharing data about environmental change and progress towards sustainability in order to support policy and practice at different levels.

Who will Future Earth be?

By 2025 Future Earth will have

Enabled and mobilised capacities to co-produce knowledge, across cultural and social differences, geographies and generations

Key areas for focus are:

1. Inspiring and supporting a new generation of scholars and practitioners doing integrated science for global sustainability to carry forward Future Earth's vision and mission.
2. Building a diverse and connected community of participants and organisations, including scientists, policy makers, civil society practitioners, private sector actors and funders from all regions of the world.
3. Engaging influential stakeholders globally in the UN system, including major assessments and the post-2015 development agenda, key nations, business and civil society.
4. Mobilising capacities in all parts of the world to cooperate on research that connects local to global processes and promotes alternatives for sustainable development trajectories.
5. Creating a critical mass of scientists, policy makers and civil society leaders who believe in and can serve as ambassadors for Future Earth, including a body of Future Earth Fellows.

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7.2 Affiliated Organizations

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

Annual Report of the International Association for Biological Oceanography (IABO)

IABO General Assembly
The IABO General Assembly was held in conjunction with the 3rd World Conference in Marine Biodiversity in Qingdao, China on 13-16 October 2014 http://wcmb2014.csp.escience.cn/dct/page/1. The IABO Executive Committee met on 15 October 2014 at the World Conference of Marine Biodiversity.

IABO thanks SCOR for grants for delegates from Developing Countries to its GA (WCMB III). These grants, and some others, have now been offered to applicants.

Ten delegates from developing countries received travel grants from SCOR to the IABO General Assembly, i.e.:

1. Sanna Durgappa (India)
2. Girish Beedessee (Mauritius)
3. Mhairi Alexander (South Africa)
4. Fernando A. Zapata (Colombia)
5. Joel Kareithi Gatagwu (Kenya)
6. Olesia S. Vishchuk (Russia)
7. Hoang Dinh Chieu (Vietnam)
8. Junior Vitor (Peru)
9. Nadeem Nazurally (Mauritius)
10. Tammy (Tamara) Robinson (South Africa)

The **4th WCMB** will be held in Montreal in May 2018 (Table 1).

Table 1. Statistics on the WCMB.

	Location	Dates	Delegates	Talks	Posters
1st	Valencia, Spain	11-15 November 2008	600	200	160
2nd	Aberdeen, Scotland	26-30 September 2011	800	500	400
3rd	Qingdao, China	12-16 October 2014	480	154	89
4th	Montreal, Canada	May 2018			

Keynote talks at the IABO GA and 3rd WCMB
A recurring theme in many of the keynote presentations was the value and insights from collaborative international research:

- Angelika Brandt described exciting discoveries of deep-sea diversity and productivity in the Kurile Kamchatka Trench by joint German and Russian cruises.
- Suchana Apple Chavanich reviewed the state of marine biodiversity in the Western Pacific (SE Asia) following disturbances ranging from over-fishing to tsunami, and how new international scientific programmes are leading research in the region.
- Sun Song described the factors influencing how jellyfish blooms near Qingdao may provide a template for how such blooms occur elsewhere in the world.
- Graham Edgar summarised some of the analyses from a replicated global survey of over 2,400 sites through collaboration with citizen scientists in the Reef Life Survey programme
- Emmett Duffy introduced approaches to develop methods for monitoring ecological interactions that can be replicated globally.
- Mark Costello illustrated insights from using global species databases to see trends in taxonomic discovery and biogeographic patterns in species richness, including latitudinal gradients, involving over 65,000 species.
- John Gunn presented recent efforts to define “essential ocean variables” that could be a basis for monitoring trends in the oceans at global scales, and the need for a top-down approach to their definition.

The first keynote speaker and President of IUBS, Nils Stenseth, was unable to attend due to illness.

A call for **new committee members** resulted in 6 new members. Thus the present committee (with country and affiliations) of

- David Paterson (Scotland, convenor WCMB II)
- Patricia Miloslavich (Venezuela)
- Annelies Pierrot (Past-President, Netherlands);
- Michael Thorndyke (Sweden)
- Sun Song (China, convenor WCMB III, SCOR Vice-chair)
- Mark Costello (President, New Zealand, WoRMS, GEO BON)

are joined by

- Eulogio Soto (Chile)
- Tina Molodtsova (Russia)
- Isabel Sousa Pinto (Portugal) (IPBES, GEO BON)
- Suchana Apple Chavanich (Thailand, IOC/WESTPAC)
- Prof Siew Phang Moi (Malaysia)
- Philippe Archambault (Canada, 4th WCMB convenor)

Other activities

The committee and the President of IUBS published a joint paper calling for greater coordination within the marine biodiversity community:

> Costello, M. J., Archambault, P., Chavanich, S., Miloslavich, P., Paterson, D. M., Phang, S. M., Sousa Pinto I., Pierrot-Bults A., Song S., Soto E.H., Stenseth N.C., Molodtsova T.N., Thorndyke, M. 2015. Organizing, supporting and linking the world marine biodiversity research community. *Journal of the Marine Biological Association of the United Kingdom*, 95(3), 431–433.

ICSU
IABO's nomination, Dr Annelies Pierrot, was selected to the ICSU ad hoc panel for the review of SCAR and SCOR.

IABO Email list
IABO has an email list with ca. 1,000 subscribers. It welcomes SCOR Working Groups and associated organisations to subscribe and send out news of new positions available, meetings, publications and questions to subscribers.

- MARINE-B, the MArine Research Information NEtwork on Biodiversity
- official email network of the International Association for Biological Oceanography www.iabo.org
- for communication related to marine biodiversity research
- Archived at https://listserv.heanet.ie/marine-b.html
- to join send message "SUBSCRIBE MARINE-B firstname surname" to listserv@listserv.heanet.ie

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

The International Association of Meteorology and Atmospheric Sciences 2015 Report to SCOR
(www.IAMAS.org)

IAMAS is one of the eight associations dealing with the Earth system and its environs that make up the International Union of Geodesy and Geophysics (IUGG). The scope of IAMAS includes the atmospheres of the Earth and other planets. IAMAS is made up of ten international commissions and one committee that play a major role in implementing IAMAS activities. The ten commissions cover *Atmospheric Chemistry and Global Pollution* (ICACGP), *Atmospheric Electricity* (ICAE), *Climate* (ICCL), *Clouds and Precipitation* (ICCP), *Dynamical Meteorology* (ICDM), the *Middle Atmosphere* (ICMA), stratospheric *Ozone* (IOC), *Planetary Atmospheres and their Evolution* (ICPAE), *Polar Meteorology* (ICPM), and atmospheric *Radiation* (IRC). The *Committee on Nucleation and Atmospheric Aerosols* (CNAA) brings together scientists covering the areas of Nucleation Theory and Experiment, Tropospheric and stratospheric aerosols, Cloud Drop and Ice Nucleation and Aerosol-Climate Interactions.

