4.0 INFRASTRUCTURAL AND OTHER ACTIVITIES

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.