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4.1 IOC/SCOR International Ocean Carbon Coordination Project *Telszewski, Halpern*

International Ocean Carbon Coordination Project Progress Report for SCOR, June 2017



Understanding and quantifying the role of ocean biogeochemical cycles in the global climate system requires efficient coordination of multi-platform observations of carbon and carbon-related biogeochemical variables, carried out on a myriad of spatial and temporal scales.

To this end, the International Ocean Carbon Coordination Program promotes the development of a global network of ocean carbon and biogeochemistry observations as part of a multidisciplinary global ocean observing system which is fit-for-purpose, sustainable in the long term and globally feasible. IOCCP coordinates the development of globally acceptable strategies and provides technical coordination developing methodologies and practices and standards, homogenizing efforts of the research community and scientific advisory groups. IOCCP also provides communication services for the marine biogeochemistry community, as well as advocacy and links to a multidisciplinary sustained global observing system.

This report highlights main activities of the IOCCP between June 2016 and May 2017.

Projects and Major Activities

New IOCCP SSG Terms of Reference

The IOCCP was established as a standing project of SCOR and IOC-UNESCO in 2005 when the coordination capabilities of a small advisory panel shared between the two organizations no longer met the needs of the community. The complexity of the marine carbon cycle and its numerous connections to carbon's atmospheric and terrestrial pathways meant that a wide range of types of observations had to be made in order to establish carbon's qualitative and quantitative role in the global climate system. The initial Terms of Reference for IOCCP provided guidance for the SSG on how to coordinate this myriad of activities focused on carbon observations and related data management.

Over the past decade, the IOCCP was recognized as a successful model; however our ever-increasing understanding of the inter-correlation of marine carbon cycle with carbon-related biogeochemical parameters demands a coordinated, comprehensive biogeochemistry observing system that serves the current needs for information related to issues like ocean acidification, ocean deoxygenation, eutrophication and more. The coordination activities of IOCCP have naturally expanded to incorporate these issues and the IOCCP SSG decided it was timely to re-define the project's ToRs to reflect the current coordination needs of the marine carbon and biogeochemistry community as defined by their requests for action from IOCCP. The updated ToRs, approved by SCOR and IOC-UNESCO, are listed below.

THE INTERNATIONAL OCEAN CARBON COORDINATION PROJECT

A joint project of Scientific Committee on Oceanic Research and Intergovernmental Oceanographic Commission of UNESCO and an affiliate program of the Global Carbon Project.

Terms of Reference

Approved at the XII Session of the SSG, 6-7 February 2017, Miami, USA

The International Ocean Carbon and biogeochemistry Coordination Project (IOCCP) promotes the development of a global network of ocean carbon and biogeochemistry observations, coordinates the development of globally acceptable strategies and provides technical coordination for developing operating methodologies, practices and standards, homogenizing efforts of the research community and scientific advisory groups. IOCCP also provides communication services for marine biogeochemistry community as well as advocacy and links to a multidisciplinary sustained global observing system.

Here we consider the term biogeochemistry to include the Global Ocean Observing System (GOOS) Essential Ocean Variables (EOVs) for Biogeochemistry. These EOVs enable the understanding and quantification of the following phenomena: ocean acidification, ocean deoxygenation, eutrophication, exchanges between the atmosphere, surface ocean and deep ocean, and carbon and nutrient remineralization and sequestration.

- 1. Identify priority measurements for implementation of GOOS observations of ocean carbon and biogeochemistry, and promote development and adoption of necessary measurements and measurement technology.*
- 2. Develop activities to implement the goals and recommendations set by international and intergovernmental bodies relevant to the work of IOCCP.*
- 3. Develop and maintain a set of specifications, implementation goals, and progress metrics for EOVs for ocean carbon and biogeochemistry parameters for GOOS and corresponding Essential Climate Variables for the Global Climate Observing System (GCOS).*

4. *Promote international agreements on measurement methodologies and best practices, primary and secondary data quality control and quality assurance procedures, data and metadata formats, and development and use of certified reference materials.*
5. *Coordinate activities of individual networks and programs to streamline ocean carbon and biogeochemistry measurements.*
6. *Facilitate a dialogue with stakeholders to implement a scientifically and economically effective, fit-for-purpose observing system for ocean carbon and biogeochemistry.*
7. *Develop and support training activities for users of observing technologies (instruments, sensors and platforms) for ocean carbon and biogeochemistry.*
8. *Promote and develop interoperable data management activities and policies to ensure open access to, and preservation of, fully documented ocean carbon and biogeochemistry data.*
9. *Promote the integration of ocean carbon and biogeochemistry information into research and assessments including the use of relevant data synthesis products (e.g., SOCAT, GLODAP).*
10. *Serve as an international communication centre on ocean carbon and biogeochemistry observing activities.*
11. *Report to sponsors and the global ocean carbon and biogeochemistry observing community on the state of planning and accomplishments of IOCCP.*
12. *Raise funds to implement IOCCP activities.*

The ToRs are also available to read and download from the IOCCP website at <http://www.ioccp.org/index.php/about-us/tors>

Towards a Global Data Assembly Centre for Marine Biogeochemistry

Up until 2016, the international ocean biogeochemistry community has mainly been using and depending upon one global data centre, the Carbon Dioxide Information Analysis Center ocean trace gases section (CDIAC-Oceans) at the U.S. Department of Energy's Oak Ridge National Laboratory (ORNL), USA. As emphasized in the [IOCCP Position Statement on Data Management](#), "CDIAC-Oceans provided data management support for ocean carbon measurements from Repeat Section cruises, Volunteer Observing Ship (VOS)/Ship of Opportunity Programme (SOOP) lines, time series and moorings data, has accommodated most community requests for data archival and data access and has also actively engaged with the science community, supporting large synthesis projects like Surface Ocean CO₂ Atlas (SOCAT), the Lamont-Doherty Earth Observatory (LDEO) global surface pCO₂ database, Global Ocean Data Analysis Project (GLODAP), CARbon dioxide IN the Atlantic Ocean (CARINA), PACIFIC ocean Interior CARbon (PACIFICA) and GLODAPv2."

In the fall of 2016, it was announced that the data management activities of CDIAC-Oceans at ORNL would be stopped. In response to the many concerns of the international community, strongly voiced by IOCCP, serious steps were immediately taken to minimize the negative impacts of this stoppage on the oceanographic community.

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In light of the fact that CDIAC-Oceans will cease all operations on September 30, 2017, IOCCP has felt obliged to continue informing the community about the consequences of this development and steps that are being taken to minimize potential damage, most recently through an article on this topic in the recent newsletter - the IOCCP Conveyor [Issue #37](#).

It has been ensured that data, numerical data packages (NDPs), data synthesis product pages, utilities and DOI landing pages will continue to be accessible to the international community until CDIAC will cease operations. CDIAC-Oceans' data and services are being transferred to NOAA's National Centers for Environmental Information ([NCEI](#)) where will be long-term archived and made available through the newly funded Ocean Carbon Data System (OCADS).

OCADS is responsible for hosting and providing access to ocean carbon data as previously done by [CDIAC-Oceans](#). Alex Kozyr, former CDIAC director responsible for CDIAC-Oceans, started working at NCEI as a NOAA affiliate staff member and is supporting the global ocean carbon data management as before.

The main aim is to make the transition as smooth as possible for users, but some changes are inevitable. NCEI will adopt a framework that not only is capable of managing rich metadata information for ocean carbon data, but also can be integrated with the broader data management system at NCEI.

Having long recognized the vulnerability of the marine carbon and biogeochemistry data management system, IOCCP has been engaging in coordinating and fundraising efforts towards the formation of a Global Data Assembly Centre for Biogeochemistry – a BGC GDAC. Over the past year a great of effort was taken to inform the community that there is no competition between the formation of GDAC and existing data repositories. To the contrary, the formation of the GDAC would be an unprecedented undertaking towards consolidating and unifying BGC data.

Members of the IOCCP SSG have attended several informal meetings and conferences to introduce the GDAC concept and a strategy for its implementation. As a result, the proposed GDAC has already received letters of support from many other data providers, such as EMODNET. Observing networks with existing data management systems, as such as BGC Argo, have also expressed interest in streaming data through the GDAC, thus providing the user with the vital multi-platform and multi-parameter context for otherwise float-specific data.

Global Ocean Acidification Observing Network (GOA-ON)

The Global Ocean Acidification Observing Network (GOA-ON) has expanded its membership to 354 members representing 66 nations, demonstrating marked progress toward achieving global OA observing capacity. IOCCP plays an active role in GOA-ON through presence of its two SSG members Richard Feely and Benjamin Pfeil, and Project Director Maciej Telszewski on the GOA-ON Executive Council.

There have been several developments within GOA-ON over the past year, some stemming from the successful 3rd GOA-ON Symposium held in Hobart in May 2016, co-organized by IOCCP.

The recently published 3rd GOA-ON workshop [Summary for Policymakers](#) provides an overview of ongoing global and regional network activities.

A key achievement was the June 2016 launch of the [GOA-ON portal](#), which features global OA data measurements, such as pH, pCO₂; derived fields, such as aragonite saturation state; and world-wide asset inventory and metadata data; and will feature data synthesis products. Researchers world-wide are encouraged to make new submissions or update old ones through a Web-based survey accessible from [here](#).

Another GOA-ON activity was the launch of the Pier2Peer program – a scientific mentorship program supporting the expansion of OA observing capacity through two-way sharing and capacity-building activities.

In March 2017, GOA-ON members moderated the Ocean Action Hub online forum for OA discussions in advance of the UN [Ocean Conference](#) on addressing the UN Agenda 2030 Sustainable Development Goal 14 (SDG-14). The discussion was on the implementation of SDG14.3, aimed at minimizing and addressing the impacts of OA. Various stakeholders were encouraged to post a comment on their experience in the forum.

Moreover, regional efforts of GOA-ON have expanded significantly over the past year. The Latin-American Ocean Acidification ([LAOCA](#)) Network has been gradually maturing since its kick-off meeting in December 2015. With the assistance of IOCCP, among other partners, LAOCA has begun to hold capacity-development training and regional science conferences for network members. In Africa, all scientists conducting or interested in conducting OA monitoring and research have been encouraged to join the newly formed OA Africa Network, which aims to provide a platform for sharing ideas, designing collaborative research programs, troubleshooting challenges, and facilitating international collaboration and support. Efforts to connect African OA research with global efforts are also augmented by the parallel kick-off of the OceaAn pH Research Integration and Collaboration in Africa (ApHRICA) project - a public-private partnership launched in July 2016 with the aim of installing and operating ocean sensors on platforms operated by colleagues studying OA in East Africa.

In May 2017, GOA-ON held its Executive Council Meeting in Paris, France, focused to a large extent on contributions to the SDG 14 and securing funds for GOA-ON's secretariat. Details of the meeting can be found in the Workshops and Meetings section of this report.

Global Ocean Observing System Biogeochemistry Expert Panel (GOOS BGC Panel)

Over the past year, IOCCP has been strongly involved in leading the activities of the GOOS Biogeochemistry Panel. Our activities were focused on two elements:

- (1) implementation of the Framework for Ocean Observing through the Essential Ocean Variable (EOV), and
- (2) involvement with the G7 process.

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EOVs: update and harmonization across GOOS disciplinary expert panels

After the publication of the February 2016 version of the Biogeochemistry EOV Specification Sheets, the process of preparing the next updated version started almost immediately. The main goals included (i) harmonizing the EOV-related definitions and Specification Sheet structures across the three disciplinary expert panels of GOOS, and (ii) improving internal consistency of the content of the Biogeochemistry EOV Spec Sheets. In addition, IOCCP (as the GOOS BGC Panel) was charged with the task of developing an Ocean Colour EOV in consultation with the ocean colour community; and with initiating a dialogue with the United Nations Environment Programme (UNEP) in relation to the potential development of a Marine Pollutants/Contamination EOV.

The harmonization of EOV-related definitions and Specification Sheet structures occurred through two in-person meetings and remotely through frequent email communication. In June 2016, GOOS Panel co-Chairs and Secretariat met for a half-day workshop to discuss the first steps towards harmonizing the EOV Specification Sheets. Clear distinctions between the EOV selection processes adopted by the three panels became apparent. The complexity of the ecosystem structure and functionality make it particularly challenging for the Biology and Ecosystems Panel to adopt a shared set of principles and definitions, much easier adhered to in the physics & climate and biogeochemistry realms. The main meeting outcome was the identification of major discrepancies and inconsistencies across the three panels. The participants agreed to strive towards a more consistent picture of EOVs at the following meeting.

In September 2016, the three panels met again in Oostende, Belgium, this time for a two-day meeting, preceding another two-day meeting of the Biology & Ecosystems Panel meeting. The discussions resulted in the development of common definitions and guidelines for the harmonized implementation of the terms included in the Framework for Ocean Observing as well as those required for the development of the EOVs Specification Sheets. Subsequently, specific goals were set for the next months of work of all GOOS panels and discussed the plan of action needed to achieve these goals. The measurable outcome of these two meetings will be (a) publication of the latest EOV specification sheets on the new GOOS website (expected date: mid-2017), and (b) publication of a manuscript on the implementation of the Framework for Ocean Observing through GOOS EOVs (Expected date: late 2017).

Ocean Colour EOV

In the second half of 2016, IOCCP also initiated its work towards creating an Ocean Colour EOV Specification Sheet. A series of informal consultations was carried out during a number of meetings: with the ocean colour community at the Colour and Light from Earth Observations (CLEO) workshop (see Workshops and Meetings section), as well as with relevant experts from the GOOS Panels during the Oostende workshop. As a result of the consultations, IOCCP presented three alternative options for best representing ocean colour measurements in the EOV framework, considering the multidisciplinary nature of their application and strong overlaps with existing EOVs.

The three options were presented and discussed with members of GOOS Executive. In January 2017, the decision was made to include Ocean Colour as a new, stand-alone EOV with the Specification Sheet modified as needed. The process of developing the Specification Sheet was

discussed informally among selected GOOS Panel members and representatives of the International Ocean Colour Coordinating Group (IOCCG) at a side meeting to the IMSOO workshop. As per recommendations from that meeting, in May 2017 IOCCP officially approached the IOCCG Committee with a request for assistance in developing the Specification Sheet and in curating the Ocean Colour EOVS together with the Biogeochemistry Panel in the future.

Marine contaminants/pollutants

IOCCP has also initiated the communication with UNEP considering the requirements and current observing capacities with respect to monitoring marine contaminants, in the context of representing these observations in the EOVS framework. These ongoing discussions were augmented by consultations with the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), represented by Peter Kershaw, who was invited by IOCCP to take part in the AtlantOS-sponsored Setting Observing Targets for Biogeochemistry held in Sopot, Poland, in of November/December 2016.

Kershaw's valuable contribution to the workshop included draft specification sheets for a number of marine contaminant groups that could potentially fall under the new EOVS, such as PCBs, hydrocarbons, plastics, and heavy metals. It was agreed earlier among GOOS Panels that underwater noise would be treated separately from chemical pollutants, and that the Biology and Ecosystems Panel would lead the efforts on collecting information on this parameter.

Finally, at the GOOS Executive meeting in February 2017 in Miami, FL, USA, it was proposed that a new group of EOVS be created: Human Pressure Variables. If accepted, this would mean that Marine Contaminants EOVS would fit under that category, subject to curation by a separate GOOS panel created by experts in human impacts on the global ocean.