Many of these commissions play international leadership roles in their specialist areas [see www.iamas.org/Commissions.html]. The commissions provide an important supplement and extension to the leadership and research role of the *World Meteorological Organization* (WMO), which is the governmental body with a comparable scientific scope to IAMAS.

a) The IAMAS Bureau and members played an active part in the planning for the 26th IUGG Assembly, which was held in Prague, Czech Republic over 22 June to 2 July 2015. The meeting was a great success with over 4,300 participants taking part, of which around 550 were associated with IAMAS. There were more than 5,300 presentations given in 202 symposia.

b) Two meetings of the IAMAS Executive were held in Prague during the IUGG Assembly, and many of the IAMAS commissions also organized business meetings. A new Bureau of IAMAS was elected for 2015 - 2019 consisting of John Turner, UK (President), Joyce Penner, USA (Vice President), Laura Gallardo, Chile (Vice President), Teruyuki Nakajima, Japan (Secretary General), Peter Pilewski, USA (Deputy Secretary General). In addition, five Members-at-Large were elected - Lisa Alexander (Australia), Keith Alverson (USA/Kenya), Iracema Cavalcanti (Brazil), Daren Lu (China), and Colin Price (Israel).

c) The IAMAS Early Career Scientist Medal is presented every two years to an early career scientist working in any area of the atmospheric sciences who has carried out excellent scientific research and who has the potential to make a significant contribution in the future. The 2015 medal

was awarded to Dr. Yuan Wang of JPL, USA for “his seminal contributions in elucidating the role of natural and man-derived atmospheric particles in air quality, atmospheric dynamics and climate”. The medal was presented to Dr. Wang at the second meeting of the IAMAS Executive.

d) Planning is underway for the IAPSO/IAMAS/IAGA assembly, which will be held in Cape Town, South Africa over 27 August – 1 September 2017. A conference web site is now available at http://www.iapso-iamas-iaga2017.com and a call is out for possible symposia.

e) Some recent IAMAS activities have been:

- A meeting of the IAMAS Bureau, 17 – 18 July 2014 in Munich, Germany.
- High Latitude Dynamics workshop (ICDM and ICPM), 23-27 March 2015, Rosendal, Norway
- Atmospheric Composition and the Asian Monsoon workshop (ICACGP and ICDM), 8-10 June 2015, Bangkok, Thailand
- Conference on Sun-Climate Connections (ICMA), 16-19 March 2015, Kiel, Germany
- 13th Solar-Terrestrial Physics symposium, SCOSTEP, 12-17 October 2014, Xi'An, China
- 13th quadrennial ICACGP symposium, 22-26 Sep. 2014, Natal, Brazil
- 15th ICAE conference, 14-19 June 2014, Norman, OK, USA
- Global data for solar - terrestrial variability studies, SCOSTEP, 28-30 Sep. 2015, Tokyo, Japan

f) IAMAS periodically issues an Information Email to the IAMAS community. Up to July 2015 these were edited by Assistant Secretary General Jenny Lin, but since that time this responsibility has been taken over by the new Assistant Secretary General Yoshi Sasaki. Past Information Emails can be accessed via http://www.iamas.org/NewsLetters/

For more information on IAMAS please contact :

John Turner, President (jtu@bas.ac.uk)
Teruyuki Nakajima, Secretary General (nakajima.teruyuki@jaxa.jp)

Submitted by John Turner, IUGG/IAMAS representative to SCOR
[23 October 2015]

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

Smythe-Wright

IAPSO Report to SCOR in 2015

Introduction

IAPSO has the prime goal of "promoting the study of scientific problems relating to the oceans and the interactions taking places at the sea floor, coastal, and atmospheric boundaries insofar as such research is conducted by the use of mathematics, physics, and chemistry." IAPSO works mainly through 1) biennial scientific assemblies; 2) working groups; 3) commissions; 4) services and 5) website information. Of special importance to IAPSO is to involve scientists and students from developing countries in the oceanographic activities.

IAPSO maintains formal liaison with other scientific commissions and committees. These include the ICSU's Scientific Committee on Oceanic Research (SCOR), and UNESCO's Intergovernmental Oceanographic Commission (IOC). For more information see http://iapso.iugg.org/.

Administration

The IAPSO office has been situated at Gothenburg University, Sweden until June 2015, and the day-to-day business has been managed by the Secretary General (SG) Johan Rodhe, Sweden. In July 2015 the IAPSO office moved to the Institute of Marine Science of the National Research Council of Italy, Trieste and since then the day-to-day business has been managed by the newly elected SG, Stefania Sparnocchia.

The new Bureau of IAPSO comprises the President, Denise Smythe-Wright, the Past President, Eugene Morozov, the SG, Stefania Sparnocchia and the Treasurer, Ken Ridgway. The SG is responsible for the IAPSO website and in July 2015, a new IAPSO page was created in the Facebook social network, with the aim of facilitating the spreading of information in the community (see https://www.facebook.com/iapso.iugg.org).

In 2015, there were four IAPSO business meetings and meeting of the EC during the IUGG General Assembly in Prague. Other IAPSO discussions were maintained by means of e-mail communication.

Activities

The IUGG General Assembly in Prague, was held from 22 June - 2 July 2015. The meeting was characterized by the central theme: “Earth and Environmental Sciences for Future Generation”. The Assembly attracted over 4,200 participants from 90 countries covering all five inhabited continents. Almost 5,400 contributions out of more than 5,700 submissions were presented (more than 2,200 as posters) in a total of 202 symposia and workshops, divided into 639 sessions. IAPSO contributed to the 26th IUGG General Assembly 2015 by organizing 13 IAPSO-only symposia and 11 interdisciplinary symposia. 345 scientists registered as IAPSO participants, with 446 oral or poster presentations.

The next Scientific meeting will be the IAPSO-IAMAS-IAGA Joint Assembly in Cape Town, South Africa, from 27 August - 1 September 2017. A first meeting for planning was held in Prague, involving IAPSO, IAMAS and IAGA officers. Information about the conference at http://www.iapso-iamas-iaga2017.com/.

President Eugene Morozov and Secretary General Johan Rodhe participated in the SCOR General Meeting in Bremen, Germany, on 15-18 September 2014. One important issue during the meeting was the decision about which working groups to fund.

Working groups

IAPSO has co-funded with SCOR several working groups that have produced important books and/or special journal issues. Detailed information about SCOR activity and WGs is on the IAPSO webpage. The following WG started in 2014 and is continuing its activity:
SCOR/IAPSO Working Group 145 "Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)", co-chaired by D. Turner, S. Clegg and S. Sander.

IAPSO Commissions and Services:

- Commission on Mean Sea Level and Tides (CMSLT), President: Gary T. Mitchum. Website: www.psmsl.org/
- Tsunami Commission (Joint with IASPEI and IVACEI). Chair: Dr. Vasily V. Titov. Website: www.iaspei.org/commissions/JCT.html
- GeoRisk Commission (Joint with IAMAS, IAHS, IASPEI and IAVCEI). Website: www.iugg-georisk.org/
- Permanent Service for Mean Sea Level, hosted by Proudman Oceanographic Laboratory, UK. Contact: Dr. Lesley Rickards. Website: www. www.psmsl.org/
- IAPSO Standard Seawater Service, hosted by OSIL, Havant, Hampshire, UK. Director: Paul, Ridout; Website Website www.osil.co.uk
- The working groups, commissions and services report to IAPSO. These reports are posted on the IAPSO website http://iapso.iugg.org/working-groups

Prince Albert I Medal

IAPSO and the Monaco Royal Family established the Prince Albert I Medal for excellence in physical and/or chemical oceanography. The winner is selected every two years and the ceremony is held during the Assemblies. Emeritus Professor Toshio Yamagata from University of Tokyo and Director of Application Laboratory, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), was awarded the medal in 2015 for "his ground-breaking work and exceptional contribution to our understanding of El Niño/Southern Oscillation and the newly discovered Indian Ocean Dipole". The Award ceremony took place on June 29 at IUGG 2015 in Prague, during which Prof. Yamagata gave the Albert I Memorial Lecture.

Eugene LaFond Medal

This Medal, created in honour of Eugene LaFond who was a former SG of IAPSO, is awarded to a scientist from a developing country for an oral or poster presented at an IAPSO Assembly. IAPSO forms a special commission to select the winner. In 2015, the medal was awarded to Dr. Sana Ben Ismail from Tunisia for her oral presentation "Surface circulation features along the

Tunisian coast (central Mediterranean sea): the Atlantic Tunisian current", delivered within the IAPSO symposium "Physics and Biogeochemistry of Semi-Enclosed and Shelf Seas" during the IUGG 2015 General Assembly.

Members of IAPSO Executive Committee (EC) for 2015-2019:
President: Dr Denise Smythe-Wright (UK); Secretary General: Dr Stefania Sparnocchia (Italy); Past President: Dr Eugene Morozov (Russia); Treasurer: M.App.Sc. Ken Ridgway (Australia); Vice Presidents: Dr Isabelle Ansorge (South Africa); Dr Trevor McDougall (Australia); EC Members: Dr Agatha de Boer (Sweden), Prof Toshiyuki Hibiya (Japan), Dr Christa von Hildebrandt-Andrade (USA and Puerto Rico), Dr Chris Meinen (USA), Dr Satheesh Chandra Shenoi (India), Dr Hans van Haren (The Netherlands).

