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## The IOCCP Conveyor No. 38, October 2017

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### A Word from the Editors

Dear Ocean Carbon & Biogeochemistry Community,

Time flies when the agenda is full and so it is, that six months have passed in an eye blink since our last newsletter. A lot has happened during that time, and

we, at IOCCP, want you to know all about it. This is why you might find this issue a bit lengthier than usual.

This year we are celebrating 10 years of the Surface Ocean CO<sub>2</sub> Atlas (SOCAT), so we take a look at the tremendous, continuing achievements of this unprecedented activity in our community. We also report on our strong presence at the ICDC10

Conference, e.g. through organization and co-organization of two important side events: on carbon and biogeochemistry data management and synthesis, and on future ocean carbon cycle research, respectively.

We continue our “meet IOCCP SSG” series with a profile of Doug Connelly, whose role is also highlighted in an article on the recently updated Sensors and Instrumentation Roadmap document. A relatively large chunk of the Conveyor focuses on activities of IOCCP as GOOS Biogeochemistry Expert Panel. Our efforts there include the release of the revised version of the Essential Ocean Variable Specification Sheets and the co-organisation of the Implementing Multi-disciplinary Sustained Ocean Observations (IMSOO) workshop and its follow-up activities.

Last but not least, this issue features some important news from the community, such as the publication of two major reports on the status of our ocean. And if you're looking to fill up your next year's calendar a bit more, be sure to check out our Upcoming Events section.

We hope that you will find this issue of the Conveyor informative and useful. Otherwise, please let us know how we can improve!

*Maciej Telszewski & Artur Palacz*

## SOCATv5 released at 10<sup>th</sup> SOCAT Anniversary

Celebrating its **10<sup>th</sup> anniversary** in 2017, SOCAT represents a milestone in biogeochemical and climate research, and in informing policy.

The SOCAT data is discoverable, accessible and citable. SOCAT enables quantification of the ocean carbon sink and ocean acidification and evaluation of ocean biogeochemical models.

In June, we were happy to inform you about the release of **SOCAT Version 5**, which has 21.5 million quality-controlled, surface ocean  $f\text{CO}_2$  (fugacity of carbon dioxide) observations from 1957 to January

2017 for the global oceans and coastal seas. Calibrated sensor data are also available in SOCATv5. Automation allows annual, public releases of SOCAT.

The SOCAT website ([www.socat.info](http://www.socat.info)) provides access to synthesis and gridded data products for version 5. Users can explore the data products via two powerful, interactive online viewers, the Data Set Viewer and the Gridded Data Viewer. Alternatively, users can download of the synthesis and gridded products with MATLAB code available for reading these files.

Figure 1 below illustrates the new data contribution of SOCATv5 and presents all data available to date, also derived from sensors. For more details on SOCATv5 please check out the  attached poster.

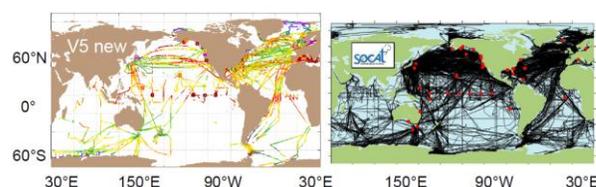


Figure 1. (left) New  $f\text{CO}_2$  values ( $\mu\text{atm}$ ) in version 5. (right) Location of moorings (red) and tracks of ships and drifters (black) for all data in version 5.

The  attached article (Bakker et al., 2016) documents the data products and quality control criteria in SOCAT version 3, which also apply to versions 4 and 5.

Users are kindly asked to follow the  SOCAT Fair Data Use Statement by generously acknowledging the contribution of SOCAT scientists by invitation to co-authorship, especially for data providers in regional studies. User feedback is essential for shaping future SOCAT products.

Please mark your calendars for the following two milestones before SOCATv6 release:

-  Data submission for version 6 ends **15 Jan 2018**.
-  Quality control for version 6 ends **31 Mar 2018**.