G7 Future of the Oceans and Seas Working Group

The Science and Technology Ministers of the G7 (Canada, France, Germany, Italy, Japan, UK, US) and the EU met in Tsukuba City, Japan on May 15-17 2016. In their [communiqué](#), the G7 ministers expressed their will to support the enhancement of multidisciplinary sustained global ocean observing system, promote open data sharing infrastructure and call for an enhanced system of ocean assessments. In the attachment to the Tsukuba Communiqué, the G7 also provided a series of recommendations based on the G7 expert workshop on Future of the Oceans and Seas. These recommendations are built on the Global Ocean Observing System approach, with specific mention of individual observing networks like profiling floats, ships, moorings and gliders, the need to develop new observing technologies to support the implementation of the Essential Ocean Variables, and the need for more effective use of marine information gathered through observations.

IOCCP co-Chair Toste Tanhua played an active role in the G7 Future of the Oceans and Seas Working Group, which was tasked with recommending a list of actions in response to the Tsukuba Communiqué. IOCCP thus contributed to the final format of the G7 Ministers recommendations, thus ensuring that development of ocean biogeochemistry observations is maintained high on the priority list of actions. Efforts were made to promote the FOO approach and its implementation through EOVS. In particular, one action identified during the experts

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meeting in December 2016 is the development of a G7 GOOS Implementation Group to liaise and support GOOS while coordinating enhancements to G7 observing.

G7 has a specific interest in producing more regular assessments for the ocean, akin to the ones made by IPCC on climate. A key requirement is to identify and mobilize the national funding for sustained observations, which means that requests for more operational-based funding schemes be put forward to national governments. Some specific recommendations drafted so far and of relevance to IOCCP consider a request for 2 person months per year for SOOP-CO₂ support, and 6 person months per year for GO-SHIP. Also, a dedicated GOOS G7 Office is in planning, with headquarters outside of the IOC, but very related to ongoing GOOS activities. Such a structure would potentially enable new funds raised for IOCCP, GOOS BioEco Panel and observing network activities. The recommendations document is currently in an iterated review stage, and will be submitted to G7 national representatives later this year.

2015 Inter-comparison study of Certified Reference Material for Nutrients in Seawater, and the use of CRMs by ocean observing networks

'IOCCP-JAMSTEC 2015 Inter-laboratory Calibration Exercise of a Certified Reference Material for Nutrients in Seawater' was published online in June 2016 as IOCCP Report Number 1/2016 and ISBN 978-4-901833-23-3. The report was printed and 2 copies were sent to each participating laboratory in December 2016, one for the participant and for the library of the institute/organization/university.

From the report itself it seems clear that at present the comparability among the results from the 2015 I/C exercise are quite similar with previously obtained comparability in 2012 I/C study, as well as previous I/C studies. To improve comparability of oceanic nutrients data the following actions are proposed:

- Continue the series of Inter-laboratory Calibration Experiments to observe how the performance of the community changes following the introduction of CRMs for nutrients.
- Specifically for nitrate, several laboratories reported results that were significantly lower than the expected value, suggesting that for this particular measurement there is still a wide margin for improvement. To remedy the situation, a 'Silicate workshop' is planned at NIOZ (Netherlands) in November 2017 by SCOR WG#147.
- Interactive discussion with participating laboratories on how to continue and improve the Inter-laboratory Calibration Experiments is planned. Michio plans to send out a questionnaire to all the participants with questions designed to improve the effectiveness of future inter-comparisons.
- A scientific paper which will analyze the details of the results of the 2015 IOCCP-JAMSTEC I/C is also planned.

IOCCP will co-sponsor the next inter-comparison exercise, which will most likely take place in late 2017.

The IOCCP continues to encourage the purchase of new CRMs (<http://www.jamstec.go.jp/scor/>). The response from the community has so far been very poor. Based on the questionnaire filled by 74 laboratories prior to production process, the initial demand was assessed to be at the order of 3,000 bottles per year. So far (18 months after bottling of the first batch), 137 bottles were ordered by 7 laboratories. The CRMs are currently 60% cheaper than initially thanks to a subsidy grant aimed at increasing the use of CRMs. The CRMs have an official shelf-life of 72 months, but in reality are thought to be of unchanged concentration through a 10-year period. The use of nutrient CRMs will be listed as a Standard Operating Procedure in the updated Nutrients chapter (currently finalized) of the GO-SHIP Manual. IOCCP will work closely with GO-SHIP to effectively enforce the use of CRMs by stating that any cruise that does not use CRMs will not qualify as a Level 1 GO-SHIP cruise. The IOCCP Panel unanimously recommends the use of Nutrients CRMs, and expressed hope that this becomes an absolute requirement on GO-SHIP cruises as soon as possible.

Coordinating global ocean oxygen observations

With the gradual expansion of IOCCP communication and coordination services from ocean carbon observations into ocean biogeochemistry observations, in accordance with the newly accepted IOCCP SSG Terms of Reference, efforts have been initiated to

- (1) play a more active role in global coordination of non-carbon Biogeochemistry EOVs, starting with oxygen, the global observations of which are likely most mature; and
- (2) extend the breadth of expertise in the IOCCP SSG panel by introducing a new SSG member responsible for the theme of oxygen observations.

IOCCP Oxygen Theme and responsible SSG member

Creating a new Oxygen theme is a consistent continuation of the panel expansion initiated in 2013 with the inclusion of the Nutrients theme, and with the invitation of Michio Aoyama to join the SSG Panel. A similar modus operandi was applied for Oxygen this year. Véronique Garçon has been unanimously approved by the IOCCP SSG to join the Panel as the expert responsible for coordination and communication concerning global ocean oxygen observations. Véronique will take up the position at the beginning of 2018. It should be noted that she already attended the XII IOCCP SSG meeting as a guest, in February 2017.

Global Ocean Oxygen Network (GO₂NE)

IOCCP's mission to coordinate global ocean oxygen observations is also realized through a strong participation in the Global Ocean Oxygen Network (GO₂NE), a new expert group formed by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. GO₂NE, which assembles coastal and open ocean scientists; modellers; and biological, chemical and physical oceanographers, seeks to integrate worldwide research efforts on deoxygenation in the open ocean and coastal areas. The network offers scientific advice to policy makers to counter the concerning decreases in ocean oxygen and to preserve marine resources in the presence of deoxygenation. Currently, the members of the core working group represent 21 institutions in 11 countries. Maciej Telszewski represents IOCCP as a member of the GO₂NE Executive Council.

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The objectives of GO₂NE are the following:

- (1) Integrate the disparate research efforts on deoxygenation that are taken worldwide and offer a global and multidisciplinary view of the problem. This overview of current knowledge will allow the network to identify gaps and to propose a framework/strategy to fill these;
- (2) Facilitate communication with established networks, working groups, observation systems, IOC Member States, stakeholders, policymakers in order to stimulate the awareness on the deoxygenation issue with meaningful and understandable messages;
- (3) Promote scientific development and cooperation and identify emergent fields of research; and
- (4) Increase research capacity and knowledge transfer.

The Network's scientific work, outreach, and capacity building efforts include facilitating communication with other established networks and working groups, including IOCCP, but also GOOS, International Group for Marine Ecological Time Series (IGMETS), GOA-ON, GlobalHAB, WESTPAC O₂NE, among others. This way GO₂NE strives to improve observation systems, identifying and filling knowledge gaps, as well as developing related capacity-development activities.

Moreover, in collaboration with the Collaborative Research Center (SFB) 754 funded by the German Research Foundation (DFG) at the Kiel University and GEOMAR, GO₂NE has recently initiated the news site www.ocean-oxygen.org to provide information on deoxygenation to scientists, stakeholders and the interested public.

Continued developments in the Surface Ocean CO₂ Atlas (SOCAT) project

SOCATv4 released

The Surface Ocean CO₂ Atlas (SOCAT, www.socat.info) is a synthesis activity by the international marine carbon research community (>100 contributors). In September 2016, a new version of SOCAT was released. SOCAT version 4 (SOCATv4) has 18.5 million quality-controlled, surface ocean fCO₂ (fugacity of carbon dioxide) observations with an accuracy of better than 5 µatm from 1957 to 2015 for the global ocean and coastal seas. Automation of data upload and initial data checks speeds up data submission and will allow annual releases of SOCAT from version 4 onwards. In the future, the automation process will also include metadata upload.

A new SOCAT paper highlights its wide scientific impact

Also in the fall of 2016, IOCCP reported on the publication of the SOCAT version 3 article in the journal *Earth System Science Data* (ESSD, open-access entitled: "[A multi-decade record of high-quality fCO₂ data in version 3 of the Surface Ocean CO₂ Atlas \(SOCAT\).](#)") This "living data" publication documents the methods and data sets used for the assembly of SOCATv3 data collection and compares these with those used for earlier versions. Moreover, the paper discusses

the importance of SOCAT by highlighting its citation in three categories of high-impact reports, as well as the use of SOCAT for a variety of scientific applications.

Apart from discussing the methods and data used for the assembly of SOCATv3, the paper discusses the importance of SOCAT by highlighting its citation in three categories of high-impact reports, notably

- reports on ocean observing systems,
- assessments of climate change and global carbon budgeting, including carbon observing strategies, and
- ocean acidification studies.

Submission for SOCATv5 requested

In early 2017, two deadlines related to SOCATv5 passed. The end of January saw the closing of the data submission deadline, and the end of March 2017 was the deadline for quality-control operations.

Since the onset of the automation of data upload, the plan is to release a new version of SOCAT annually, in the first half of the year, in order to facilitate preparing annual updates for the Global Carbon Budget.

It should be noted that, in spite of its success, expanding scope of services offered and a wide array of its applications in the ocean and climate communities, SOCAT remains without any sustained funding, thus jeopardising the longevity of this community-based effort.

EU Horizon2020 AtlantOS (Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems) project

Capacities and gaps analysis

In a recently delivered report on “Capacities and Gap Analysis” IOCCP, along with other partners of EU Horizon2020 project AtlantOS, took up the challenge of analysing the current capacities and gaps of all three disciplinary components of the Atlantic Ocean Observing System (OOS). This task was in itself unprecedented due to the very different levels of “maturity” in setting societal requirements for designing and carrying out sustained measurements of physical, biogeochemical and biological phenomena and the EOVs needed to observe key ocean processes. To this end, expert meetings and an intense dialog within the group and in consultation with leading international expert groups under IOC, such as the GOOS Panels, are conducted. Following up on an earlier integrated look at the societal requirements across the three disciplines, the report outlines a strategy towards a comprehensive capacity and gap analysis of the OOS.

The design of an optimal OOS—in this case for the Atlantic Ocean—includes several logical steps which follow the approach of the Framework for Ocean Observing:

- (1) Define the requirements – societal drivers for information to address specific questions.
- (2) Identify the scientific approaches associated with the requirements

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- (3) Identify the phenomena and Essential Ocean Variables (EOVs) to be captured, based on the scientific approach
- (4) Use the existing observing infrastructure for data acquisition of the respective set of phenomena and EOVs
- (5) Use accessible data to derive information products that address the Observing Objective (point 1), thus providing a measure of the current capacity of the OOS
- (6) If information cannot be derived, perform a Gap analysis (data acquisition, product generation)
- (7) Ensure a “Fit for Purpose”, enhanced and optimized OOS.

Constant monitoring of our ocean observing capacity and gaps in the system is a core activity to ensure an optimized, and thus cost efficient, sustainable OOS. In this respect, sustained ocean observing is different from ocean observing for fundamental research performed for a defined period only. However, both, the sustained OOS and the observing efforts in the context of fundamental research benefit from each other. The most obvious link is via data exchange - while observing in the sustained system must provide open-access data, the fundamental researchers should make sure that their data are also open access, to ensure these data are integrated into the ocean observing value chain.

Analysing the existing observing capacity for several EOVs in the Atlantic Ocean cannot be done without considering the respective observing objective. However, “baseline” information is first required before an optimization can be performed. In respect to baseline information we conclude the following:

- Basic physical parameters such as temperature and salinity are relatively well observed in most parts of the Atlantic Ocean, although areas of low density of observations can be identified.
- For other EOVs – physical, biogeochemical and biological – geographical gaps are much more evident.
 - It should be stressed that the examples of observing capacity provided in the report reflect data that are publicly available in databases such as Copernicus Marine Environment Monitoring Service ([CMEMS](#)) In Situ Thematic Assembly Centre (INSTAC), the European Marine Observation and Data Network ([EMODnet](#)), [SeaDataNet](#), International Council for the Exploration of the Sea ([ICES](#)) and through community-based data synthesis such as the SOCAT and GLODAP; which unfortunately do not include all the data available for the Atlantic Ocean.
- Additionally, it is well-known that a substantial amount of data are not, for various reasons, made publicly available by the data owners, and this can be seen as lost data in the framework of a sustained Atlantic OOS.

The report provides examples of “generic” gaps identified in the system (e.g., missing baseline data). However, it has been suggested to concentrate a future gap analysis around four subjects: (i) gaps in the observing networks, (ii) gaps in data availability, (iii) gaps in sustainability, and (iv) gaps in technology.

A detailed gap analysis would furthermore rely on detailed requirements and scientific approaches for an Atlantic OOS to be established. Determination of the adequacy in spatial and temporal resolution of sampling, the parameter suite, the measurement quality and other sampling requirements etc. are not possible before some of the “maturity” issues mentioned above are addressed properly. In fact, the ocean observing value chain that is executed fully through the AtlantOS should ultimately be reflected in its ability in data provision for user needs.

Setting biogeochemical observing targets

With ongoing advances in observing technology, and a set of Biogeochemical Essential Ocean Variables (EOVs) already in place, priorities for designing an optimum observing system for marine biogeochemistry are now shifting towards a system-wide definition of a set of accepted observing targets for biogeochemical phenomena and EOVs developed in a process driven by relevant scientific and societal requirements.

In the context of the EU AtlantOS Project, IOCCP started its work towards defining quantifiable targets for the biogeochemical element of the observing system. As with the development of EOVs, IOCCP is looking forward to wide community input over time. The first step of this effort was to focus on the Atlantic Ocean before expanding the process to other basins.

The goal of the AtlantOS-sponsored workshop on "Setting Observing Targets for Biogeochemical Observing System in the Atlantic", held on 29 November–1 December 2016, in Sopot, Poland, was to respond to the challenge of setting observing targets while simultaneously taking into account the myriad of spatio-temporal scales of the distinct biogeochemical phenomena of interest and the complex array of corresponding observing elements.

The concept of defining phenomena-based targets is different but complementary to setting a more pragmatic observing network-based target of, for example, deploying X number of platforms in a given basin. Phenomena-based targets offer the advantage of setting a target that responds directly to a given scientific question. Also, a combination of several observing networks can better relate to such a target by utilising their relevant capacities, such as specific spatial and temporal resolution, measurement accuracies or parameters observed. One example of such a (proposed) target is to “establish the baseline number of OMZs (with 3D distribution of oxygen levels within them) in the Atlantic Ocean”. To this end, adequate Biogeochemistry EOVs (e.g., oxygen, nitrous oxide) need to be measured on spatio-temporal scales matching those on which the phenomenon of deoxygenation operates. Meeting this phenomenon-based target will provide a direct answer to a key scientific question of “How large are the ocean’s ‘dead zones’ and how fast are they changing?”.

Comparing the targets developed during this workshop with the current observing capabilities will in the long term enable a comprehensive gap analysis aimed at providing recommendations for designing an optimized and enhanced global ocean observing system. The outcomes of the

workshop will not only inform the project deliverables, but will also be further socialized with the community for input and expansion to other basins.

An important lesson from this pilot workshop is the need to simultaneously account for the requirements in collocated physical and biological measurements necessary to observe and model a given biogeochemical phenomenon. Proper consideration of targets related to measuring all relevant EOVs is fundamental to developing an optimal sampling design. Such a multidisciplinary approach would further promote synergies between the observing networks and communities traditionally confined to a single discipline – a prerequisite to a successful implementation of any phenomenon-based target.