Denise Smythe-Wright
IAPSO President

Stefania Sparnocchia
IAPSO Secretary General

1 September 2015

7.3 Affiliated Programs

SCOR-Affiliated Projects and Programs

SCOR sponsors many, but not all, of the major international ocean research projects and programs. Some projects not co-sponsored by SCOR can gain benefits from association with SCOR, such as (1) increased visibility; (2) participation in SCOR activities, such as project coordination meetings and annual SCOR meetings; (3) opportunities to provide comments on working group proposals and membership; (4) access to national SCOR contacts; and (5) opportunities to apply for SCOR funding for travel of scientists from developing countries and countries with economies in transition to their workshops and symposia. In 1995, SCOR developed the option of formal affiliation of relevant projects/programs with SCOR. Unlike projects sponsored by SCOR, affiliated projects and programs receive funding from organizations besides SCOR and do not need staff support from SCOR.

SCOR's role in relation to affiliated projects and programs is one of advice and regular review. SCOR gives advice about appropriate balances on the projects' steering committees and adequate rotations of these committees to renew the committees' memberships regularly. SCOR's national contacts can be used to find new members in regions where there is a need, or to entrain new countries into projects. SCOR can also provide an independent mechanism for the review of planning documents such as science or implementation plans.

Application for SCOR Affiliation

Application to SCOR for program affiliation should be initiated with a proposal of 2 to 5 pages, sent to SCOR at least three months before an annual SCOR meeting. The proposal should include an outline of the program's science plan, the terms of reference, current membership of the steering committee, and rotation procedures and schedule. The proposal for SCOR affiliation should also address the following criteria, accepted at the 1995 SCOR Executive Committee meeting (see *1995 SCOR Proceedings*). The Executive Committee agreed that in order to become a SCOR-affiliated project/program, an activity must

- be truly international, with a committee membership that rotates on a regular basis;
- show evidence of existing financial and/or organizational support;
- demonstrate a benefit from SCOR affiliation;
- have a scientifically well-integrated theme;
- show that it is in SCOR's interests to establish this affiliation;
- be of broad scale and global importance;
- show, as appropriate, that any scheme of membership dues includes some nominal level so as to encourage the widest possible international participation by all countries; and
- be willing to adhere to the SCOR Publication Policy.

After a program is affiliated with SCOR, annual reports are required, and scientific presentations may be requested at any annual SCOR meeting, as a basis for the decision on continuing the relationship between SCOR and each project/program. The Chair of each affiliated

project/program serves as an ex-officio member of SCOR as a Scientific Rapporteur (see SCOR Constitution, paragraph 4). Continued affiliation with SCOR depends on the project meeting the guidelines specified above, and maintaining high scientific quality and adequate rotations of committee members and chairs.

Reports to SCOR
Annual reports to SCOR should answer the following questions and present any additional information that the project/program would like to transmit to SCOR:

- What scientific accomplishments have been achieved by the project/program in the past year?
- How has the project's steering committee membership changed in the past year?
- What is the financial status of the project?
- What is the status of the project's secretariat?
- What are the plans for the scientific development and implementation of the project over the next two to three years?
- How is the project interacting with and contributing to other SCOR activities?

In addition, projects/programs should communicate regularly with their SCOR Executive Committee Reporter regarding their activities and progress.

7.3.1 InterRidge - International Ridge Studies (affiliated in 1996) *Urban*

2015 InterRidge Update for SCOR

The InterRidge (IR) programme office is now in its last year at Peking University, Beijing, China. It is led by John Chen (IR Chair, marine geophysics) and Jiabiao Li(IR Co-Chair, marine geology). The Office Co-ordinator is Zengxi Ge, whose background is geophysics.

Individual IR membership is ~2,900, with about one hundred new members in 2015. The bi-weekly "interridge-mail" e-news is received by ~1,400 IR members.

InterRidge (http://www.interridge.org) promotes interdisciplinary, international studies of oceanic spreading centres by creating a global research community, planning and coordinating new science programmes that no single nation can achieve alone, exchanging scientific information, and sharing new technologies and facilities. InterRidge is also dedicated to reaching out to the public, scientists and governments, and to providing a unified voice for ocean ridge researchers worldwide. An increasing role for InterRidge is our involvement in compiling information and advice for policy makers. This includes meetings and workshops where protocols for codes of scientific conduct for studying chemosynthetic environments, and identifying sites of special scientific interest, are proposed and discussed. InterRidge also has formal links with the United Nations Environment Programme and informal links with the

Integrated Ocean Drilling program and the International Seabed Authority.

Reform of InterRidge in 2014
A reform plan for the new structure of the InterRidge membership fees and privileges of each member country was adopted at the 2014 InterRidge Steering Committee in Beijing, China on 27-28 September 2014.

Twenty-two years after its birth in 1992, InterRidge has continued to evolve based on the principle of collaboration. It is an international organization that pools the resources of its member countries to coordinate oceanic ridge research in a way that is cost-effective, cooperative and proven to be successful. InterRidge is supported by its member countries via membership fees that supports the InterRidge Office and various InterRidge initiatives and activities. Please visit http://www.interridge.org/reform for details.

Working Groups are the principal mechanism for achieving the InterRidge programme, their main function being to identify new areas of high-priority scientific research. Each Working Group has clear goals and a timescale in which to achieve them (approx. 5 years). InterRidge supports those scientific projects which would benefit from IR coordination by convening group meetings, community-wide workshops, symposia and theoretical institutes. The resulting reports represent a synthesis of international and interdisciplinary efforts to define scientific questions and a methodology of addressing them. There are currently four active IR Working Groups in 2015, including a new working group starting in 2015.

New working Group: Ecological Connectivity and Resilience
(Chairs: Anna Metaxas (Dalhousie University, Canada) and Lauren Mullineaux (Woods Hole Oceanographic Institution, USA)).

The ecological connectivity of vent communities, and their resilience in the face of disturbance, has been a hot topic of research ever since their discovery. Of late, this topic has become particularly timely and societally relevant as plans for deep-sea mining progress toward implementation. It is also directly relevant to management decisions under consideration for recently designated deep Marine Protected Areas (MPAs), such as those on the Endeavour Segment, in the Marianas region, on the mid-Atlantic Ridge off the Azores, and in the Guaymas Basin and Eastern Pacific Rise. These topics were also identified in InterRidge's third decadal plan.

2nd InterRidge International Workshop Circum-Antarctic Ridge
The 2nd InterRidge International Workshop on Circum-Antarctic Ridges will be held at the Korea Polar Research Institute (KOPRI) in Songdo, Incheon, Republic of Korea during October 12-15, 2015. The conveners are

Sung-Hyun Park (Korea Polar Research Institute)
Seung-Sep Kim (Chungnam National University, Korea)
Anne Briais (University of Toulouse, France)
Jian Lin (Woods Hole Oceanographic Institution, USA)

Charles Langmuir (Harvard University, USA)
Nobukazu Seama (Kobe University, Japan)
Chunhui Tao (Second Institute of Oceanography, China)
Please visit https://ircar.kopri.re.kr/ for more information

The third InterRidge Theoretical Institute will be held in Hangzhou, China on 25-27 September 2015

The Third InterRidge Theoretical Institute on "Magmatic and Tectonic Processes and Seabed Resources at Mid-Ocean Ridges" is going to be organized by the InterRidge Office to take place in Hangzhou, China on 25-27 September 2015. The theoretical institute will focus on the first two themes of "the InterRidge Third Decadal Plan" (www.interridge.org) and the following co-conveners will lead the scientific programs of the theoretical institute.

Theme One: Magmatic and Tectonic Processes
Dr. Jian Lin (USA), Co-Conveners
Dr. Marcia Maia (France), Co-Conveners
Dr. Nobukazu Seama (Japan), Co-Conveners

Theme Two: Seabed Resources
Dr. Jiabiao Li (China), Co-Conveners
Dr. Sergei Silantyev (Russia), Co-Conveners
Dr. Jérôme Dyment (France), Co-Conveners

Scientists from China, France, United Kingdom, Japan, Korea, Germany, Canada, Portugal and India will participate this main event.

The InterRidge Vents database has update to a Version 3.3.

Version 3.3 is the present live site hosted by InterRidge China. Version 3.3 launched on 26 May 2015 with two structural changes to the content type "vent field":

1) we added an rdf:type to match to http://dbpedia.org/resource/Hydrothermal_vent, and
2) we added a database record field to link to the Smithsonian Institution Global Volcanism Program volcano profile for those vent fields that are sub-features of these identified volcanic features.

Please visit http://vents-data.interridge.org/about_the_database for updates.

Other InterRidge Office activities in 2015

In 2015, we plan to award 3 Fellowship to early-career scientists. All Fellowships are designed to encourage international collaboration on an aspect of ridge-crest science.

InterRidge continued its new Cruise Travel Bursary scheme. This has enabled two early career scientists to make new collaborations with established scientists, with InterRidge paying their

travel and hotel costs. Details at: http://www.interridge.org/bursary/list

For more information about IR's activities and national updates, please visit the IR website (http://www.interridge.org) and recent newsletters (http://www.interridge.org/IRNewsletter).

7.3.2 International Ocean Colour Coordinating Group (IOCCG) (Affiliated in 1997)

Sun Song

IOCCG Annual Report to SCOR

By Venetia Stuart (IOCCG Project Coordinator)

Reporting Period: July 2014 – August 2015

The International Ocean-Colour Co-ordinating Group (IOCCG) is an Affiliated Program of SCOR, and was established in 1996 to promote communication and co-operation between the space agencies and the ocean-colour user community. The IOCCG has a wide-ranging mandate addressing technological and scientific issues through its scientific working groups and task forces, conducting intensive training courses in developing and developed countries, and helping to ensure continuity of the ocean-colour data stream though the CEOS Ocean Colour Radiometry-Virtual Constellation (OCR-VC). This year the IOCCG also hosted the very successful second International Ocean Colour Science (IOCS) meeting in San Francisco (15-18 June 2015). SCOR has been instrumental in helping the IOCCG secure funding from NASA to host the IOCS meeting and carry out the ongoing activities of the group. Further details about all IOCCG activities are given below. The group is currently chaired by Stewart Bernard (CSIR, South Africa), and the IOCCG Project Office is located at the Bedford Institute of Oceanography, Canada, staffed by Project Coordinator, Venetia Stuart.

1. IOCCG Scientific Working Groups

IOCCG scientific working groups are relatively short-lived (2-4 years) and investigate various aspects of ocean-colour radiometry and its applications, generally publishing an IOCCG report on the topic. Over the past year, two IOCCG reports were prepared for publication, one new IOCCG working group was established, and four IOCCG working groups are in various stages of deliberation, as follows:

1.1 Newly Published Reports from IOCCG Working Groups

- **Phytoplankton Functional Types from Space,** IOCCG Report 15 (2014), edited by Shubha Sathyendranath (PML, UK). This report provides an overview of Phytoplankton Functional Types (PFTs) and examines the advantages and limitations of various methods used to detect PFTs from space, along with suggestions for further development (see www.ioccg.org/reports/IOCCG_Report_15_2014.pdf).
- **Ocean Colour Remote sensing in Polar Seas**, IOCCG Report 16 (2015 - in press), edited by Marcel Babin (U. Laval, Canada), Kevin Arrigo (Stanford U., USA) and Simon Bélanger, (U. Québec, Canada). This report highlights some of the difficulties encountered

in using satellite remote sensing in polar seas and proposes new approaches and concepts for studying Polar Regions using ocean colour remote sensing.

1.2 Newly Established IOCCG Working Group

- **Ocean Colour Applications for Biogeochemical, Ecosystem and Climate Modeling** (Chaired by Stephanie Dutkiewicz, MIT, USA). The goal of this WG is to facilitate a better dialogue between numerical modellers and ocean colour specialists. The group aims to synthesize current uses of ocean colour products and will prepare a document that can be used by both communities to address common questions and lay out recommendations for continued and better use of ocean colour products in the future.

1.3 On-going IOCCG Working Groups

- **Joint GEOHAB/IOCCG WG on Harmful Algal Blooms** (Chair: Stewart Bernard, CSIR, South Africa). This is a joint working group between the IOCCG and GEOHAB program of IOC-SCOR, the main goal of which is to provide a resource to improve communication between the satellite ocean colour community and the *in situ* HAB scientific community. An IOCCG report on this topic should be published by the end of next year.
- **Uncertainties in Ocean Colour Remote Sensing** (Chair: Roland Doerffer, GKSS, Germany). This group will address the various sources of uncertainty in ocean-colour applications and will outline procedures on how best to determine the uncertainties, and develop methods to routinely distribute the information.
- **Intercomparison of Atmospheric Correction Algorithms Over Optically-Complex Waters** (Cédric Jamet, Wimereux, France). This group is comparing and evaluating atmospheric correction algorithms over optically-complex waters to understand retrieval differences. They will provide recommendations for improving and selecting the optimal atmospheric correction scheme for various water types, along with the range of validity and limitations of each algorithm.
- **Earth Observations in Support of Global Water Quality Monitoring** (Chairs: Arnold Dekker, CSIRO, Australia; Paul DiGiacomo, NOAA/NESDIS; Steven Greb, Wisconsin Depart. Natural Resources, USA). This WG was established to help develop a strategic plan for incorporation of Earth observation information into coastal and inland water quality monitoring efforts. To date, management agencies have been slow to embrace satellite-derived measurements, even though important parameters such as chlorophyll, suspended solids, light attenuation, and coloured dissolved organic matter have been quantified with required accuracies.

2.0 International Ocean Colour Science (IOCS) Meeting

Because of the excellent feedback from the first IOCS meeting held in Germany (2013), as well as the synergy achieved with the various international space agencies working towards common goals, the IOCCG decided to convene a second IOCS meeting, which took place in San Francisco, USA (15-18 June 2015). NASA and NOAA were the primary sponsors of the meeting, with additional sponsorship being obtained from ESA, EUMETSAT, CNES, SCOR and the Gordon & Betty Moore Foundation. SCOR sponsored four students from developing countries to attend the meeting, which is gratefully acknowledged. The IOCS meeting helped to bring together both the

users (research scientists) and providers (space agencies) of ocean colour data to collectively address common issues and goals, and also to provide a forum (breakout sessions) for discussion of new concepts and techniques. A total of 260 scientists from 29 different countries participated in the four-day meeting, including representatives from space agencies with an interest in ocean-colour radiometry.

The format of IOCS-2015 included seven invited keynote talks, eleven space agency presentations, ten breakout splinter sessions on a wide range of topics, two poster sessions, the NASA Ocean Color Research Team (OCRT) meeting, a SeaDAS/BEAM workshop as well as a plenary panel discussion. The full meeting agenda plus all the poster abstracts can be accessed via the IOCS website at iocs.ioccg.org/. All presentations given during the meeting can be viewed at iocs.ioccg.org/program/iocs-2015-presentations/.

3.0 Capacity Building

IOCCG conducted the highly successful second Summer Lecture Series at the Laboratoire d'Océanographie de Villefranche (France) from 21 July to 2 August 2014. The training course was dedicated to high-level training in bio-optics and ocean colour, and focussed specifically on current critical issues in ocean colour science. A total of 23 students from 16 different countries were selected to attend the course, out of an overwhelming 140 mostly excellent applications. SCOR sponsored three students (two from Brazil and one from Vietnam), which is greatly appreciated. Twelve prominent scientists delivered a comprehensive program including lectures, discussions and hands-on tutorials. Because of the high demand for the course, all lectures were video recorded and can be downloaded from the IOCCG website at video.upmc.fr/differe.php?collec=S_ioccg_villefranche_2014&video=khgfdf. The IOCCG is considering hosting another Summer Lecture Series in July 2016, although plans have not yet been finalised.