The next step in this process is for IOCCP to engage in applying a similar workshop format to set observing targets in the other ocean domains for the benefit of the global ocean observing system. To this end, Maciej Telszewski presented the workshop concepts to the North Pacific Marine Science Organization (PICES) community during the PICES Annual Meeting in November 2016, San Diego, CA USA. Members of the PICES Advisory Board have shown an initial interest in collaborating with IOCCP on such an exercise applied to the Pacific Ocean domain.

Formation of the Global Ocean Data Analysis Project (GLODAP) Reference Group

In early 2017, IOCCP drafted and approved the Terms of Reference for the Global Ocean Data Analysis Project (GLODAP). Efforts are currently underway to assemble the GLODAP Reference Group. First invitations have been sent out.

Below are the newly established GLODAP Terms of Reference which describe the intended scope of this project as well as the proposed management structure.

Global Ocean Data Analysis Project (GLODAP)

Terms of Reference for GLODAP Reference Group (RG)

The GLODAP will ensure the continuous provision of updated interior ocean biogeochemical synthesis products based on data from ship based surveys. It will do this by adding data to GLODAPv2, after subjecting them to primary and secondary quality control. After the completion of the ongoing repeat hydrographic survey (next one is scheduled for 2023), this group will be responsible for instigating a new full version of GLODAP (the next one will be v3), which will entail a full reevaluation of the entire product. Before then, cruises will be assessed for bias with respect to GLODAPv2 and the intermediate products released will be named GLODAPv2.YYYY where YYYY is year of release.

GLODAP is the interior ocean data synthesis project of IOCCP, which is the GOOS panel for Biogeochemistry. GLODAP is an important GOOS data product reporting on a range of Essential Ocean Variables, as well as additional interior ocean variables.

Members of the GLODAP RG are appointed primarily based on their scientific expertise related

to the technical and scientific aspects of GLODAP ('science members'). However, as the RG has a significant role to play in coordination and promotion of, and fund-raising for the GLODAP-related activities, some members can be representatives of funders and sponsoring and coordinating bodies and programs, recognizing that most of the science members will be asked to serve both functions.

Science members are appointed for one 3-year term with the possibility to extend for another 3 years. For a member who subsequently becomes a co-Chair, the maximum period of service may be extended up to 9 years, with a maximum period of 6 years as co-Chair. Appointments will normally begin at the start of the calendar year.

Composition of the Reference Group

- *The RG will be composed of two co-Chairs plus 15 - 20 members.*
- *Science members will be nominated¹ with effort for the RG to have geographic diversity, gender balance and an appropriate range of scientific expertise, with the RG collectively covering the main topic areas listed below as the RG responsibilities.*
- *Representatives (if any) of government agencies, relevant intergovernmental bodies² and national scientific programs will be appointed on the basis of their major involvement in GLODAP relevant activities.*
- *Co-Chairs should ideally have both scientific expertise and strong policy or funding linkages.*

The responsibilities of the GLODAP RG

1. *Ensure data submission to GLODAP by promoting, within the relevant scientific and observational communities, the awareness of the value-added provided by GLODAP.*
2. *Maintain and actively develop the major GLODAP products*
 - a. *a data base with original cruise data and meta data, as submitted by individual data providers but updated to WOCE Exchange formatted data files,*
 - b. *a merged data product, where data have been adjusted to remove measurement biases for key biogeochemical variables, identified through a crossover analysis, and*
 - c. *a mapped climatology consisting of a set of 3D fields of the global distribution of seawater CO₂ chemistry and other parameters at a resolution of 1x1 degrees at 33 pressure surfaces for each new "full" version of GLODAP*
3. *Develop and execute a regular and systematic GLODAP release schedule preceded by a secondary quality control process*
4. *Provide technical support to data management processes aimed at long term storage of new original cruise data and adjusted data products.*

¹ Nominations sought from existing members, on the basis of wider consultations and agreement of the nominated individual

² Currently GOOS and IOCCP

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5. *Maintain and actively develop a dedicated website, GLODAP.info*
6. *Represent GLODAP at international meetings and workshops.*
7. *Encourage national and international funding agencies to support GLODAP activities.*
8. *Encourage coordination of efforts and collaboration with organizations and projects involved in ocean interior observations.*

Expected commitment of individual GLODAP RG members

9. *Attend, in person³, one technical workshop, nominally one full day, scheduled prior to the release of GLODAP version update.*
10. *Participate in regular RG teleconferences⁴ expected to be more frequent prior to release of a new version (planned at least 4 weeks in advance with sufficient flexibility in proposed dates).*
11. *Provide input to the agenda for the RG teleconferences.*

Training and Capacity Building

Technical Workshop on Carbonate System Measurements for members of the Latin-American Ocean Acidification Network LAOCA

On 3-11 December 2016, members of the Latin-American Ocean Acidification Network (LAOCA) were invited to take part in a training workshop to gain hands-on laboratory experience in appropriate high-precision chemical techniques and protocols related to carbonate system measurements. The workshop was held at the Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, in Ensenada, México.

Organized by IOCCP and the International Atomic Energy Agency (IAEA), with co-sponsorship from the Millennium Institute of Oceanography (IMO) and the Center for the Study of Multiple-Drivers on Marine Socio-Ecological Systems (MUSELS), the workshop proved very successful in terms of meeting the demands of the community and testing a basic model for holding similar training workshops elsewhere in the world in the future.

With representation from 8 Latin American and Caribbean countries participating in LAOCA, the course was designed to train 14 participants and therefore significantly strengthen the analytical capacity in the region. All of the participants were selected based on their current role in their laboratories indicating their active, full-time involvement with relevant analytical duties in the field and in their laboratories.

Participants were divided into four groups (max. 4 participants in each group) to provide each participant with first-hand experience in handling the equipment and analytical procedures for

³ Efforts will be made to at least partially support the costs of in-person meeting participation.

⁴ Occasional substitution is allowable if notified in advance, with the substitute having 'observer' status

each respective measurement (i.e., pH, total alkalinity (TA), and dissolved inorganic carbon (DIC)).

Apart from hands-on exercises, lectures on the design of the observing system, data management practices and carbonate system calculations were included to allow the participants to understand a wider context of making measurements and collecting data.

Upon completion of the training course, participants gained increased knowledge in the following aspects:

- Observing system design based on their needs in the framework of internationally accepted protocols (e.g., Framework for Ocean Observing, Essential Ocean Variables) and data management procedures based on established data products such as SOCAT and GLODAP with explicit focus on the need for ancillary parameters (i.e., temperature, salinity, nutrients, barometric pressure and more)
- Monitoring carbonate chemistry, including detailed methodology for measurements of potentiometric and spectrophotometric pH, TA with an open-cell titration method, and DIC, the use of certified reference materials, analytical know-how such as the typical sample volume required, and specific challenges related to each method.
- Advantages and disadvantages of the different platforms for carbonate system measurements, such as moored surface sensors, gliders, underway measurements, and discrete water samples; requirements for handling, maintenance, calibration and validation of specific platforms and instruments.
- The use of carbonate system calculating tools including error propagation.

This workshop paved the way for what IOCCP foresees to be a series of training courses on carbonate system measurements, which would increase the regional capacity to observe changes in marine biogeochemistry in a globally comparable way.

Workshops and Meetings

5th Global Ocean Observing System Steering Committee meeting (GOOS-SC-5), 1-3 June 2016, Sopot, Poland

The 5th Session of the GOOS Steering Committee was held at IOPAN in Sopot, Poland on 1-3 June 2016. The meeting was hosted by the IOCCP Office which was also joined by IOCCP co-Chair Toste Tanhua in representing the GOOS Biogeochemistry Panel.

Toste Tanhua and Maciej Telszewski gave overview presentations on the status of carbon and marine biogeochemistry observations in the global ocean, the progress in developing Biogeochemistry EOVs and efforts to harmonize EOVs with ECVs on the occasion of working towards a new 2016 GCOS Implementation Plan.

Based on discussions with the SSC, several important recommendations were made for the GOOS Biogeochemistry Panel to consider in relation to the following issues:

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- Ocean Colour measurements in the EOVS framework
- Contamination/pollution expertise in GOOS in association with UNEP
- Developing targets for the biogeochemical global observing system

These were all acted upon and are described elsewhere in the report, under relevant actions taken by the GOOS Biogeochemistry Panel.

2nd AtlantOS General Assembly meeting and associated workshops, 27 June–1 July 2016, Kiel, Germany

The EU Horizon2020 AtlantOS (Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems) project General Assembly (GA) was held on 29-30 June 2016, at the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany. IOCCP was represented by Maciej Telszewski and Artur Palacz and several IOCCP SSG members: Toste Tanhua, Siv Lauvset, Benjamin Pfeil, and Bjoern Fiedler. All AtlantOS partners took part in presenting a summary of the activities within individual WPs, and took part in an overview of the planned contributions to the AtlantOS Blueprint, which will propose an enhanced and optimised integrated observing system for the Atlantic for the years 2020-2030. Several break-out sessions were designed to help facilitate cross-WP interactions and generate progress towards individual sections of the Blueprint, which is seen as the final outcome of the project.

Additionally, IOCCP was also represented at a series of associated thematic workshops focused on specific activities of individual work packages scheduled around the GA meeting. Tightening the information exchange flow between individual WPs was also on the agenda.

On Monday 27 June, Artur Palacz took part in the workshop organized by WP5 (“Integrated regional observing systems”) in order to gather information about the status of regional observing networks in both the north and south Atlantic to optimize IOCCP’s contribution to WP1 Task 1.2: “Capacities, gaps and feasibility.”

On Tuesday 28 June, Artur Palacz and Maciej Telszewski also took part in the WP1 workshop to discuss the final outcome of Task 1.1: “Requirements for sustained ocean observations of the Atlantic”; to review the status of Task 1.2.; and to set a detailed plan for meeting the objectives set in Task 1.3: “Observing System Design Studies.” One of the priorities for the meeting was to identify the needs for organizing two workshops that help support obtaining goals set for WP1. One of the workshops was decided to be organized by IOCCP and hosted at IO PAN, Sopot, Poland.

Moreover, IOCCP was invited to present the concept of FOO and Essential Ocean Variables (EOVs) on the example of biogeochemistry to members of WP8 (“Societal benefits from observing/information systems”) in order to discuss issues of mismatch between the EOVS approach adopted by WP1 and AtlantOS in general, and the EMODnet approach chosen by WP8. A presentation by Artur Palacz was followed by a discussion that aimed to set

recommendations on how to enable a better harmonization of outputs given the required feedback between WPs.

The last of the series of workshops took place on 1 July. It was organized by WP1 and aimed at developing scenarios for test as part of the AtlantOS observing network enhancements. IOCCP was invited to contribute with its oversight of the current capacities and gaps of the biogeochemical observations in the Atlantic. One of the outcomes of this workshop was the decision to organize an AtlantOS-sponsored workshop on setting biogeochemical observing targets for the Atlantic Ocean, which eventually took place on 29 November–1 December 2016, in Sopot, Poland.

Colour and Light in the Ocean from Earth Observation (CLEO) Workshop, 6-8 September 2016, Frascati, Italy

The Colour and Light in the Ocean (CLEO) Workshop, organized by the European Space Agency (ESA) and the Plymouth Marine Laboratory (PML) was held on the ESRIN, the ESA Centre for Earth Observations, at Frascati, Italy on 6-8 September 2016. The objectives of the workshop were to evaluate the current state of the art in ocean products available from remote sensing observations and to recommend plans for future steps through identifying challenge areas and research priorities for future Earth observation data exploitation activities, among other purposes. To meet the ambitious goals set for this workshop, the organizers assembled a tremendous breadth of expertise in ocean colour product development and their various applications in climate and marine ecosystem research.

The CLEO workshop presented a unique opportunity for IOCCP to carry out informal consultations among the ocean colour community regarding the development of the Ocean Colour EO, as recommended by the GOOS SC during their June 2016 meeting.

IOCCP was represented by Artur Palacz, who was invited to take part in consultations aimed at verifying the needs of the scientific community in the field of oceanography for the future development of space missions to enable better and new application of remote sensing methods in oceanographic research. To this end, IOCCP actively participated in plenary and breakout group discussions. The effect of the CLEO workshop plenary and breakout group consultations was the publication of an ESA report, which includes recommendations from the ocean research community for planning future space missions, to be considered not only by European, but also American and Japanese space agencies. The report can be accessed from: <http://esaconferencebureau.com/2016-events/Cleo/workshop-report>

For IOCCP, the key outcome of this meeting was a list of challenges associated with formulating a dedicated Ocean Color EO specification sheet, as well as suggestions for alternative representation of this key set of measurements in the EO framework. Based on the feedback collected from CLEO workshop participants, the IOCCP Office then drafted three alternative proposals for executing the GOOS SC recommendation for including Ocean Colour as an EO, with the objective of reflecting the multidisciplinary character of ocean data products obtained from both in situ and remote sensing ocean colour measurements.

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GO₂NE Executive Council meeting, 7-9 September 2016, Paris, France

The Global Ocean Oxygen Network (GO₂NE) Executive meeting was held on 7-9 September 2016 in Paris, France. IOCCP was represented by Maciej Telszewski - a member of the Executive.

Following requests from marine biogeochemistry community over the past decade or so for increased cooperation and communication related to low oxygen concentration regions in the marine environment, IOC-UNESCO developed a Working Group focused on low oxygen research in both the open ocean and coastal areas. The GO₂NE working group assembled coastal and open ocean scientists, modellers, and biological, chemical and physical oceanographers.

The meeting discussions were aimed at producing a work plan and terms of reference for the group, including research as well as outreach and capacity building. General topics included how to facilitate communication with other established networks and working groups, improving observations systems, identifying and filling knowledge gaps, as well as developing related capacity-development activities. A wide range of actions are planned for the upcoming years to raise awareness on current and future impacts of declining oxygen concentrations on ocean and human health. The three major recommendations listed below were developed during the meeting and are currently the focus of the group's activity:

- There is an urgent need to extend the observation of oxygen in the marine environment in both the coastal and open ocean to provide data to better document current conditions, to improve simulations of the future ocean, to develop effective management strategies and to document the effectiveness of management efforts.
- Substantial efforts are needed to understand the effects of deoxygenation on fisheries at the scale of fish stocks, as well as to better quantify both the local and large-scale the economic and ecological consequences of negative effects of low oxygen on living resources, and society.
- Innovative solutions and multidisciplinary research approaches are needed to understand and reduce the combined effects of the wide range of stressors that affect open ocean and coastal systems (for example, the decreased pH, increased temperature and fisheries effects that co-occur with decreased oxygen) in order to preserve ecosystem functions and services.

Following the meeting, members of the expert group submitted a manuscript on global deoxygenation to Science, with IOCCP's Maciej Telszewski as a co-author. If accepted, this paper could provide a first milestone on GO₂NE's road to raising awareness and promoting continued ocean oxygen observations for the benefit of the society. Currently, the expert group is preparing a summary on deoxygenation for policy makers.

7th Everyone's Glider Observatory (EGO) meeting, 26-29 September 2016, Southampton, UK

The 7th EGO meeting was held on 26-29 September 2016 at the National Oceanography Centre, Southampton, UK. IOCCP was represented by Maciej Telszewski.

The IOCCP plenary presentation and break-out group discussions related to IOCCP were focused around each of the 8 EOVS Specification Sheets (available from <http://www.ioccp.org/index.php/foo>). These still have many gaps which IOCCP hopes to fill over the coming months and years. Many of these gaps will have to be filled by the development of a coordinated global glider observing network, utilizing the advantages that gliders have over other observing networks such as surface and subsurface ship observations, surface and subsurface moorings, floats, drifters and satellites.