4.0 Project Management and Coordination

The IOCCG Committee meets once a year to coordinate the activities of the group as a whole and review the progress of the various working groups. They also discuss plans for the year ahead, and the Executive Committee approves a budget for the coming year. The IOCCG-20 Committee meeting took place in Paris, France (3-5 March 2015, see minutes at www.ioccg.org/reports/Minutes-20-FINAL.pdf). The 21st IOCCG Committee meeting is planned for 1-3 March 2016 in Santa Monica, California, USA.

5.0 IOCCG Membership (2015)

The IOCCG Committee consists of members drawn from space agencies as well as the scientific ocean-colour community. Rotation of members is being implemented according to a roster: the five members marked with an asterisk (*) are new members for 2015. The IOCCG Executive Committee consists of representatives from the sponsoring agencies.

Antoine, David (Past-Chair)	-	Curtin University, Australia
Bélanger, Simon	-	Université du Québec à Rimouski, Canada

Bergeron, Martin*	-	Canadian Space Agency, Canada
Bernard, Stewart (Chairman)	-	University of Cape Town, South Africa
Bontempi, Paula	-	NASA HQ, USA
Boss, Emmanuel	-	University of Maine, USA
Chauhan, Prakash	-	ISRO, India
Dierssen, Heidi	-	University of Connecticut Avery Point, USA
DiGiacomo, Paul	-	NOAA, USA
Dowell, Mark	-	JRC, Italy
Dutkiewicz, Stephanie	-	Massachusetts Institute of Technology, USA
Escudier, Philippe*	-	CNES, France
Franz, Bryan*	-	NASA GSFC, USA
Hardman-Mountford, Nick	-	CSIRO, Perth, Australia
He, Xianqiang*	-	Second Institute of Oceanography, China
Hirata, Taka	-	Hokkaido University, Japan
Kampel, Milton	-	INPE, Brazil
Kwiatkowska, Ewa	-	EUMETSAT, EU, Germany
Loisel, Hubert*	-	Université du Littoral, France
Murakami, Hiroshi	-	JAXA EORC, Japan
Park, Youngje	-	KIOST, Korea
Regner, Peter	-	ESA/ESRIN, Italy
Ryu, Joo-Hyung	-	KIOST, Korea
Tyler, Andrew	-	University of Stirling, UK
Wiafe, George	-	University of Ghana, Ghana
Wilson, Cara	-	NOAA / NMFS, USA
Yoder, James	-	Woods Hole Oceanographic Institution, USA
Zibordi, Giuseppe	-	Joint Research Centre, EU, Italy

6.0 IOCCG Sponsors

Activities of the IOCCG are supported by contributions from various national space agencies and other organisations (see www.ioccg.org/about/sponsor.html) and in-kind support (office space, informatics) from the Bedford Institute of Oceanography (Canada). SCOR provides infrastructure support for submitting proposals to NASA, and manages the NASA funds.

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

Global Alliance of CPR Surveys (GACS) – report of activities.

Sonia Batten, Chair of the Board of Governance
soba@sahfos.ac.uk
GACS@sahfos.ac.uk

Dr Graham Hosie stepped down as the Chair of the GACS Board of Governance after three years and following his retirement from the Australian Antarctic Division. I was pleased to take over the position and hope to build on the solid foundations set during the first few years of the Alliance.

The most recent annual meeting was held at the offices of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) in Plymouth in September 2015. With specific funding ending in 2014, the meeting was scheduled to take advantage of some members existing travel plans, as well as utilising technology to facilitate remote participation. The meeting reviewed GACS progress and set priorities for the upcoming year:

- Development of the GACS database was acknowledged to be slower than originally anticipated, owing for the most part to the high turnover rate of IT personnel – many surveys had seen key database staff move to new appointments – leading to inevitable delays as new staff are appointed and get up to speed. Probably most impacted by personnel movements has been SAHFOS itself, which houses the GACS database, so that progress in the last year has stalled. On a positive note, recruitment of new personnel has recently occurred here and a clear way forward was set at the annual meeting.
- The next Global Status Report is due to be produced in 2016, according to the planned two-year publication cycle, with an annual report highlighting more ad hoc results to be released each spring. Future Status Reports will rely on peer-reviewed, published results but time-scales are too long for this to be completed in time for the 2016 report, which will therefore be modelled on its predecessor.
- Training and capacity building has been a particular strength of GACS recently, with a workshop held at SAHFOS in September to provide CPR workshop training to survey members from Brazil and Australia. It was originally intended that participants from India would also attend but visa problems caused last minute changes to that plan. SAHFOS has agreed to host an additional training workshop for the Indian participants early in the new year so that the POGO funding can still be utilised. Exchange of personnel has also been very active with North Atlantic Survey members visiting the AusCPR and MedCPR surveys this autumn.
- As a consequence of both the training and taxonomy workshops held recently (see previous reports for more details) and through personnel exchanges the Standards and Methodologies Working Group (SMWG) achievements can be considered a significant highlight of the first few years of GACS. There is now a strong overall awareness of the methods used by the different surveys, where issues of comparability may complicate analyses, agreements on where methods can be improved or refined, and most

importantly, a large body of reference material for establishing surveys to draw on. The SMWG has now become a task team which will consider ad-hoc issues as they arise, including exploring technological advancements to automate protocols such as the Phytoplankton Colour Index, and investigating the mechanism and utility of recording microplastic variables in CPR samples.

- Conducting and publishing the first global analysis from the GACS database was seen as a major priority, and will focus initially on representative Essential Ocean Variables (EOVs) currently being discussed by the GOOS community. By bringing together the data from individual CPR surveys GACS offers the best opportunity for describing plankton community variability at quasi-global scales.

Interfacing with other programmes

The Executive Director of POGO, Dr Sophie Seeyave, attended the GACS meeting and presented information on the GEO Blue Planet program, which aims to facilitate interactions between observing activities, programmes and systems. The upcoming 3rd symposium in Monterey, September 2016 offers an opportunity to promote GACS and improve links to these other programmes.

The recently established GOOS Biology and Ecosystems Panel invited Dr Batten as the chair of GACS to participate as a panel member. The panel will use the experience of its members with sustained ocean biological and ecosystem observations to develop and identify relevant Essential Ocean Variables (EOVs). It is hoped that promotion of the EOVs and expanding successful observing systems will enable them to become part of a sustained, GOOS framework. The goals of GACS match very closely with the goals of the panel and our involvement should be mutually positive.

7.4 Other Organizations

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

Partnership for Observation of the Global Oceans (POGO)
Report to SCOR Annual General Meeting 2015

Introduction
POGO was established in 1999 by a group of directors of marine research institutions who met to discuss ways in which they could work together more effectively in support of global oceanography. As stated at the founding of POGO, the objective of POGO is to make a major contribution to the attainment of sustained in situ observations of the global ocean that meet the requirements of international research and operational programmes.

In the last fifteen years, POGO has established itself as a respected and credible voice for the marine science community. Members value POGO as a forum in which they can meet their peer-directors at least annually, in well-attended meetings, to discuss matters of common interest.

The POGO programme in capacity-building is universally admired; it receives substantial support from the Nippon Foundation. The pool of former scholars trained under Nippon Foundation-POGO initiatives have been integrated into a global network (NANO), which now has a biannual newsletter and five regional, collaborative research projects and one outreach project. Since 2011, POGO has taken a leadership role with GEO in the formulation of an oceans Task, "Oceans and Society: Blue Planet". On a broader scale, POGO has created an informal grouping, Oceans United, to allow many organisations to speak with a common voice on issues of relevance to oceans and society. POGO enjoys excellent working relations with all relevant partner organisations.

Collaboration with SCOR

SCOR is the leading international organisation in the marine science arena, and it is essential that POGO maintain good relations with it. We enjoy the highest level of cooperation with SCOR, especially with its Executive Director, Dr Ed Urban. For example:

- POGO funds jointly with SCOR a fellowship programme that enables young scientists from developing countries to study for up to three months in a major oceanographic institution chosen by the candidate. The programme is managed by POGO. Candidates are selected by a committee in which both POGO and SCOR are represented.
- SCOR also runs a Visiting Professorship modelled on the POGO one, and on several occasions the two programmes have complemented one another (for example, in Southern Africa).
- POGO and SCOR also collaborate in assessing capacity building at the world level in marine science and coordinate their respective capacity-building programmes. Together with partner organisations IOC/IODE, SCOR and POGO have created a website advertising summer schools and other training opportunities in ocean sciences (www.oceansummerschools.org).
- In 2015, SCOR and POGO Secretariats have been working on an impact evaluation questionnaire to send all past trainees of their respective and joint training programmes. They are planning on using the data obtained for joint publications on the POGO-SCOR fellowship and professorship programmes.
- SCOR has established jointly with POGO a new research initiative, the International Quiet Ocean Experiment (IQOE). This is a programme aimed at the acoustic background in the ocean, including its anthropogenic and natural components. The Science Plan was published in 2015. The Sloan Foundation was instrumental in starting up this initiative, and in providing seed funding for coordination.
- POGO contributed to the establishment, and continues to support the development, of the SCOR-SCAR Southern Ocean Observing System (SOOS).
- Both POGO and SCOR support the Global Alliance of Continuous Plankton Recorder Surveys (GACS).
- POGO has an interest in contributing to the activities planned under the International Indian Ocean Expedition 50th anniversary (IIOE-2), an initiative of SCOR and IOC.

Priorities for 2015

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

Deep-ocean observations (Leaders Uwe Send/ Pedro Velez/Alicia Lavin)
Mini-presentations were given by Pedro Vélez-Belchí (IEO), Mike Meredith (BAS), Tony Knap (GERG), Alicia Lavin (IEO) and Uwe Send (Scripps), on current and planned deep layer observing elements.

The group then addressed what POGO could do to underline the economic need for and impact of deep ocean observations. It also discussed how POGO could support existing initiatives and opportunities (promote, enhance, supplement, add to, fund…). Some ideas included

- Adding biogeochemical and ecosystem sensors
- Adding capability for benthic layer
- Coordinating/synergizing Go-Ship, deep Argo, deep OceanSITES
- Issuing a POGO Declaration.

Once POGO becomes a legal entity in Europe in can be part of funding proposals as a guarantee for quality. POGO itself cannot provide enough funding for a seed project, but can encourage its members to donate equipment, as was done for the OceanSites.

The DOOS document is a very comprehensive and solid statement of the need for deep observations, although POGO could make a contribution on the technology readiness levels. POGO could issue a Declaration similar to the Sao Paolo declaration, indicating the need to observe the deep ocean. Another idea would be to translate the DOOS strategy into a summary for policy makers.

Members would need a clear mandate to create a Working Group. For example, to produce a Declaration, an assessment of the technology readiness, or an overview paper focused on stake-holders.

POGO actions to follow up:

- Directors to discuss what they can and want to do
- POGO to assure deep coordination with new GOOS panels.

Ocean observations and Marine Protected Areas (Leaders Stefan Hain/Margaret Leinen)
The group discussed the following:

- Objectives of observations
- Communities involved in the observations
- Scales of areas

- Degree of consensus about strategies of observation and what kinds of measurements are allowed
- Technologies for observation.

It was agreed that the best way forward was probably to convene another Workshop at POGO-17 to educate the POGO community about the issues surrounding MPAs. We would need to invite external participants from the MPA community, e.g. from the Convention on Biological Diversity (CBD), and those who are involved in setting up MPAs.

Enhancing visibility of and access to long-term data (Leader Karen Wiltshire/Alex Kraberg)
The group briefly discussed the historical and emerging challenges surrounding time-series data:

- Diversity of data types (images, sequence information, numeric data)
- Increasing diversity of methodologies (technological advances are a blessing and a curse)
- Different methodologies
- Increasingly complex metadata
- Data access
- Potential lack of interoperability
- Still many geographic areas not represented sufficiently in ongoing data-collection efforts
- Considerable differences in visibility of time series
- Lack of inclusiveness.

All of these issues could potentially make large-scale comparisons difficult. They could also threaten the internal consistency of the time series.

The group agreed on issues that were either beyond or within the scope of POGO:

Beyond the scope of POGO activities (based on data):

- Support technical solutions to data integration repositories (e.g. new portal)
- Contributions to standardization efforts, metadata catalogues, standardization of vocabularies.

Within the scope of POGO (based on metadata only):

- Address lack of (and unevenness of) visibility of data and further data discovery
- Review data gaps and provide advice
- Produce guidelines on maintaining internal consistency

An unresolved issue was whether POGO should engage in time series-specific capacity building, e.g. combined ship/land-based training. This issue needs to be addressed as part of a more general discussion.

The agreed goal was to enable visualisation of global time-series data in a WebGIS (simple use case already established at AWI). This will facilitate data discovery without having to access the data themselves, and provide a description of time series, but leaving judgement on usability for purpose x,y,z to potential users. The broad mission is to capture existing, historic and emerging time series.

The first steps are to:

- Produce and circulate a concept with suggested data layers to be included
- Set up a small working group to organize work between meetings
- Collect simple metadata and parameter information for as many time series as possible
- Explore the use of Google tools for metadata visualisation (maps)
- Explore the use of DOI/handle for metadata summaries
- Can overlay base map with bathymetry (deep sea stations).

Possible layers could include:

- Duration
- Depth
- Parameters
- Networks
- Sensor types
- Sampling frequencies
- Links to data
- Regions

Possible links to Google were discussed, and ESRI was highlighted as having more scientifically-oriented tools than Google (e.g. WebGIS).

Engaging with industry: lessons learned, successes and failures (Leader Susan Avery)

Short presentations were given by:

- Sam Walker: BP, formerly NOAA
- Jim Bellingham: WHOI, formerly MBARI, co-founder of Blue Fin Robotics
- Len Srnka: Scripps, formerly Exxon, Professor of Practice
- Ken Lee: CSIRO, formerly DFO
- Steve de Mora: PML.

The group discussed the diverse benefits to industry and academia, such as:

- Training, research and development projects
- Solutions-oriented problems that are interdisciplinary

- Risk management, Operational and safety requirements, engineering integrity
- Ocean governance and policy – conflict avoidance.

The participants then discussed opportunities and barriers, such as:

- World Ocean Council (WOC), which has a large number of members
- Scientific community coordination: POGO
- IOGP – International Oil &Gas Partnerships – 40 years
- Joint Industry Partnerships (JIP – Arctic Response Technology; JIP – Sound and Marine Life (more opportunities here), hardware, making measurements
- Very few projects where Met Ocean data shared between companies
- IP, intellectual dividend, perspectives, cultures, training, business decision-making
- Talking at right levels from both sides, people with time to commit
- Lack of clarity about who to go to (and how?).

What works:

- Dialogue, WHOI, NOC, CSIRO, PML place and industry specific
- Trust, open, engage with business on home space.

Unintended or unanticipated consequences:

- Long-term project within changing business environment
- Conflict of interests, impacts on individuals
- Being drawn into litigation and associated cultural impacts.

Opportunity for POGO:

- Business advisory council for POGO – focus on advice on approaches
- Bridge to WOC
- POGO representation means industry will engage -- further advice can be taken
- Engage with industry associations.

As of 2015, POGO has started providing funding for Working Groups and new training initiatives proposed by its members. A call for proposals was issued in February 2015, and four proposals were successful:

- WG on Observing and Modeling the Meridional Overturning Circulation in the South Atlantic (SAMOC), led by Edmo Campos (Brazil).
- WG on Implementation of IQOE Science Recommendations on Marine Noise Exposure and Broad-Scale Acoustic Monitoring, led by Alexander Vedenev (Russia) and Peter Tyack (UK).

- International Training Course on ‘Emerging trends in Ocean Observations with special emphasis on Moored Buoys and Time series Data Analysis and Applications’ at INCOIS, India.
- Technical Training in Continuous Plankton Recorder Survey Operations at the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) –funding for participants from NIO, India.