IOCCP updated the glider community across disciplines on IOCCP efforts and presented short- and long-term strategies for the future. As the IOCCP works directly with several formal bodies programmatically connected to the WMO-IOC JCOMM to integrate ocean carbon and biogeochemistry observation information into the GCOS IP in support of the UNFCCC, the World Summit on Sustainable Development, GEO, and other international and intergovernmental strategies, we are obliged to bring every single observing element to the “table” and discuss their relevant role in the system. In our opinion, a direct communication and coordination with communities focused on platform types is necessary to fully connect the opportunities arising in the decision and policy-making arena with the technical developments occurring globally at the national and regional levels. The EGO meeting served as a platform for exactly that type of communication and coordination. Perhaps no immediate actions will arise from this communication, but the steering group of EGO took notice and will be directly involved in future GOOS activities.

International Conference on Marine Data and Information Systems (IMDIS), 11-13 October 2016, Gdańsk, Poland

The International Conference on Marine Data and Information Systems (IMDIS) took place on 11-13 October 2016, in Gdańsk, Poland. IOCCP Project Officer Artur Palacz and IOCCP SSG Member Benjamin Pfeil, responsible for the Data and Information Access Services theme, represented IOCCP at this event. By attending this meeting, IOCCP achieved two goals:

- (1) To promote and gather community support for initiating the Global Data Assembly Centres (GDACs) for marine biogeochemistry; and
- (2) To gather an overview of existing data management solutions and challenges with respect to multi-platform and multi-EOVS data integration efforts.

The first goal was achieved through a poster presentation and a series of informal consultations conducted by Benjamin Pfeil throughout the three-day meeting.

The second goal was achieved collectively through participation in several sessions, and through targeted consultations with marine data managers, working on both national and international data in terms of long-term archival, quality control, and information product delivery to stakeholders, among others tasks.

North Pacific Marine Science Organization (PICES) Annual Meeting, November 2016, San Diego, CA, USA

The 25th Anniversary Annual Meeting of the North Pacific Marine Science Organization (PICES) was held from November 2 to 13, 2016 in San Diego, CA, USA. Responding positively to annually reoccurring invitations from PICES Executive Secretary, the IOCCP took this opportunity to present various aspects of IOCCP activity to selected panels and committees of PICES. IOCCP was represented by Maciej Telszewski. Specific discussions with PICES panels are summarized below:

PICES Section on Carbon and Climate (S-CC)

Inter-programmatic discussions were focused on 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 the 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.

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. A 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.

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 EOVS-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 datasets.

Setting Observing Targets for Biogeochemical Observing System in the Atlantic – AtlantOS workshop, 29 November–1 December 2016, Sopot, Poland

The “Setting Observing Targets for Biogeochemical Observing System in the Atlantic” AtlantOS workshop, co-organized by the Institute of Oceanology of the Polish Academy of Sciences (IO PAN) and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), was held on 29 November–1 December 2016 at the Institute of Oceanology of the Polish Academy of Sciences (IO PAN) in Sopot, Poland. It brought together 15 experts (and two remote participants) in biogeochemical observations and modelling from several countries around the

Atlantic: Brazil, United States, Norway, Ireland, United Kingdom, Belgium, France, Germany and Poland. The broad expertise of workshop participants, reaching across the different ocean disciplines and including a perspective on data requirements for societal benefits, was critical to meeting the ambitious goals of this workshop, which were to

- (1) Define what an observing target is in the context of the BGC observing system
- (2) Decide phenomena for which to set observing targets (based on the list of phenomena developed by AtlantOS WP1)
- (3) Set observing targets for BGC phenomena (described by relevant variables)
- (4) Analyse feasibility of set targets with respect to current capacities and identified gaps
- (5) Provide recommendations for designing an optimized Atlantic Ocean observing system

The majority of the time during this 3-day workshop was spent in breakout groups tasked with assigning quantitative and qualitative targets for each of the key biogeochemical phenomena to observe in the Atlantic.

In this workshop the following definition of a phenomenon was used, as adopted by GOOS in the context of EOVs and setting targets for their observations:

*A **phenomenon** is an observed process, event, or property, with characteristic spatial and time scale(s), measured or derived from one or a combination of EOVs, and needed to answer at least one of the GOOS Scientific Questions.*

Prior to the workshop, the Organizing Committee drafted a working definition of an observing target. This definition was approved during the workshop as follows:

*An **observing target** is set to allow the observing system to detect changes in a given phenomenon sufficiently to address the relevant scientific questions and societal needs. Such a target needs to be set at the spatial and temporal scales the phenomenon is sensitive to, and at a desirable/known level of uncertainty, with consideration of all relevant EOVs.*

In setting biogeochemical observing targets for an enhanced and optimized Atlantic observing system the participants considered first of all those phenomena, knowledge of which relies on biogeochemical measurements. Additionally, selected phenomena which have high impact on biogeochemical cycles in the ocean were also considered, even if they were not necessarily regulated by biogeochemical processes, events or properties.

Detailed outcomes from the workshop will be soon published in a report, available for download [here](#).

Implementation of Multidisciplinary Sustained Ocean Observations (IMSOO) workshop, 8-10 February 2017, Miami, FL, USA

On 8-10 February 2017, Global Ocean Observing System (GOOS) Panels for Physics, Biology & Ecosystems and Biogeochemistry (IOCCP), and the Ocean Research Coordination Network

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(Ocean RCN) co-organized a workshop on "Implementation of Multi-disciplinary Sustained Ocean Observations (IMSOO)".

The 3-day workshop took place at the Florida International University campus, just north of Miami, FL, USA. Forty-nine experts in observing and modelling ocean phenomena, representing 35 institutions from 11 countries, focused their energy on identifying the requirements for and benefits of co-located, multi-disciplinary, sustained observations around three scientific problems: open ocean-shelf interactions, oxygen minimum zones, and plankton community changes. The outcomes of this workshop will be instrumental in setting the stage for the upcoming OceanObs'19 Conference. The initial set of implementable recommendations is being formulated and will be soon published in the workshop proceedings, and followed through by the organizers over the next 2 to 5 years.

With advances in observing technology, and the definition of EOVs, clear opportunities exist to improve the coordinated planning and implementation of observing activities measuring EOVs across the three disciplines.

The IMSOO workshop was designed to identify priority steps by bringing together users of established observing networks and experts in EOVs and science in all three ocean observation disciplines.

The major aims of the workshop were:

- Building on the established societal and scientific requirements expressed in EOVs, identify the key applications and phenomena that will benefit from co-located multi-disciplinary sustained observations
- Identify near-term innovation priorities for observing platforms and sensors to enable multi-disciplinary observations, and
- Identify programmatic and professional connections between existing and emerging observing networks that will increase multi-disciplinary observations

Most of the workshop was spent in breakout groups where priority steps for implementation of multi-disciplinary sustained observations were discussed with respect to three demonstration themes:

- Changes in plankton communities (including ocean colour)
- Oxygen Minimum Zones
- Open ocean, Shelf and Coastal Ocean Interactions

These themes were chosen because they represent global and challenging problems that are best addressed through collaboration of physical, biogeochemical and biological observations and analyses. Examining these three preselected themes provided a mechanism for looking at convergence across the ocean observing disciplines. Each breakout group, composed of both

experts and non-experts in a particular theme, effectively introduced a wider perspective and a more critical approach to fulfilling the workshop aims. Members of IOCCP SSG were distributed across all three themes, thus contributing with their knowledge of the state of the art and forward thinking ability with respect to marine biogeochemistry and multidisciplinary ocean observations.

Benefits of this cross-fertilization of ideas, skilfully synthesized into recommendations for an implementation plan by the workshop attendees, are expected to percolate through the ocean observing community and their efforts, as we gradually move closer to fulfilling the ambitious implementation goals set at this workshop, and in the long term improve the capability of GOOS to serve specific information needs, and to raise awareness of the foundational role of sustained ocean observations in delivering societal benefit.

The immediate outcomes from the workshop, based on specific demonstration themes, are a clear series of actions with some related milestones for efforts of collaborations across disciplines and observation platforms. These will be initially realized through joint participation in meetings and workshops planned for 2017 and 2018, with specific actions already taken to hold side meetings devoted to IMSOO topics.

Other immediate actions focus around conceiving synthesis, review and position statement publications to provide the necessary context for enhancing multidisciplinary sustained observations under each demonstration theme and in response to societal needs. Finally, only a few of the planned actions fall within currently funded activities; therefore, the groups will now turn towards securing required resources through funding avenues identified at the workshop.

Detailed outcomes are documented in the workshop proceedings, published and available for download from www.goocean.org/imsso-report.

GOOS Executive Meeting, 11 February 2017, Miami, FL, USA

The GOOS Steering Committee Executive is composed of the chairs and secretariat of the GOOS panels, GRAs, and the JCOMM Observations Coordination Group. It met immediately following the NSF Research Coordination Network - GOOS Implementation of Multi-Disciplinary Sustained Ocean Observations workshop (8-10 February 2017, Florida International University, Miami, USA).

The priority for the meeting was to discuss the development of a forward-looking, aspirational, 5-10 year strategy for GOOS. The GOOS Strategy would also drive alignment of the priority actions in the structures of GOOS, and would also be instrumental for setting priorities for IOCCP as leading the GOOS Biogeochemistry Expert Panel.

Second on the agenda was the planning and organization of the OceanObs'19 Conference. IOCCP was asked to propose suitable candidate(s) to represent ocean biogeochemical and/or multidisciplinary observations as co-Chair(s) of the Organizing Committee. Among several requirements listed, key is the demonstrated ability to connect to the user space.

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The remainder of the meeting was devoted to discussing progress in developing EOVs. IOCCP reported on progress and decisions concerning the Ocean Colour EOV and the potential Marine Contaminants EOVs. Toste Tanhua also briefed the Executive on the current status of work of the G7 Future of the Oceans and Seas Working Group, putting emphasis on the many opportunities for extra resources for implementing a sustained, multidisciplinary global ocean observing system as a result of the recommendations put forward by the Working Group.

The 4th Integrated Carbon Observation System (ICOS) Monitoring Stations Assembly (MSA) and Ocean Thematic Centre (OTC) meeting, 1-2 March 2017, Bergen, Norway

The fourth ICOS OTC and MSA meeting was held in Bergen on 1-2 March 2017. The target group for the meeting was all station PIs in the ocean network and representatives of the Ocean Thematic Center hosted by the Bjerknes Centre, Uni Research Climate and Geophysical Institute. The aim of the meeting was to agree on criteria for the station labelling of the different ocean stations. Most stations are operational today, but after station labelling, the stations provide high-quality certified traceable ICOS data used to calculate the ocean's role in the carbon cycle, in particular concerning the recording of greenhouse gases due to human emission.

IOCCP was represented by Maciej Telszewski and the major aim of this participation was to provide the global perspective to this regional effort, seeking mutual benefit from lessons learned over the 12 months prior to the meeting. The target group for this particular meeting was all station operators in the ocean part of ICOS and representatives of the Ocean Thematic Center itself. IOCCP's major interest was to highlight the need for inclusion of carbon-relevant measurements as "Desired" in the certification process. Most stations are operational already, but after certification, the stations will start to formally provide high-quality certified traceable ICOS data.

Also, in the light of the fact that ICOS does not exist in many countries in the region, the IOCCP acted as an informal advocate for inclusion in ICOS of individual stations from countries where ICOS structures are not developed or not in the process of being developed. Although this suggestion was considered valuable and potentially beneficial, regulatory restrictions exist which at the moment prevent its implementation. Further considerations will be given during the intersessional period and communication will be reported to potentially interested parties.

GOA-ON Executive Council meeting, 25-27 April 2017, Paris, France

The Executive Council conducted their annual meeting at the UNESCO headquarters in Paris between 25 and 27 April 2017. IOCCP was represented by Maciej Telszewski and Richard Feely.

Major issues discussed include the potential for a hosted GOA-ON secretariat, the plan for developing a GOA-ON implementation strategy, including how to integrate the exciting work happening within the regional networks, ongoing global and regional efforts to enhance OA data collection and sharing, and opportunities for GOA-ON to engage with other international initiatives.

8th Session of the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM)'s Observation Coordination Group (OCG), Qingdao, China, 22-25 May 2017

Representatives of most observing networks forming the Global Ocean Observing System, as well as those serving operational needs of marine meteorology, reported on the status, issues and challenges of their particular network. This bi-annual meeting provides a platform for cross-fertilization as well as drawing interdisciplinary, multiplatform strategies. IOCCP was represented by Maciej Telszewski. Issues discussed during the 8th Session included but were not limited to the following:

- Network status – measured against requirements with details of variables (scales, accuracies, application)
- Metrics - definition and implementation progress
- Standards and best practices (draft and documented)
- Evolution of network/new technologies/sensors
- Logistics and resource issues
- Capacity-building opportunities/requirements
- Issues and challenges, ideas for integration, way forward

IOCCP continues to advocate the needs of biogeochemical measurements being implemented throughout the system. Many of the participating networks were developed with ocean physics and meteorology in mind, and it is crucial that the needs for interdisciplinary knowledge are explicitly expressed and actions are taken to gradually equate the proportion of observations made with specific disciplines in mind.

As an outcome from this year's meeting, the IOCCP was asked to develop a 2-year and a 5-year strategy aimed at permanent integration of biogeochemical observing efforts with the ongoing and future JCOMM-OCG activities. The 2-year strategy will focus around the following four issues:

1. A comprehensive overview of biogeochemical observations on all platforms represented at the annual JCOMM-OCG meeting

Each observing network that aspires to conduct biogeochemical observations should report on their detailed status (such as number of assets in the water, sampling duration and frequency, EOVs measured etc.)

2. Annual evaluation of the Technical Readiness Levels of all observing networks conducting biogeochemical observations

Each observing network that aspires to conduct biogeochemical observations should report on their globally assessed TRL to observe each claimed EOV. This would enable development of targeted activities aimed at improving the readiness level of specific networks and EOV measurements.

3. Formation of SOOP-BGC observing network

This is aimed at creating support for dedicated secretariat time for SOOP-BGC

4. Guidance to the Time Series community on how to organize into an observing network

This capacity is lacking. Scattered efforts by IOCCP, U.S. OCB and IGMETS have dissipated since 2013. We need leadership placing an umbrella over these communities, also including OceanSITES.

All the meeting information including the final meeting report, background documents and PowerPoint presentations can be downloaded from the meeting website: http://ioc-unesco.org/index.php?option=com_oe&task=viewEventRecord&eventID=1919.

Project Office (PO)

Co-chairmanship system introduced by IOCCP SSG

Over the 6-months period prior to the meeting, the IOCCP SSG discussed several fundamental elements of its structure and that included the strategy for chairmanship. The SSG decided that the expanding scope of the program (as expressed in the updated Terms of Reference to include several carbon-related Essential Ocean Variables in its coordination efforts) requires additional engagement of one of the SSG members to share the workload associated with chairing of IOCCP. In the light of this decision, Dr. Masao Ishii was asked to step-up to a co-Chair position and he kindly accepted the role. Until now, Masao served as the SSG member responsible for Interior Ocean Observations, and he will also remain in that role all through 2017.

XII IOCCP SSG Meeting

The XII Session of the IOCCP Scientific Steering Group was held on 6-7 February 2017, at the Roz and Cal Kovens Conference Center, Florida International University, Biscayne Bay Campus, Florida, USA. Ten SSG members were joined by two PO staff and four guests (representing IOC-UNESCO, GOOS and individual observing networks).

Beyond discussions related to the many exciting activities related to individual IOCCP themes, the group focused on a few overarching developments that shape the global perspective on current and future requirements for ocean observing, and which provide context for ongoing and future IOCCP activities.

One such event was the verification of the 2016 GCOS Implementation Plan in Marrakech during the COP-22 in November 2016. IOCCP was heavily involved in writing the ocean chapters in the 2016 GCOS IP and Toste Tanhua presented relevant elements of the Plan at COP-22. The connection between climate and ocean observing systems is clearly on the intergovernmental agenda and with the COP decisions being implemented on the political and

governance levels, the IOCCP's contributions are going to be soon realized through a top-down (requirements-funding-implementation) structures on top of, traditional for IOCCP, bottom-up (scientific questions – observing capacities – information products) efforts.