8.0 ORGANIZATION AND FINANCE

8.1 Membership ***Urban***

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Report on Membership Changes Since 2014 General Meeting, **p. 8-1**

Member Nations and Nominated Members, **p. 8-2**

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8.2 Publications Arising from SCOR Activities, p. 8-4 ***Urban***

8.3 Finances, p. 8-5 ***Finance Committee, Urban***

8.0 ORGANIZATION AND FINANCE

8.1 Membership

8.1.1 National Committees

Report on Membership Changes Since 2014 SCOR General Meeting

AUSTRALIA	Peter Doherty has been added as a Nominated Member
CANADA	Bjorn Sundby has rotated off the Canadian SCOR committee and will be replaced at a later date
ITALY	Leonardo Langone has replaced Giuseppe Manzella
JAPAN	Toshio Yamagata, Kaoru Kubokawa, and Jing Zhang replaced Motoyoshi Ikeda, Satoru Taguchi, and Toshitaka Gamo
PAKISTAN	Nuzhat Khan has replaced Ali Rashid Tabrez
SWEDEN	Helén Andersson and Bengt Karlsson replaced Ingemar Cato and Agneta Andersson
USA	Robert Duce, Mary Feeley, and Dawn Wright replaced by E. Virginia Armbrust, Robert Hallberg, and David Halpern

8-2

Member Nations and Nominated Members

Australia	Trevor McDougall	John Volkman	
Belgium	J.C.J. Nihoul	François Ronday	
Brazil	José Maria Landim Dominguez	Mauricio M. Mata	Ilana Wainer
Canada	Robie Macdonald	**Paul Myers**	
Chile	Patricio Carrasco	Carmen Morales	Carlos A. Zuniga
China - Beijing	Hong Huasheng	Sun Song	
China - Taipei	Ben Chao	C.-F. Dai	**Shu-Kun Hsu**
Denmark	Birger Larsen	Torkel Gissel Nielsen	
Ecuador	Leonor Vera San Martin	Mario Hurtado	Francisco Medina
Finland	Riitta Autio	**Jorma Kuparinen**	Timo Vesala
France	Catherine Beltran	**Sabine Schmidt**	Marie-Alexandrine Sicre
Germany	Uli Bathmann	Colin Devey	Wolfgang Fennel
India	**M. Dileep Kumar**	Manish Tiwari	Satheesh C. Shenoi
Israel	**Yossi Loya**		
Italy	**Annalisa Griffa**	Leonardo Langone	
Japan	Kaoru Kubokawa	Toshio Yamagata	Jing Zhang
Korea	**Jung- Keuk Kang**	Kuh Kim	Sinjae Yoo
Mexico	**Elva Escobar**	Mario Martinez Garcia	Clara Morán
Netherlands	**Corina Brussaard**	Gerald Ganssen	Maria van Leeuwe
New Zealand	Julie Hall	Keith A. Hunter	
Norway	Dag Aksnes	**Peter Haugan**	
Pakistan	**Asif Inam**	Nuzhat Khan	Samina Kidwai
Poland (chair: **Marcin Plinski**)	Czeshaw Druet	Piotr Szefer	Jan M. Weslawski
Russia	Victor A. Akulichev	Sergey Dobrolubov	Sergey Shapovalov
South Africa	John Compton	Mike Lucas	Coleen Moloney
Spain	**Marta Estrada**	Alicia Lavín	Pere Masqué
Sweden	Helén Andersson	Bengt Karlsson	**Johan Rodhe**
Switzerland	Daniel Ariztegui	Karl Föllmi	Kurt Hanselmann
Turkey	Temel Oguz	Bilge Tutak	
United Kingdom	Peter Burkill	**Gideon Henderson**	Karen Heywood
United States	E. Virginia Armbrust	Robert Hallberg	David Halpern

Membership in the Scientific Committee on Oceanic Research (SCOR)

(available in English, Spanish, and French at http://www.scor-int.org/memnats.htm)

The Scientific Committee on Oceanic Research (SCOR) was founded in 1957 and is a component of the International Council for Science (ICSU). SCOR is the primary non-governmental organization for planning, promoting, and implementing international cooperative activities in oceanography. The international aspects of large ocean science programs such as the Joint Global Ocean Flux Study (JGOFS), the Global Ocean Ecosystem Dynamics (GLOBEC) project, the World Ocean Circulation Experiment (WOCE), and the study of Tropical Oceans and Global Atmosphere (TOGA) all had their origins in SCOR-sponsored groups. WOCE and TOGA became incorporated into the World Climate Research Programme (WCRP), and JGOFS and GLOBEC have been completed. On-going projects include the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project, the Surface Ocean – Lower Atmosphere Study (SOLAS), the GEOTRACES project on marine trace elements and isotopes, the International Quite Ocean Experiment (IQOE), and the second International Indian Ocean Experiment (IIOE-2).

For the past 31 years, SCOR has provided travel grants to scientific meetings for scientists from developing nations and nations with economies in transition. Hundreds of scientists have received full or partial travel support through this program, with support from the U.S. National Science Foundation. Several SCOR activities relate to scientific and environmental issues that are of special relevance to developing nations, such as harmful algal blooms, hypoxia, fisheries, etc.

Presently, 31 nations are members of SCOR, belonging to one of five membership categories. The only difference among the membership categories is the level of dues paid, with Category I nations paying US$2,370 in 2015 and Category V nations (Japan, Russia, and the United States) paying US$41,000. A nation's membership category is roughly based on its gross domestic product, and is also related to a nation's level of activity in ocean sciences. However, each nation determines its membership category and SCOR encourages nations to move to higher categories over time as they experience the benefits of membership.

Benefits

Membership in SCOR benefits nations in several ways. The advantages of membership in SCOR include the opportunity to comment on proposals for scientific activities as they develop, to assist in the formulation of international scientific priorities, and to encourage the involvement of a nation's scientists in these international efforts. The most tangible benefit is the increased exposure of a nation's scientists to international ocean science activities and the increased likelihood of participation in working groups and other SCOR activities. This is particularly important for nations that are still developing their ocean science capabilities and infrastructure. SCOR officers are elected from national SCOR committees. The alternating annual General

Meeting and Executive Committee meetings of SCOR are generally hosted by national SCOR committees. These meetings provide opportunities for host nations to present the science being conducted locally.

SCOR working groups provide another means of exposure for scientists from member nations to the worldwide oceanographic community. Nominations for working groups are sought from all national members and SCOR include members of working groups from developing nations. The SCOR budget for these activities includes travel funds for scientists selected to participate in them, so this should not be a burden on the nation that nominates working group members.

Member nations receive background material for all annual SCOR meetings and have an opportunity to provide comments in person or in writing regarding working group proposals, the composition of SCOR working groups and the scientific steering committees of major oceanographic programs, and other SCOR actions. Support for travel of a nation's Nominated Members to SCOR's annual meetings are the responsibility of the nation.

Obligations

The main requirement to apply for SCOR membership is the demonstration that some national mechanism exists, or could be created, to serve as a National Committee for SCOR. The National Committee should include representation from the various marine science disciplines and from the various types of institutions in a nation's marine science community. The National Committee should nominate three individual scientists to represent the nation's SCOR Committee as Nominated Members of SCOR. The national Nominated Members are responsible to serve as a liaison and channel of information between SCOR and the nation's ocean science community.

A formal application for membership can be presented and accepted at SCOR's annual meetings or between meetings. Requests should be sent to the SCOR Secretariat. Any request for membership should include a very brief overview of the status of oceanographic research in the applying nation, including a short description of the major institutions, scientific interest, and other relevant information.

8.2 Publications Arising from SCOR Activities

The following publications resulted from SCOR-sponsored activities (working groups and other activities) since the 2014 General Meeting. Please see project reports in Section 3 for more detailed lists. Each project maintains lists of their publications on their Web sites.

Cunliffe, M. and O. Wurl. 2014. *Guide to Best Practices to Study The Ocean's Surface* – WG 141

German, C.R., L.L. Legendre, S.G. Sander, N. Niquil, G.W. Luther III, L. Bharati, X. Han, and N. Le Bris. 2015. Hydrothermal Fe cycling and deep ocean organic carbon scavenging: Model-based evidence for significant POC supply to seafloor sediments. *Earth and Planetary Science Letters* 419:143-153. – WG 135

Hood, R.R., M. McPhaden, and E. Urban. 2014. New Indian Ocean Program Builds on a Scientific Legacy. *Eos, Transactions of the American Geophysical Union* 95:349-350.

Klais, R., J.E. Cloern and P.J. Harrison. 2015. Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems. *Estuarine, Coastal and Shelf Science* 162:1-160. Special issue from WG 137. See http://www.sciencedirect.com/science/journal/02727714/162.

Lohan, M.C., K.N. Buck, and S.G. Sander (eds.). 2015. Organic ligands – A key control on trace metal biogeochemistry in the oceans. *Marine Chemistry* 173 – Special issue from WG 139

Miller. L.A., F. Fripiat, B.G.T. Else, J.S. Bowman, K.A. Brown, R.E. Collins, M. Ewert, A. Fransson, M. Gosselin, D. Lannuzel, K.M. Meiners, C. Michel, J. Nishioka, D. Nomura, S. Papadimitriou, L.M. Russell, L.L. Sørensen, D.N. Thomas, J.-L. Tison, M.A. van Leeuwe, M. Vancoppenolle, E.W. Wolff, and J. Zhou. 2015. Methods for biogeochemical studies of sea ice: The state of the art, caveats, and recommendations. *Elementa: Science of the Anthropocene* DOI 10.12952/journal.elementa.000038 – WG 140

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

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

Reports on SCOR finances will be provided at the meeting.

9.0 SCOR-RELATED MEETINGS

9.1 SCOR Annual Meetings

9.1.1 2015 Executive Committee Meeting: Goa, India, **p. 9-1** *Burkill*

9.1.2 2016 General Meeting: Sopot, Poland, **p. 9-1** *Burkill*

9.1.3 2017 Executive Committee Meeting, **p. 9-1** *Burkill*

9.2 Locations of Past SCOR Annual Meetings, p. 9-1

9.3 SCOR-Related Meetings Since the 2013 SCOR Executive Committee Meeting and Planned for the Future, p. 9-2

9.0 SCOR-RELATED MEETINGS

9.1 SCOR Annual Meetings

9.1.1 2015 Executive Committee Meeting – Goa, India *Burkill*

The SCOR Executive Committee has accepted an invitation from the Indian SCOR Committee to hold the 2015 SCOR Executive Committee Meeting in India. The meeting will be held on 7-9 December, immediately after a symposium in Goa to celebrate the Golden Jubilee of the National Institute of Oceanography, the 50th Anniversary of the completion of the International Indian Ocean Expedition, and the launch of the Second International Indian Ocean Expedition.

9.1.2 2016 General Meeting – Sopot, Poland *Burkill*

The SCOR Executive Committee has accepted an invitation from the Polish SCOR Committee to hold the 2015 SCOR Executive Committee Meeting in Poland, at the Institute of Oceanology of the Polish Academy of Sciences.

9.1.3 2017 Executive Committee Meeting *Burkill*

SCOR welcomes offers from national SCOR committees to host the 2017 SCOR Executive Committee meeting.

9.2 Locations of Past SCOR Annual Meetings (bold = future meetings)

Member Nations	Place and Date
Argentina	Mar del Plata, 2001
Australia	Canberra, 1974; Hobart, 1986; Cairns, 2005
Belgium	
Brazil	Rio de Janeiro, 1997; Sao Paulo, 1978
Canada	Halifax, 1963, 1982, 2012; Victoria, 1977, 1994
Chile	Concepción, 2006
China-Beijing	Qingdao, 1993; Beijing, 2009
China-Taipei	
Denmark	Copenhagen, 1960, 1972
Ecuador	Guayaquil, 1974
Finland	Helsinki, 1960, 2011
France	Brest, 1978; Marseilles, 1965; Paris, 1958, 1961, 1962, 1963, 1969, 1983; Roscoff, 1984; Toulouse, 2010
Germany	Hamburg, 1964; Kiel, 1980; Warnemunde, 1967, 1990; Bremen, 2014
India	Goa, 1999; **2015**
Israel	Jerusalem, 1967
Italy	Rome, 1965, 1966; Venice, 2004
Japan	Sapporo, 2002; Tokyo, 1970
Mexico	Acapulco, 1988; Mexico City, 1969
Netherlands	Amsterdam, 1998; Texel, 1973

New Zealand	Hamilton, 1991; Wellington, 2013
Norway	Bergen, 2007
Pakistan	
Poland	**Sopot, 2016**
Russia	Moscow, 2003
South Africa	Stellenbosch, 1975; Cape Town, 1995
Spain	Madrid, 1971
Sweden	Fiskebackskil, 1981; Goteberg, 1969, 1992
Switzerland	Zurich, 1987
Turkey	
UK	Edinburgh, 1976; London, 1962, 1970; Oban (Scotland), 1972; Southampton, 1996
USA	La Jolla, 1968; New York, 1959; Seattle, 1965, 1985; Tallahassee, 1989; Washington, D.C., 2000; Woods Hole, 1957, 1980, 2008

9.3 SCOR-Related Meetings Since the 2014 SCOR Executive Committee Meeting and Planned for the Future

2014		
6-10 October	GEOTRACES SSC and DMC Meetings	Stellenbosch, South Africa
14-17 October	WG 141 on Sea-Surface Microlayers	Qingdao, China
3-7 November	WG 137 on Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation	Zhuhai, China

2015		
16-17 March	WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders	Brest, France
20 March	WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces	Lucca (Barga), Italy
7-11 April	WG 139 on Organic Ligands: A Key Control on Trace Metal Biogeochemistry in the Ocean	Sibenik,Croatia
12-13 April	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	Sibenik, Croatia
14-15 April	WG 147: Towards Comparability of Global Oceanic Nutrient Data (COMPONUT)	Vienna, Austria
7-10 June	SOOS Scientific Steering Committee and Associated Meetings	Hobart, Tasmania, Australia

8-10 June	IMBER Scientific Steering Committee Meeting	Santa Cruz, California, USA
13-17 July	GEOTRACES Data Management Committee and Scientific Steering Committee	Vancouver, British Columbia, Canada
15-17 July	WG 146 on Radioactivity in the Ocean, 5 Decades Later (RiO5)	Woods Hole, Massachusetts, USA
30 August - 3 September	WG 144 on Microbial Community Responses to Ocean Deoxygenation	Warnemunde, Germany
30 August-4 September	WG 138 on Planktonic foraminifera and ocean changes (with IGBP)	Catalina Island, California, USA
4 September	WG 143 on Dissolved N2O and CH4 measurements: Working towards a global network of ocean time series measurements of N2O and CH4	Kiel, Germany
7-11 September	SOLAS Open Science Conference	Kiel, Germany
12-13 September	SOLAS Scientific Steering Committee Meeting	Hamburg, Germany
16-18 September	Workshop on Seafloor Ecosystem Functions and their Role in Global Processes	Naples, Italy
26-30 October	IMBER IMBIZO IV	Trieste, Italy
30 November-4 December	NIO Golden Jubilee, Celebration of 50 Years of Indian Ocean Research Since Completion of IIOE, and Launch of IIOE-2	Goa, India
7-9 December	SCOR Executive Committee Meeting	Goa, India
2016		
19-21 February	IMBER Scientific Steering Committee Meeting	New Orleans, Louisiana, USA
27 February	WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders	New Orleans, Louisiana, USA
February	WG 141 on Sea-Surface Microlayers	New Orleans, Louisiana, USA
February	WG 145 on Chemical Speciation Modelling in Seawater to Meet 21st Century Needs (MARCHEMSPEC)	New Orleans, Louisiana, USA
16-18 March	WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII)	Paris, France

12-14 May	SOOS Scientific Steering Committee	La Jolla, California, USA
5-7 September	SCOR General Meeting	Sopot, Poland
12-16 September	GEOTRACES Data Management Committee and Scientific Steering Committee	Toulouse, France