Another overarching issue discussed in Miami was the UN Agenda 2030 and particularly its ocean-related Sustainable Development Goal 14 (SDG14): *Conserve and Sustainably use the Oceans, Seas and Marine Resources for Sustainable Development* (<https://sustainabledevelopment.un.org/sdg14>). As the development of targets and indicators for SDG14 is an ongoing process, the IOCCP community should provide organized and/or individual input to further these concepts, allowing IOCCP to progress the underlying science and monitoring efforts. The earliest opportunity to do so comes in the form of 'Ocean Conference: Our Oceans, Our Future: Partnering for the Implementation of SDG14', to be held on 5-9 June 2017, in New York, USA.

Finally, the Panel noted the important implications of the recent developments with regard to the G7 Science and Technology Ministers setting ocean observation as a priority for the future of the ocean. This process started with the meeting in Tsukuba in 2016, followed by the Tsukuba Communiqué. Recommendations from the G7 ocean working group for the ocean observing system are being actively influenced by leaders of the major observing networks, with hope that they will become implementable action items for the seven economies and beyond.

With these high-level political agendas and many exciting technological developments furthering our capacity to observe the intertwined complexity of ocean systems, the IOCCP plans to take full advantage of all the opportunities for promoting ocean biogeochemistry observations to provide critical information necessary for assessing the past, current and potential future variability and potential impact of this variability on current and future human and nature wellbeing.

The full report from the XII session, including detailed description of almost 50 action items, is available from the IOCCP website at: http://www.ioccp.org/images/D3meetingReports/IOCCP-SSG-XIIth-Session-Report_FINAL.pdf.

Website and newsletter

Over the past year, the IOCCP put strong emphasis on updating the content of the project website. Frequent updates were noted by the community and were met with a lot of frequently expressed enthusiasm. This development is only possible thanks to the employment of the second staff person for the office. On top of improvements in the content, significant updates to the content management system were made, allowing additional features and improving security. The site was moved to a dedicated server, and a careful analysis of user statistics was initiated. Furthermore, dedicated thematic pages on the IOCCP website were subject to update and expansion, when necessary. Individual teleconferences were organized on approximately half of the themes, under the guidance of respective SSG members to discuss and update the relevant page on the IOCCP website, including careful analysis of existing and missing content, as well as connections to resources available elsewhere. The remainder of the pages will be gradually

updated over the course of 2017.

In 2016, IOCCP released three issues of its newsletter, with another one appearing in April 2017. Gradually, the scope of the newsletter is being expanded by introducing new regular columns, such as the ‘new IOCCP SSG profile’ and focusing on one chosen thematic theme per issue.

Publications

IOCCP partially supported the activities leading to the publications below through the U.S. National Science Foundation grant (OCE- 1243377) to SCOR.

- [Olsen, A.](#), Key, R.M., van Heuven, S., [Lauvset, S.K.](#), Velo, A., Lin, X., Schirnack, C., Kozyr, A., [Tanhua, T.](#), Hoppema, M., Jutterström, S., Steinfeldt, R., Jeansson, E., [Ishii, M.](#), Pérez, F.F., and Suzuki, T. (2016). The Global Ocean Data Analysis Project version 2 (GLODAPv2) – an internally consistent data product for the world ocean, *Earth Syst. Sci. Data*, 8, 297-323, doi:10.5194/essd-8-297-2016.
- [Lauvset, S.K.](#), Key, R.M., [Olsen, A.](#), van Heuven, S., Velo, A., Lin, X., Schirnack, C., Kozyr, A., [Tanhua, T.](#), Hoppema, M., Jutterström, S., Steinfeldt, R., Jeansson, E., [Ishii, M.](#), Perez, F.F., Suzuki, T., and Watelet, S. (2016). A new global interior ocean mapped climatology: the 1° × 1° GLODAP version 2, *Earth Syst. Sci. Data*, 8, 325-340, doi:10.5194/essd-8-325-2016.
- Bakker, D.C.E., [Pfeil, B.](#) Landa, C.S., Metzl, N., O’Brien, K.M., [Olsen, A.](#), Smith, K., Cosca, C., Harasawa, S., Jones, S.D., Nakaoka, S., Nojiri, Y., Schuster, U., Steinhoff, T., Sweeney, C., Takahashi, T., Tilbrook, B., Wada, C., [Wanninkhof, R.](#), Alin, S.R., Balestrini, C.F., Barbero, L., Bates, N.R., Bianchi, A.A., Bonou, F., Boutin, J., Bozec, Y., Burger, E.F., Cai, W.-J., Castle, R.D., Chen, L., Chierici, M., Currie, K., Evans, W., Featherstone, C., Feely, R.A., Fransson, A., Goyet, C., Greenwood, N., Gregor, L., Hankin, S., Hardman-Mountford, N.J., Harlay, J., Hauck, J., Hoppema, M., Humphreys, M.P., Hunt, C.W., Huss, B., Ibáñez, J.S.P., Johannessen, T., Keeling, R., Kitidis, V., Körtzinger, A., Kozyr, A., Krasakopoulou, E., Kuwata, A., Landschützer, P., [Lauvset, S.K.](#), Lefèvre, N., Lo Monaco, C., Manke, A., Mathis, J.T., Merlivat, L., Millero, F.J., Monteiro, P.M.S., Munro, D.R., Murata, A., Newberger, T., Omar, A.M., Ono, T., Paterson, K., Pearce, D., Pierrot, D., Robbins, L.L., Saito, S., Salisbury, J., Schlitzer, R., Schneider, B., Schweitzer, R., Sieger, R., Skjelvan, I., Sullivan, K.F., Sutherland, S.C., Sutton, A.J., Tadokoro, K., [Telszewski, M.](#), Tuma, M., Van Heuven, S.M.A.C., Vandemark, D., Ward, B., Watson, A.J., Xu, S. (2016) A multi-decade record of high quality fCO₂ data in version 3 of the Surface Ocean CO₂ Atlas (SOCAT). *Earth System Science Data* 8: 383-413. doi:10.5194/essd-8-383-2016.

IOCCP SSG members and staff are marked in [blue](#).

Future Directions

Specific Action Items developed during the XII IOCCP SSG meeting (6-7 February 2017, Miami, FL, USA) will be instrumental in guiding the coordination and communication services provided by IOCCP in the near future. Many of these planned actions are dictated by the growing needs and challenges of the marine biogeochemistry community, as accounted for in the new IOCCP Terms of Reference. A set of general priorities and examples of specific near-future activities is presented below, grouped by IOCCP theme.

Surface Water CO₂ Observations

With the onset of new and upcoming $p\text{CO}_2$ sensors capable of performing inline measurements, deployed not only for ship-based underway observations, but also for other platforms, there is a need to ensure that rigorous requirements for data accuracy are met. Future IOCCP efforts will aim at coordinating a concerted community effort to fully constrain the uncertainty, accuracy and performance characteristics of the new generation of $p\text{CO}_2$ sensors, as well as to better constrain uncertainties of other carbonate system elements being measured, including CO_2 in the atmosphere. A series of intercomparison studies should take place in 2017 and 2018 to meet this goal.

First, in 2017 a second global inter-laboratory comparison of seawater CO_2 measurements is planned under the leadership of Andrew Dickson. The goal of this comparison is to assess the present quality of seawater CO_2 measurements for total alkalinity, total dissolved inorganic carbon, and pH.

Second, an intercomparison of all underway $p\text{CO}_2$ systems will be organized, likely in 2018. This exercise, currently in planning stages, could benefit from support of other partner projects, such as EU Horizon2020 AtlantOS, to ensure proper evaluation of intercomparison results, and an ultimate production of a best practices guide to all underway $p\text{CO}_2$ sensors.

Further efforts will consider the accuracy requirements for air-sea CO_2 flux calculation. A workshop on the correct application of data reduction protocols is envisaged for the first part of 2018. It is imperative that such protocols be used not only to calculate fluxes from ship-based measurements, but also from moorings and other platforms. Meeting this requirement would also increase the quality of data submitted annually to SOCAT. IOCCP plans to engage significantly in this process, including making relevant software and protocols accessible from the IOCCP website.

Data Synthesis Activities: Surface Ocean

Significant progress has been achieved by the SOCAT team over the past few years. Most notably, for SOCATv4 published in 2016 the data providers submitted their data using the new automated dashboard. The dashboard integrates the upload of data, metadata and other reports, with the data submission and preliminary data viewing allowing the data provider to do an initial assessment of their data quality. Automation of SOCAT is key in terms of timely delivery of synthesis products used downstream, for example, by the Global Carbon Project, and in the future, hopefully other assessment reports, such as the World Ocean Assessment.

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Some outstanding challenges laid out in the past year's report remain, such as inclusion of ancillary biogeochemical variables, and the expansion to other synthesis products. The future of SOCAT will be discussed at length during the IOCCP-sponsored workshop on "Marine Carbon and Biogeochemistry Data Management and Synthesis" – a side event to the ICDC10 Conference at Interlaken, Switzerland in August 2017. This workshop will bring together the communities engaged in delivering and using existing and planned marine carbon and biogeochemistry data products, including SOCAT.

Based on lessons learned during the development of SOCAT and GLODAP, the aim of the workshop is to discuss (i) the challenges and opportunities related to connecting the carbon and biogeochemistry data currently available from several sources globally, and (ii) the need to build an integrated access point for different carbon and biogeochemistry data types from major observing platforms (ships, moorings, floats, gliders).

Moreover, the workshop sessions will discuss a pathway towards extending the existing and planned data products beyond primarily carbonate chemistry measurements and into a full scope of Biogeochemistry EOVs, which in many cases are measured using novel sensor technology.

Ocean Interior Observations

The main future actions under this theme concern (i) the development of the revised GO-SHIP Repeat Hydrography Manual, and (ii) the recommendations from observing networks to the G7 Future of the Oceans and Seas Working Group.

The GO-SHIP Repeat Hydrography Manual ("Hydro Manual") (<http://www.go-ship.org/HydroMan.html>) is now under considerations for update. The current edition (V1) is missing a chapter dealing with the measurements of dissolved organic matter (DOM). The Hydro Manual also does not comprise Standard Operation Protocols for fluorescence or backscattering and they became urgently needed in the light of rapid development of the Biogeochemical Argo (BGC Argo). A rapidly increasing number of floats carry these sensors and operators often rely on GO-SHIP data for Calibration/Validation. Update of the macronutrients chapter is also ongoing.

Recommendations of the G7 Future of the Oceans and Seas Working Group present a number of opportunities for IOCCP. G7 has an interest in producing more regular assessments of the ocean, akin to the ones made by IPCC on climate. A key requirement is to identify and mobilize national funding for sustained observations, which means that requests for more operational-based funding schemes need to be put forward to national governments.

Some specific recommendations drafted so far of relevance to IOCCP consider a request for 2 person months for SOOP-CO₂ support, and 6 person months for GO-SHIP. Also, a dedicated GOOS G7 Office is being planned, with headquarters outside of the IOC, but very related to ongoing GOOS activities. Such a structure would potentially enable new funds raised for IOCCP and observing network activities. It should be noted that BGC Argo is on top of the list of

specifications for implementation. Deep Argo, OceanGliders and SOOP-CO₂ are also of high importance to the Working Group.

The recommendations document is currently in an iterated review stage, and will be submitted to G7 national representatives later this year. FOO and EOVS concepts, which appear ubiquitously in the drafted recommendation documents, will be central to the implementation of these recommendations.

Data Synthesis Activities: Interior Ocean

With the development of the new GLODAP Reference Group (RG) and associated Terms of Reference, priority is now to start inviting candidates to join the GLODAP RG. It is likely that the RG will have two co-Chairs, with Are Olsen being one of them to ensure continuity of GLODAP activities. The GLODAP RG will mostly be a virtual group, however, one face-to-face meeting should be planned in association with every new GLODAP product version release.

Moreover, there is an urgent need now to develop a strategy for obtaining funding for the GLODAP RG IT infrastructure and activities (mainly technical workshops), without which the planned work will not occur. IOCCP will maintain its support for GLODAP, but other sources of funding are required.

Immediate future actions include resolving website hosting for past and future GLODAP releases. This task is urgent considering the shutdown of CDIAC-Oceans.

A critical action is to hold a technical workshop at which new adjustments will be agreed in order to proceed with the publication of GLODAPv3 product, foreseen for mid-2018. The workshop is pending the final assembly of the RG and adjustment tables becoming available.

Although GLODAP challenges and future directions will be discussed at the IOCCP side event at the ICDC10 Conference, holding the technical workshop alongside this meeting was deemed premature. Instead, IOCCP plans to hold the workshop in conjunction with the 2018 Ocean Sciences Meeting in Portland, OR, USA, in February 2018.

Time Series Efforts

Future IOCCP actions with respect to Time Series Efforts will focus on tightening the collaboration with U.S. Ocean Carbon & Biogeochemistry (OCB) and IGMETS. There is a need to jointly revive the communication and information exchange among the programs and among time-series station PIs, both those engaged initially during the [2013 International Time Series Methods workshop](#) and those currently responsible for time-series measurements on various platforms around the globe.

Key topics to discuss between the programmes include a potential time-series data product, plans and ideas for the OceanObs'19 Conference, and the most recent status of the development of EOVS.

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For the development of a ship-based time-series data product, concurrent developments and improvements of handling bottle data and partial automatization of QC routines as part of GLODAP and SOCAT will be highly beneficial. The time-series community could piggyback on this infrastructure and the experience that exists within GLODAP and SOCAT. The idea of a community-driven time-series data product should be discussed amongst major time-series sites, with IOCCP coordinating such a process.

Nutrients

Following the very successful 2015 inter-laboratory comparison exercise, IOCCP has confirmed its commitment to support the next inter-laboratory nutrient comparison, to be conducted in late 2017 or early 2018. A questionnaire was recently sent out to participants of the first exercise. The responses will help better tailor the second comparison to the community needs and expectations.

Furthermore, IOCCP will strongly recommend that the use of SCOR-JAMSTEC CRMs for nutrients become mandatory for all GO-SHIP Repeat Hydrography cruises. IOCCP will urge the community to take up a more pro-active approach in securing financial resources to enable purchases of adequate number of CRMs for each planned cruise.

Ocean Acidification

As in the case of Time Series Efforts, key future actions for IOCCP with respect to Ocean Acidification should be oriented around conceptualizing, developing and implementing OA-related synthesis product(s). IOCCP SSG recognized the urgent need for responding to societal requirements for new data synthesis products for OA-related indicators to help meet the relevant SDG14 targets and Aichi Biodiversity targets, called for by the UN Agenda 2030 and the Convention on Biological Diversity (CBD), respectively.

IOCCP must rely strongly on its scientific partners (SOLAS, IMBER, CLIVAR) to drive the generation of new information products. Potential overlaps between synthesis product-related activities in relevant themes of IOCCP will need to be avoided, ideally by combining such activities (or at least scoping workshops).

On a regional level, tighter coordination of OA efforts in Africa is expected as a result of the newly formed OA Africa hub, as well as through several recent and planned training workshops and networking events. In Latin America, LAOCA is organizing its first scientific symposium to be held in Buenos Aires, Argentina, in October 2017. The symposium themes will include ocean acidification observing systems, modelling and regional projections of ocean acidification in Latin America, physiological and ecological impact of ocean acidification: from organisms to ecosystems, and human dimension of ocean acidification research.

Framework for Ocean Observing

Future IOCCP actions related to the Framework for Ocean Observing will focus on curating the Biogeochemistry EOVs, as well as continuous work towards better harmonization of all GOOS EOVs. IOCCP plans to post a revised version of all BGC EOV Specification Sheets in the boreal summer 2017. The 2017 version will reflect important changes to the Specification Sheet structures, better consistency between BGC and other EOVs, and a more comprehensive list of phenomena described through given EOV measurements.

Efforts to produce the first draft of the Ocean Colour EOV Specification Sheet are ongoing. Pending the decisions on the nature of IOCCG's involvement in the process, it is anticipated that the document will be made available in the early 2018.

Considering that the concept of EOVs is not unique to GOOS, but rather has already been used in an increasing number of contexts, for example, deep ocean EOVs, Southern Ocean EOVs, to name just a couple, it is of prime importance to document the GOOS EOV process in a peer-reviewed publication. A first draft has been produced and is undergoing a review by the writing team, composed of members of the GOOS Executive. The paper is expected to be published in early 2018.

In the longer perspective, IOCCP will turn its focus towards Observing Network Specification Sheets. Though interlinked with the EOV Specification Sheets to some extent, the former are intended to provide comprehensive descriptions of the sampling design and methodologies adopted by various programmes, projects and panels, such as GO-SHIP, BGC Argo, SOOP-CO₂ and others.

Data and Information and Access Services

Much of the activities pertaining to the Data and Information and Access Services theme were described under Data Synthesis Activities as well as Ocean Acidification and Time Series Efforts.

First, the focus will be on expanding the portfolio of synthesis products to OA and Time Series, building on the experience and data systems used for SOCAT and GLODAP.

Second, the need to build an integrated access point for several carbon and biogeochemistry data types from various observing platforms (ships, moorings, floats, gliders) will be attended to. Challenges and needs of the community will be discussed at the IOCCP workshop on "Marine Carbon and Biogeochemistry Data Management and Synthesis" – a side event to ICDC10.

Third, efforts will continue to implement the Biogeochemistry GDAC, as envisioned by IOCCP in its [2016 Data Management Position Statement](#). With the support of the community already gathered, the realization of IOCCP's vision depends on the successful collection of funds.

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Instruments and sensors

The remainder of 2017 and first half of 2018 will see IOCCP devote a substantial amount of resources to preparing the second edition of the IOCCP Sensors Summer Course. The provisional date is set for June 2018, and the venue will again be the Sven Lovén Centre for Marine Infrastructure in Kristineberg, Sweden.

In the coming weeks IOCCP will seek partners to assist IOCCP with financial and human resources for organizing the course and will clearly define the scope of the workshop. Considering that IOCCP is downstream from sensor development activities, the focus of the course should be on the established sensors, and not on promoting cutting-edge technology. The course will expand beyond moorings as sole observing platforms used for training and may include sailing boats, floats and surface autonomous vehicles. Similarly, the scope of the course should reach beyond carbonate chemistry and include oxygen and nutrients, as previously. The target audience for this course was agreed to include less-experienced users, that is, postdocs and late-stage PhD students.

Oxygen

Starting January 2018, IOCCP will add Oxygen to its list of themes. Veronique Garçon will become the SSG member responsible for oxygen-related issues. IOCCP is looking forward to expanding its expertise and scope of activities with respect to this component of the global ocean observing network, which is not only maturing rapidly but which is also gaining increasing attention in the end user space.

As part of GO₂NE, in the coming years IOCCP plans to take part in several actions to raise awareness of current and future impacts of declining oxygen concentrations on ocean and human health. In this context, GO₂NE is committed to broaden the understanding and support underlying science regarding the impacts of nutrient pollution on increased deoxygenation (SDG 14.1). It further supports the implementation of sustainable fisheries (SDG 14.7), and aims to improve the knowledge of how reduced oxygen levels are linked to additional stressors, such as harmful algal blooms, ocean acidification and global warming, that combine to reduce marine ecosystem resilience and ecosystem services (SDG 14.3). Some of the suggested actions include:

In 2017:

- A technical brief and scientific synthesis on deoxygenation in the ocean
- Coordination with GOOS through following up on the recommendations from the IMSOO workshop (see below)
- Ongoing support of newsfeed website with regard to deoxygenation and the impacts on the ocean in collaboration with SFB754

In 2018:

- Support of the O₂ international scientific conference, which will bring together the watershed-based and open ocean deoxygenation researchers, and scientists from Small

Island Developing States (SIDS), developing countries, and developed economies (<https://www.sfb754.de/o2conference2018>)

- Global Atlas on ocean low-oxygen areas
- Capacity building – workshops, planning of summer school

In 2019 and beyond:

- Outreach products, capacity building, scientific exchange
- Convene an oxygen theme session at OceanObs'19 to elevate awareness and discussion
- Actively develop innovation and scientific coordination related to deoxygenation observing, technology transfer, management practices (mitigation and adaptation) in the context of the International Decade of Ocean Science for Sustainable Development

VOICE: Variability in the Oxyclyne and its ImpaCts on the Ecosystem

An example of such a globally coordinated action jointly coordinated with GOOS is described in an implementation strategy for the project VOICE: “Variability in the Oxyclyne and its ImpaCts on the Ecosystem”, which is currently in planning stages. VOICE was conceived at the recent Implementation of Multidisciplinary Sustained Ocean Observations (IMSOO) workshop, held in February 2017, in Miami, FL, USA. Co-organized by IOCCP and attended by members of GO₂NE, IMSOO focused on drafting implementation strategies for three selected demonstration themes that by their nature require sustained, multidisciplinary ocean observations. VOICE was developed by participants of the Oxygen Minimum Zones (OMZs) demonstration theme breakout group, who agreed on a project that would target a specific key feature of the OMZ that is of high relevance in the context of many of the scientific objectives – the upper oxyclyne.

The project would be carried out in several phases, and would include an analysis of historical data from the selected sites, and the development of a conceptual model of oxyclyne dynamics, among other products. The major anticipated outcome of the VOICE project would be a blueprint of a multi-disciplinary sustained OMZ observing system, outlining a minimum and optimized set of observational and modelling requirements for a fit-for-purpose system that is capable of informing society about the variability of the oxyclyne and its impacts on the ecosystem and which is applicable within the global ocean observing system. Details of the proposed project will appear in the IMSOO proceedings, to be published in a couple of weeks.

A successfully completed 5-year VOICE project would be a critical element in designing and implementing, as well as securing funding for, an observing system within ten years that is capable of addressing the overarching question of “How do changing Oxygen Minimum Zones (OMZs) affect the spatio-temporal distribution, productivity and trophic structure of the benthic and pelagic communities?”

The first step towards implementing the strategy is planned for September 2017, through a two-day workshop back to back with the next GO₂NE Executive Meeting in Monterey, Calif, USA.



SOOS
SOUTHERN OCEAN
OBSERVING SYSTEM

THE SOUTHERN OCEAN OBSERVING SYSTEM

ANNUAL REPORT

TO THE SCOR EXECUTIVE COMMITTEE

2017

Background

SOOS is a joint initiative of the Scientific Committee on Antarctic Research (SCAR) and the Scientific Committee on Oceanic Research (SCOR), and endorsed by the Partnership for Observations of the Global Ocean (POGO), and the Climate Variability and Predictability (CLIVAR) and Climate and Cryosphere (CliC) projects of the World Climate Research Programme (WCRP).

SOOS was launched in 2011 with the mission to facilitate the collection and delivery of essential observations on dynamics and change of Southern Ocean systems to all international stakeholders, through design, advocacy, and implementation of cost-effective observing and data delivery systems.

SSC Membership

Co-chairs: Physical Sciences Co-Chair: Prof. Anna Wåhlin (Sweden) and Biological Sciences Co-Chair: Prof. Oscar Schofield (USA)

Vice-chairs: Physical Sciences Vice-Chair: Dr. Sebastian Swart (Sweden) and Biological Sciences Vice-Chair: Dr. Andrew Constable

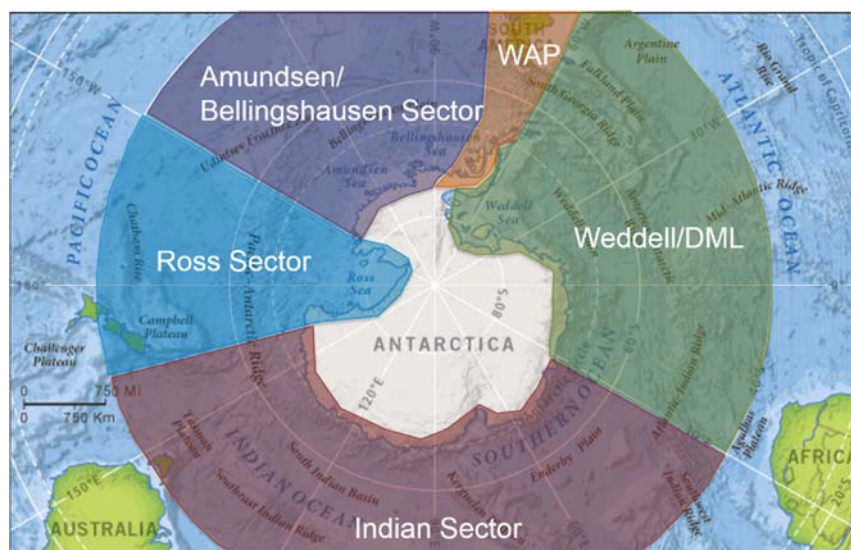
Other Members: Dr. Parli Venkateswaran Bhaskar (India), Prof. Dake Chen (China-Beijing), Prof. Daniel Costa (USA), Dr. Sang Hoon Lee (Korea), Prof. Mauricio Mata (Brazil), Prof. Michael Meredith (UK), Dr. Matthew Mazloff (USA), Dr. Burcu Ozsoy (Turkey), Dr. Jean-Baptiste Sallee (France), Prof. Anya Waite (Germany), and Dr. Mike Williams (New Zealand)

Update on key activities

- **SOOS Regional Working Groups - status (more information [here](#))**

SOOS is developing 5 Regional Working Groups that will coordinate and implement the observing system in their region, bringing together efforts in planning, logistics, resources, data management and access. These regional groups will encompass national observing

efforts, and will work with circumpolar observing programs and projects to ensure required coverage of observations.



- **West Antarctic Peninsula Working Group:**
 - * Chairs: Oscar Schofield (USA), Kate Hendry (UK), Sian Henley (UK), South American chair to be identified
 - * 2016 activities: 1) Organisation of the first workshop from 15-16 May 2017, hosted by BAS, UK
- **Southern Ocean Indian Sector Working Group:**
 - * Chairs: Tsunuo Odate (Japan), Philippe Koubbe (France), So Kawaguchi (Australia), Andrew Constable (SOOS Liaison)
 - * 2016 activities: 1) development of leadership; 2) identification of host and venue for the first workshop (13-16 August 2017, NIPR and TUMSAT, Japan)
- **Ross Sea Working Group:**
 - * Chairs: Mike Williams (New Zealand), Walker Smith (USA), Giorgio Budillon (Italy)
 - * 2016 activities: 1) development of leadership, 2) planning of first workshop (hosted by Meng Zhou, 11-15 Sept 2017, Shanghai Jiao Tong University, China), 3) workshop funding proposal to U.S. CLIVAR (decision pending), 4) discussions with CCAMLR Ross Sea Marine Protected Area planning group, 5) involvement of Chairs in the CCAMLR Ross Sea MPA workshop on development of monitoring and observation requirements
- **Weddell/DML Working Group:**
 - * Chairs: To be identified
 - * 2016 activities: 1) outreach to the Alfred Wegener Institute to gauge interest in development 2) planning for initial scoping meeting. This will be a half-day joint

SOOS-AWI symposium (13 June 2017, hosted by AWI, Germany) with involvement of representatives from other nations involved in the region, including South Africa, France, Norway, UK and Brazil.

- **Amundsen/Bellingshausen Working Group:**
 - * This working group has not yet been initiated. Discussions will be held at the June 2017 Scientific Steering Committee meeting to plan a way forward for its development.
- **SOOS Capability Working Groups - status (more information [here](#))**

SOOS Capability Working Groups help develop important observational capabilities, such as developing and implementing technologies, improving observational design, efficiency and coverage, and enhancement of information management and dissemination. They are either initiated by SOOS or proposed by the broader community.

- **Censusing Animal Populations from Space:**
 - * Chairs: Mark Hindell (Australia), Peter Fretwell (UK)
 - * 2016 activities: 1) Development of a number of research grants submitted to international funding agencies; 2) an annual workshop alongside SCAR OSC; 3) workshop report
- **Southern Ocean Fluxes:**
 - * Chairs: Seb Swart (Sweden), Sarah Gille (USA)
 - * 2016 activities: Working group is fully established, with finalised Terms of References following the 2015 workshop. Has developed four focused Task Teams to push specific activities.
- **Benchmarking (eEOV):**
 - * Chairs: Andrew Constable, Others TBA
 - * 2016 activities: Specific working group activities have stalled, but future efforts will be coordinated as part of the Theme 4 program of work of the “Marine Ecosystem Assessment for the Southern Ocean ([2018 MEASO](#))” conference. This international conference will be sponsored by SOOS and will develop community efforts around assessment of the status and trend of habitats, key species and ecosystems in the Southern Ocean. This will form the basis for ongoing work of this working group.
- **SOOS-initiated POGO Working Group Observing and Understanding the Ocean beneath Antarctic sea ice and ice shelves (OASIIS):**
 - * Chairs: Esmee van Wijk (Australia), Richard Coleman (Australia), Pierre Dutreix (USA), Laura Herraiz-Borreguero (UK), Alexander Brearley (UK)

- * 2016 activities: 1) Successful proposal for funding of working group by Partnership for Observation of the Global Oceans (POGO); 2) development of leadership team; 3) Organisation of first workshop (14-17 June 2017, AWI, Germany)

- **SOOS Key Products – 2016 progress and current status**

- **Community review of Southern Ocean satellite data needs** : A joint SOOS-CliC-SCAR effort, providing a statement on Southern Ocean satellite data needs, across research, industry and logistical communities, and with the scientific rationale required to underpin future strategic planning and investment.

- **Database of Upcoming Expeditions to the Southern Ocean “DueSouth”:**

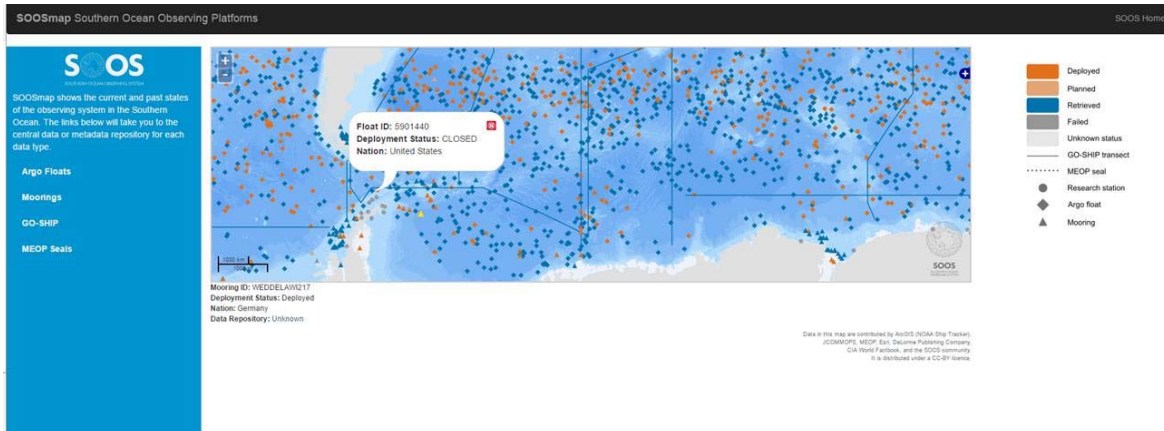


This is a tool that enables the community to share information on upcoming field campaigns and voyages. It enhances opportunities for collaboration and sharing of resources, as well as support logistics and planning. Developed with in-kind resources by the

Australian Antarctic Division, the database is currently sitting at <https://data.aad.gov.au/duesouth/> and will be moved to its own url at www.duesouth.soos.aq within the next few weeks. It will be integrated and coordinated with the efforts of COMNAP and SCAR to better inform the scientific community of activities in the region. SOOS is open to community involvement in development and population of this database. A direct link from our [homepage](#) will be provided after the site goes live.

- **SOOS Map:**

SOOSmap will be an interactive web map of the major observing platforms in the Southern Ocean, with the capacity to filter the results by time and by platform type. It will demonstrate the status of the Southern Ocean Observing System. Towards development of an initial “un-resourced” version of this product, the SOOS data officer was successful in a funding proposal and in 2016 undertook a professional development course in web mapping through Penn State University. The initial infrastructure for the map has been built, and contributing data streams have been identified and included (see below, not yet online).



In order to provide a more functional and well-supported tool long-term, SOOS is currently in discussion with communities such as JCOMMOPS and EMODnet-Physics groups, who have the resources and infrastructure to develop and host maps of Southern Ocean Observing Platforms. We hope to deliver a fully supported community product by the end of 2017.

– **Annual Community Calendar:**

An online, interactive calendar that provides an annual view of all upcoming meetings of relevance to the Southern Ocean observational community. This will help avoid schedule clashes, enhance joint-meeting planning, and keep the community up-to-date on SOOS activities.

– **Southern Ocean Mooring Network and data rescue:**

This project has two components:

- 1) To provide location and status information on all moorings deployed in the Southern Ocean via an [online map](#);

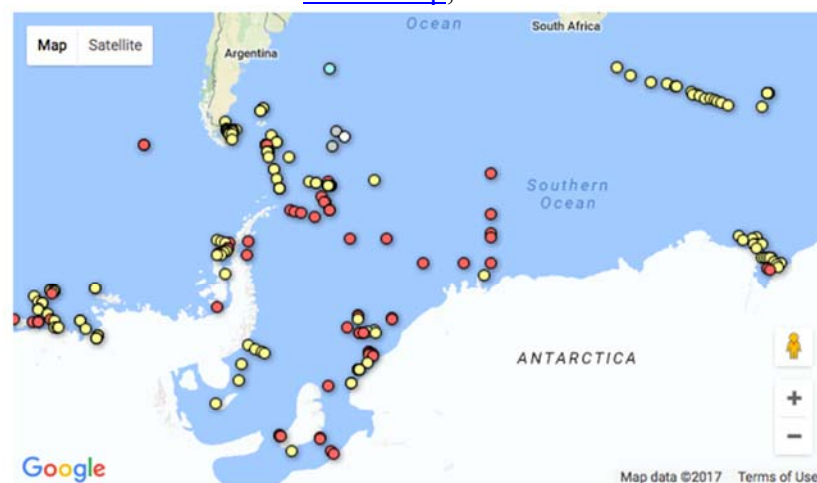


Fig. 1. Map of Southern Ocean mooring locations. Red = currently deployed, yellow = retrieved, grey = unknown deployment status, white = failed, turquoise = planned.

- 2) Support submission of orphan mooring data. Funded by the U.S. Big Earth Data Initiative, this is a joint SOOS-NCEI (US National Center for Environmental Information) effort to rescue and publish data from international oceanographic moorings. Thus far, the project has translated mooring data from New Zealand, USA (multiple institutional datasets), Italy and Sweden and this will soon be available through NCEI. Translation of mooring data from other institutes in the USA, Korea and China is currently being negotiated. If time allows, this project may focus on registration of mooring platforms at JCOMMOPS.
- **NASA GCMD [SOOS Metadata portal](#) :**
Continued growth of individual researchers' metadata records, and negotiations for bulk harvest of metadata from key portals (e.g., AODN, PANGAEA, CCHDO, SeaDataNet)
 - **[NECKLACE](#) data management:**
Identification of data issues and requirements of NECKLACE community, identification of available infrastructure to meet community needs, and development of a NECKLACE data policy
- **Programmatic Connections of note in 2016**
 - CCAMLR: The CCAMLR secretariat and SOOS IPO meet regularly to ensure collaboration on aligned objectives. CCAMLR is involved in all SOOS Regional Working Group workshops. SOOS is involved in discussions on development of the Ross Sea MPA, and other MPA proposals
 - SC-CCAMLR and CEP: SOOS was involved in the 2016 Joint CEP and SC-CCAMLR workshop
 - WMO Year of Polar Prediction (YOPP): SOOS IPO is supporting the WMO YOPP effort through outreach and communication activities. An official SOOS point-of-contact for YOPP has been nominated (Matthew Mazloff, SIO, USA) and is engaged at a scientific and coordination level
 - **Communication and Outreach in 2016**
 - 3 Newsletter issues published – subscribe here
<http://www.soos.aq/index.php/registration>
 - 6 peer-reviewed [publications](#)
 - 2 [Workshop Reports](#)
 - SOOS 2016 [Posters and Presentations](#) published online
 - Regular updates to social media channels
 - **Meetings and Workshops in 2016**
In 2016, SOOS was presented or represented at 21 international meetings/workshops. SOOS also held the following meetings:
 - SOOS Data Management Sub- Committee Meeting (May 2016, Scripps USA)

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- Joint SOOS-SOCCOM Workshop (May 2016, Scripps USA)
- International workshop of SOOS-endorsed NECKLACE project (Oct 2016, Sweden)
- SCAR OSC Scientific Session (Aug 2016, Malaysia)
- **SOOS Governance and Strategic Activities in 2016**
 - 3 new members of the Scientific Steering Committee (SSC): Anya Waite (Germany), Burcu Ozsoy (Turkey), Dake Chen (China)
 - 3 new National Representatives: Sandra Barreira (Argentina), Piotr Kuklinski (Poland), Bruno Delille (Belgium)
 - SOOS SSC Meeting (May 2016, Scripps USA)
 - SOOS Executive Committee Meeting (May 2016, Scripps USA)
 - Finalisation of the [5-Year Implementation Plan](#) (still in progress)
 - Development of the 5-Year Business Plan (currently under approval)
 - Development of the SOOS Stakeholder Engagement strategy (currently in draft)

Upcoming Activities in 2017/2018

- The following meetings will take place in 2017:
 1. West Antarctic Peninsula Working Group (May 2017, UK)
 2. SOOS Executive Committee Meeting (June 2017, Germany)
 3. SOOS Scientific Steering Committee meeting (June 2017, Germany)
 4. SOOS Data Management sub-Committee meeting (June 2017, Germany)
 5. POGO OASIIS Working Group (June 2017, Germany)
 6. Indian Sector Working Group (Aug 2017, Japan)
 7. Ross Sea Working Group (Sept 2017, China)

Challenges

The SOOS International Project Office (IPO) is funded in the following manner:

- 1) Salaries of the 2 staff (at 1.8 %FTE) is funded by the Australian Research Council's Antarctic Gateway Partnership, with contribution by the University of Gothenburg, Sweden and overheads covered by the University of Tasmania, Australia.
- 2) Direct funding of IPO by the Australian Research Council's Antarctic Gateway Partnership, Australian Antarctic Division, and Antarctica New Zealand
- 3) In-kind sponsorship of IPO through delivery of services and expertise: University of Gothenburg (Sweden), Rutgers University (USA), Australian Antarctic Division, Australia's Integrated Marine Observing System (IMOS), Tasmanian Partnership for Advanced Computing (TPAC), NASA GCMD, Bioflex Nutrition (Australia)

Funding of staff and direct funding for the IPO is not secure long-term, and ends in mid-2018 when the Australian Research Council's Antarctic Gateway Partnership program ends. Whilst efforts are being made by SOOS and the Australian community to ensure continuation of staff and IPO support beyond 2018, no funding pathway presently exists.

In addition to this, SOOS is at a point of significant growth and activity, and existing IPO staff and resources are insufficient to support this growth. Nearly all SOOS products and activities are un-resourced, and rely on volunteer and in-kind efforts. SOOS has developed a 5-Year Business Plan (draft available by request) that articulates the resources required to deliver the 5-Year Implementation Plan (<http://soos.aq/activities/implementation>) and invites discussion with any parties interested to contribute to this international initiative.

Report to SCOR and IAPSO on JCS Activities June 2016-May 2017**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
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Industry Representatives

Richard Williams (OSIL)	UK
Barbara Laky (Anton Paar)	Austria

Meetings

JCS did not meet as a full group in 2016-2017. However, 6 JCS members did attend the 2016 IAPWS Annual Meeting in Dresden, Germany (Sept 11-16, 2016), including new member RW, head of the Standard Seawater Service. Two JCS members attended the 2016 International Symposium on Stratified Flows (San Diego, Aug 29-Sept 1, 2016).

Web site

JCS maintains a Web site at www.teos-10.org. This site gets 1,400-2,700 visitors per month (8,560 in the past year, with 55,689 “unique views” since Oct. 2010). Annual downloads have decreased slightly in the last year compared to the previous two.

Web site Item	Unique downloads June 2011- June 2013	Unique downloads June 2013- June 2014	Unique downloads June 2014- June 2015	Unique downloads June 2015- June 2016	Unique downloads June 2016- June 2017
Manual	920	360	535	552	418
Getting Started	879	362	558	547	427
Slides	704	284	374	318	219
Primer	584	197	289	297	222
GSW_MATLAB_v3_0	1920	1102	1485	1814	1235
GSW_FORTRAN_v3_	366	222	171	162	127
GSW_C_v3_0	202	84	133	151	85
GSW_PHP	-	55	61	43	29
SIA_VB	72	100	46	45	45
SIA_FORTRAN	59	118	58	44	36

Other Progress

1. SIA software version 3.01.3 and 4.0.1 released.
2. RF attended BIPM CCT meetings for WG-Hu with support of IAPWS, and for the plenary session (Sevres, France) on May 29-June 2, 2017 to discuss the redefinition of Humidity on a thermodynamic basis, supporting SI traceability. An explicit proposal (Publication [1]) was presented and well received; two subsequent companion papers on measurement principles and requisite equations are now in preparation. A detailed plan was also developed by WG-Hu to work towards inclusion of relative humidity in a future version of the SI brochure as an example of a dimensionless quantity.
3. JCS wrote a support letter for a multi-institutional proposal related to JCS tasks; however, it was not funded.
4. The 4 *Metrologia* review papers published in January 2016 continue to be heavily downloaded, especially part 4 on relative humidity, although the rate for all has

noticeably decreased since the end of open access at the end of 2016. As of 30/5/2017:

- Part 1: Overview – 3,438 downloads (986 since 31/5/2016)
- Part 2: Salinity – 2,195 downloads (671 since 31/5/2016)
- Part 3: pH – 2,209 downloads (687 since 31/5/2016)
- Part 4: RH – 4,579 downloads (1807 since 31/5/2016)
- total: 12,421

Parts 1 and 4 of the *Metrologia* papers have just been selected as one of the “2016 Highlights of *Metrologia*”. These papers have their own Web page (http://iopscience.iop.org/journal/0026-1394/page/Highlights_of_2016), are given another year of free open access, and the authors also get a nice certificate suitable for framing.

5. RP/HU carried out a second set of density anomaly measurements in Canadian Arctic Archipelago (w/ K. Brown, WHOI – July 2016).
6. FM carried out density anomaly measurements over the East Pacific Rise (April 2017).
7. SW continued a decadal series of measurements of density anomalies in the Baltic.
8. HU, FM, HW are continuing measurements of density in SSW batches; this information will be collated in a planned publication.
9. HW, HU, SW, RP are still writing the ‘Best Practices Guide for seawater Density Measurements’ (still at version 13).
10. SS is still investigating instrument effects on conductance measurements.
11. BL reports an accredited lab for density measurements.
12. FC, DS, SS and others continue work along the lines of last year’s publications, and are particularly engaged in a) measurement of alkalinity, b) uncertainty budgets and traceability, and c) education actions and tools on pH (https://iupac.org/projects/project-%20details/?project_nr=2013-013-1-500)
13. AD continues to provide seawater buffers for pH.
14. Through working with SCOR WG 145, in which he is a member, AD and two others are now funded for a 3-year program of work including developing a Pitzer model to estimate activity coefficients for Tris buffers in seawater (coordinating with SS, DS, and others).

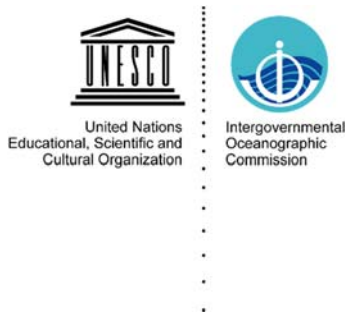
Papers published

1. R. Feistel, J.W. Lovell-Smith, Defining Relative Humidity in terms of Water Activity. Part 1: Definition. Accepted by *Metrologia*, May 2017.
2. P.M. Barker and T.J. McDougall, Stabilising hydrographic profiles with minimal change to water masses, accepted by *Journal of Oceanic and Atmospheric Technology*, May 2017.
3. T.J. McDougall, S. Groeskamp, S.M. Griffies, Comment on Tailleux, R. Neutrality versus Materiality: A Thermodynamic Theory of Neutral Surfaces, *Fluids* 2016, 1,32, *Fluids*, *Fluids* 2017,2,19: doi:10.3390/fluids2020019

R. Pawlowicz

JCS chair, June 7, 2017

4.4 GlobalHAB

Urban, Sun

GlobalHAB - the International SCOR-IOC Science Program on Harmful Algal Blooms

Program Activities 2016-2017

GlobalHAB Scientific Steering Committee members

Chair: Elisa Berdalet (Spain)

Vice-chair: Raphael Kudela (USA)

Other Members: Neil S. Banas (UK), Michele Burford (Australia), Christopher J. Gobler (USA), Bengt Karlson (Sweden), Po Teen Lim (Malaysia), Lincoln Mackenzie (New Zealand), Marina Montresor (Italy), and Kedong Yin (China-Beijing)

Liaisons:

Eileen Bresnan, Marine Scotland Science, United Kingdom, ICES representative
 Keith Davidson, The Scottish Association for Marine Science, United Kingdom, Ex-officio
 Vera L. Trainer, National Oceanic and Atmospheric Administration, USA, ISSHA and PICES representative
 Gires Usup, Universiti Kebangsaan Malaysia, Malaysia, IPHAB representative

Sponsor Representatives:

Henrik Enevoldsen, IOC UNESCO/ University of Copenhagen, Denmark
 Ed Urban, Scientific Committee on Oceanic Research, USA

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The GlobalHAB Scientific Steering Committee (SSC) acknowledges the financial and logistic support received from SCOR during this 2015-2017 period. The funds have made possible the meetings of the GlobalHAB SSC to develop the GlobalHAB Science and Implementation Plan, representation of the program at international meetings and publications completing the work of the GEOHAB programme. SCOR funds will also contribute to the implementation of some initiatives prioritized by GlobalHAB at short-term. The GlobalHAB activity is described next.

1. Development of the GlobalHAB Science and Implementation Plan

Development of the *GlobalHAB Science and Implementation Plan* was initiated by the GlobalHAB SSC during its first meeting, held in Oban, UK (March 2016) and continued afterwards through on-line communications. The first draft version of the Plan was presented at the SCOR Annual Meeting in Sopot, Poland (September 2016) by Elisa Berdalet. Further, a formal initiation of GlobalHAB took place at the 17th International Conference on Harmful Algae (ICHA) (<http://icha2016.com/about/>) with attendance of most members of the GlobalHAB SSC. A Town Hall session dedicated to GlobalHAB was held in October 12, 2016, announced also in *Harmful Algal News* N. 53. The draft of the *GlobalHAB Science and Implementation Plan* and the preliminary webpage setup were presented. The venue facilitated a useful discussion with the international community studying HABs and some implementation initiatives were presented and discussed by the attendees. The meeting allowed the invitation of the international community to participate actively in the program.

In January 2017, the first complete draft of the Plan was sent for evaluation by 9 external reviewers. GlobalHAB SSC members acknowledge the valuable concepts provided by the reviewers, which are contributing to the final version of the *Plan*.

The revised version of the plan was the focus of the second meeting of the SSC, held at the Stazione Zoologica di Napoli (SZN) in Naples (Italy) on March 28-30, 2017. The *GlobalHAB Science and Implementation Plan* follows the legacy of the former GEOHAB program, incorporating new themes and new implementation activities at short (3-year) and long-term (10-year) periods. The link of the scientific themes integrated in GlobalHAB is shown in Figure 1.

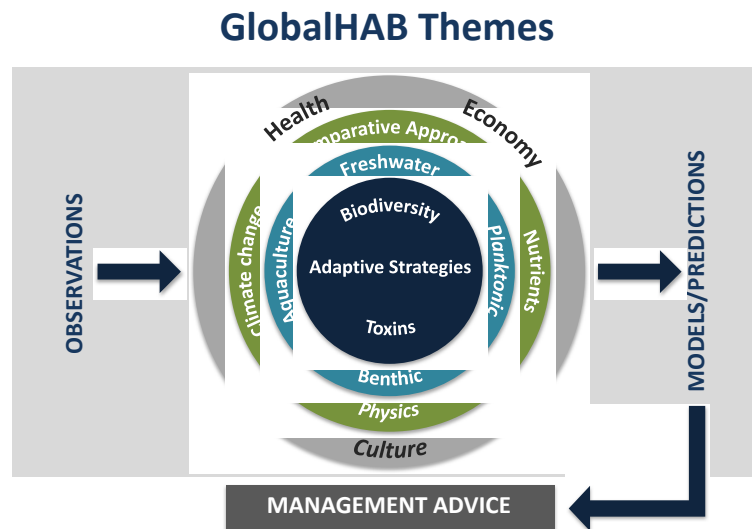


Figure 1. Themes integrated in GlobalHAB. Note that the terms "Physics", "Planktonic" and "Culture" refer to general aspects developed within the different Themes, and are included in the scheme to emphasize the multidisciplinary aspects included in GlobalHAB.

2. Meetings of the GlobalHAB SSC members



As mentioned above, the GlobalHAB SSC held its second meeting at the Stazione Zoologica di Napoli (SZN) in Naples (Italy) on March 28-30, 2017. The meeting included plenary and small working groups sessions to deal with the following agenda items:

- 1) Advance towards the finalization of the *GlobalHAB Science and Implementation Plan* considering the reviewers' comments received. Expected to be finished by mid-2017.

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2) Select a realistic set of Implementation Activities for the next short period (2017-2019) and establish the agenda to implement them, based on point 1) and including the reviewers' comments. The list of the first prioritized activities is presented in section 3.

3) Revise the GlobalHAB Website, expected to be active in mid-2017 at www.globalhab.info.

4) Analyse different issues that posed some urgency during the year: research on *Sargassum* and macroalgal blooms, coordination with the IOC GO₂NE program, a SCOR WG proposal on "HABs and Aquaculture", a proposal to NERC for an International Program Office at SAMS (UK), and collaboration with the multiagency Global Ciguatera Strategy (of IOC-IAEA-FAO-WHO).

5) Participate in developing the conceptual structure of a Good Practices Manual to investigate HABs and Climate Change. Mark Wells attended the meeting to facilitate the discussion of a first draft submitted to the SSC in advance. A second draft was produced and it was agreed that GlobalHAB will support the production of the Manual. Furthermore, the SSC will suggest an editorial team covering geographic diversity and scientific expertise to address the content of the manual.

3. Future work-plan for 2017-2019

Some of the activities to be conducted in the 2017-2019 period include:

- 1) Review paper to identify the knowledge gain and existing gaps on the biogeography and biodiversity of selected taxa. Leader: M. Montresor.
- 2) Session on HAB biogeography at the 18th International Conference on Harmful Algae (ICHA), in Nantes (France) 2018, in collaboration with ISSHA and ICHA organizers. Contact person: M. Montresor.
- 3) Coordination with the IPHAB Task Team to implement the multi-agency IOC-IAEA-FAO-WHO "Global Ciguatera Strategy". Nexus persons: E. Berdalet, H. Enevoldsen. Contact people: P. Hess, M. Chinain, P. Tester and M.-Y. Dechraoui Bottein (IAEA).
- 4) Workshop about the mode of action of fish-killing microalgae (and other related issues), in coordination with the Task team on "Fish-killing HABs". Contact person: A. Cembella, P.J. Hansen.
- 5) Endorsement of the inter-laboratory validation study on mass spectrometry methods of PSP-toxin analysis. Leader: L. Mackenzie, CEFAS-Cawthron activity.
- 6) Special issue on "Harmful Algae and Climate Change", in *Harmful Algae*, by 2019. Co-editors: C. Gobler and M. Wells.
- 7) Good Practices Manual. Nexus person: E. Berdalet. Leader: M. Wells.
- 8) Co-organization and participation in the activities of the IOC GO₂NE network. Nexus: R. Kudela. Leader: G. Pitcher.
- 9) Establish a Working Group on Macroalgal Blooms (*Sargassum*, *Ulva*). Contact people: E. Berdalet, C. Gobler, K. Yin. Leader: B. Lapointe.
- 10) Development of the GOOS Phytoplankton EOVS (Essential Ocean Variable), which includes HABs,

http://goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114.

Contact person: R. Kudela

4. Representation of the program at international events.

Information about GlobalHAB has been provided by:

- E. Berdalet at OCEANEXT: Interdisciplinary Conference, Nantes, France, 8-10 June 2016; "Multidisciplinary and coordinating initiatives to prevent and mitigate the impacts of HABs".
- P.T. Lim at the WESTPAC workshop on the development of a research strategy for HABs, Institute of Oceanography, Nha Trang, Vietnam, 19-21 Dec 2016, and at the IOC WESTPAC-HAB Workshop, 10th IOC WESTPAC Conference in Qingdao, China, from 17-20 April 2017.
- E. Berdalet, on behalf of the SSC, presented the Report of GlobalHAB Activities for the period 2015-2017 at the XIII Session of the IOC Intergovernmental Panel on Harmful Algal Blooms, UNESCO, Paris, 3-5 May 2017. The program was positively welcome and very interesting feedback was received, which will contribute to the implementation of the program.

5. GEOHAB Synthesis Products

At the official end of GEOHAB, some synthesis products were still in progress and GlobalHAB has taken responsibility to see them completed. These products include the following:

5.1. A special issue published in *Oceanography* magazine (The Oceanographic Society)

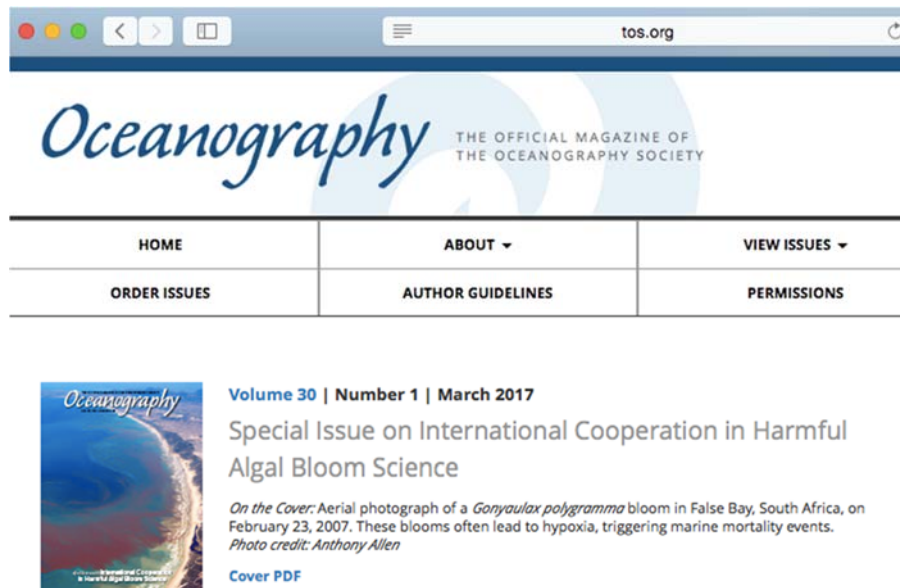
Volume 30, March 2017: <https://tos.org/oceanography/issue/volume-30-issue-01>

Title: International Cooperation in Harmful Algal Blooms Science

Guest Editors: Raphael Kudela, Henrik Enevoldsen and Ed Urban

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Sponsors: Grant OCE-1243377 from the U.S. National Science Foundation to the Scientific Committee on Oceanic Research for GEOHAB activities; the Intergovernmental Oceanographic Commission of UNESCO; and the University of Copenhagen. Additional funds were provided by the Ida Benson Lynn Endowment, University of California Santa Cruz.



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Oceanography Volume 30 | Number 1 | March 2017
Special Issue on International Cooperation in Harmful Algal Bloom Science
On the Cover: Aerial photograph of a *Gonyaulax polygramma* bloom in False Bay, South Africa, on February 23, 2007. These blooms often lead to hypoxia, triggering marine mortality events.
Photo credit: Anthony Allen
[Cover PDF](#)

Papers:

[GEOHAB—The Global Ecology and Oceanography of Harmful Algal Blooms Program: Motivation, Goals, and Legacy](#)

Kudela, R.M., E. Berdalet, H. Enevoldsen, G. Pitcher, R. Raine, and E. Urban. 2017. GEOHAB—The Global Ecology and Oceanography of Harmful Algal Blooms Program: Motivation, goals, and legacy. *Oceanography* 30(1):12–21, <https://doi.org/10.5670/oceanog.2017.106>.

[Harmful Algal Blooms in Eastern Boundary Upwelling Systems: A GEOHAB Core Research Project](#)

Pitcher, G.C., A.B. Jiménez, R.M. Kudela, and B. Reguera. 2017. Harmful algal blooms in eastern boundary upwelling systems: A GEOHAB Core Research Project. *Oceanography* 30(1):22–35, <https://doi.org/10.5670/oceanog.2017.107>.

[Harmful Algal Blooms in Benthic Systems: Recent Progress and Future Research](#)

Berdalet, E., P.A. Tester, M. Chinain, S. Fraga, R. Lemée, W. Litaker, A. Penna, G. Usup, M. Vila, and A. Zingone. 2017. Harmful algal blooms in benthic systems: Recent progress and future research. *Oceanography* 30(1):36–45, <https://doi.org/10.5670/oceanog.2017.108>.

[Harmful Algal Blooms in Fjords, Coastal Embayments, and Stratified Systems: Recent Progress and Future Research](#)

Berdalet, E., M. Montresor, B. Reguera, S. Roy, H. Yamazaki, A. Cembella, and R. Raine. 2017. Harmful algal blooms in fjords, coastal embayments, and stratified systems: Recent progress and future research. *Oceanography* 30(1):46–57, <https://doi.org/10.5670/oceanog.2017.109>.

[Globally Changing Nutrient Loads and Harmful Algal Blooms: Recent Advances, New Paradigms, and Continuing Challenges](#)

Glibert, P.M., and M.A. Burford. 2017. Globally changing nutrient loads and harmful algal blooms: Recent advances, new paradigms, and continuing challenges. *Oceanography* 30(1):58–69, <https://doi.org/10.5670/oceanog.2017.110>.

[GlobalHAB: A New Program to Promote International Research, Observations, and Modeling of Harmful Algal Blooms in Aquatic Systems](#)

Berdalet, E., R. Kudela, E. Urban, H. Enevoldsen, N.S. Banas, E. Bresnan, M. Burford, K. Davidson, C.J. Gobler, B. Karlson, P.T. Lim, L. Mackenzie, M. Montresor, V.L. Trainer, G. Usup, and K. Yin. 2017. GlobalHAB: A new program to promote international research, observations, and modeling of harmful algal blooms in aquatic systems. *Oceanography* 30(1):70–81, <https://doi.org/10.5670/oceanog.2017.111>.

5.2. A monograph on the application of Ocean Colour satellite techniques for the study of HABS. It is planned for publication in the *IOCCG Report* series. This book is the result of the collaboration between GEOHAB and the International Ocean Colour Coordination Group (IOCCG), with Steward Bernard, Raphael Kudela and Grant Picher as editors. The document will be structured around several representative case studies of HABS. Expected to be submitted to the printer in mid-2017.

5.3. A book published by Elsevier, under their *Ecological Studies* series.

Editors: Pat Glibert, Elisa Berdalet, Michele Burford, Grant Pitcher and Mingjiang Zhou.

Expected date of publication: Mid-2017 (to be send to the publisher in May 2017).

Chapters (updated list in March 2017):

	Chapter title	Authors
1	Preface	Glibert, Berdalet, Burford, Pitcher, Zhou
2	Harmful Algal Blooms: What they are, why they are harmful, where they are occurring, and the importance of understanding their ecology and oceanography	Glibert, Berdalet, Burford, Pitcher, Zhou
3	Introduction to the GEOHAB Program	Kudela, Berdalet, Enevoldsen, Pitcher, Raine, Urban
4	Harmful algal bloom expansion in concert with a sea of other global changes	Glibert et al.
5	Harmful algal blooms in a changing ocean	Wells and Karlson

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6	The role of life cycle characteristics on harmful algal bloom dynamics	Azanza, Brosnahan, Anderson, Hense, Montresor
7	Mixotrophy in HABs: Who, When, Why, Web interactions, and What Next	Flynn, Mitra, Glibert, Burkholder
8	Nutrients and HABs: Resource availability, substrate ratios, dynamic kinetics and flexible nutrition	Glibert, Heil, Wilkerson, Dugdale
9	Key questions and recent advances on HABs in upwelling systems	Pitcher, Figueiras, Kudela, Moita, Reguera, Ruiz-Villareal
10	Key questions and recent advances on HABs in eutrophic systems	Glibert, Allen, Bouwman, Burford, Zhou
11	Key questions and recent advances on HABs in fjords and coastal embayments	Roy, Montresor And Cembella
12	Key questions and recent advances on HABs in stratified systems	Berdalet, Reguera, Yamazaki, Jenkinson, Raine
13	Key questions and recent advances on HABs in benthic systems	Berdalet and Tester
14	Overview of harmful algal blooms in Asia	Furuya, Iwataki, Lim,Lu, Azanza, Kim, Fukuyo
15	Harmful algal blooms in the coastal waters of China	Yu, Lu, And Liang
16	Green tides of the Yellow Sea: massive free-floating blooms of <i>Ulva prolifera</i>	Dongyan Liu, Mingjiang Zhou
17	<i>Noctiluca</i> blooms in the Arabian Sea and Gulf of Thailand	Goes et al.
18	Recent Advances in Modeling of Harmful Algal Blooms	Peter J.S. Franks
19	Advancements in observing systems, instrumentation and operational tools for HABs	Glibert et al.
20	Emerging HAB research issues in freshwater environments	Burford, Hamilton, Wood
21	Mitigation and Control of HABs	Zhiming Yu, Xiuxian Song, Xihua Cao, Yang Liu
22	GlobalHAB	Berdalet, Kudela, Urban, Enevoldsen, Banas, Bresnan, Burford, Davidson, Gobler, Karlson, Lim, Mackenzie, Montresor, Trainer, Usup, Yin

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 in September 2015. 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.

Trends in Ecology and Evolution invited submission of a manuscript from the workshop. An update on the status of the publication will be presented at the SCOR meeting.