*Maciej Telszewski & the SOCAT Team*

## IOCCP at ICDC10

### IOCCP side event on data management

The core mission for IOCCP at the 10<sup>th</sup> International Carbon Dioxide Conference (ICDC10) in Interlaken, Switzerland, was to organize and run a half-day community workshop focused on IOCCP's activities related to data management and synthesis products development. The IOCCP side-event on "Marine Carbon and Biogeochemistry Data Management and Synthesis" took place on Wednesday, 23<sup>rd</sup> August 2017 as an official part of ICDC10, and was attended by over 50 scientists from 15 countries.



Photo 1. Participants of the IOCCP side event on data management at ICDC10.

The event highlighted the accomplishments, plans and challenges of communities engaged in delivering to and using existing and planned marine carbon and biogeochemistry data products, such as the Surface Ocean Carbon Dioxide Atlas (SOCAT) or the Global Ocean Data Analysis Project (GLODAP). Representatives of terrestrial and atmospheric carbon cycle research communities actively participated in the event and we used this opportunity to exchange perspectives on presented subjects.

Based on lessons learned during the development of SOCAT and GLODAP, the aim was to discuss (i) the challenges and opportunities related to connecting the carbon and biogeochemistry data currently available from several sources, and (ii) the need to build an integrated access point for several carbon and biogeochemistry data types from various observing platforms (ships, moorings, floats, gliders). Moreover, the five thematic sessions (surface ocean, ocean interior, time series, sensors, and general data management) discussed 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.

The side event focused on five main topics, with presentations and discussions summarized below:

### **SOCAT – Update and road ahead**

Several issues were presented and discussed during the first hour of the event. Based on the density of the agenda and large and active community participation it seems that a dedicated SOCAT-only meeting might be needed in the near future. In this article we highlight four topics, which are most relevant for the general community:

Discussions were continued around possible future inclusion of additional parameters to SOCAT. The SOCAT community agreed to include other surface parameters like nutrients, DIC, TA in SOCAT without quality control and release them in a separate file. This might start for version 7 (2019). There are ongoing discussions regarding the inclusion of surface ocean CH<sub>4</sub> and N<sub>2</sub>O in SOCAT or as a parallel data product using SOCAT infrastructure. The latest aspect of this issue concerns the inclusion of surface ocean fCO<sub>2</sub> calculated from other parameters most often based on sensor technology installed on floats and gliders. This issue will be taken further by the SOCAT and relevant IOCCP groups with the initial focus on the quality assessment of such data.

The second aspect concerns automated data upload to SOCAT. After many years of development, all SOCAT data are being submitted through the Upload Dashboard. Several advantages and some challenges were presented and discussed during the meeting. Also general gratitude to the developers of the Dashboard (Benjamin Pfeil and Camila Landa with their team in Bergen, and Kevin O'Brien and Karl Smith with theirs in Seattle).

Thirdly, the progress on the automation of the SOCAT metadata upload was discussed. The aim of the automation is to automate quality control of the metadata, in order to improve the metadata quality and to reduce the quality control effort. The objective

is to have the automated metadata upload in place for SOCAT version 7 (2019).

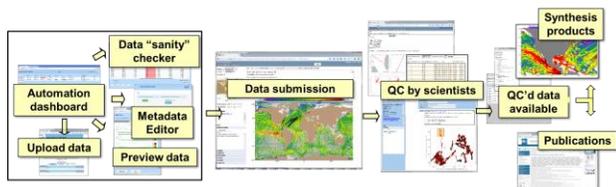


Figure 2. SOCAT automation and annual public release diagram.

Finally, the possible setup of a system for surface ocean methane ( $\text{CH}_4$ ) and nitrous oxide ( $\text{N}_2\text{O}$ ) using SOCAT infrastructure was discussed. There is a growing need for observing non- $\text{CO}_2$  greenhouse gases in marine environment, e.g.  $\text{CH}_4$  and  $\text{N}_2\text{O}$ . During the past few years, instruments measuring these two gases with the same frequency as is common for  $\text{CO}_2$  measurements by IR (infrared) instruments have become available. They can be used in existing setups for surface ocean  $\text{CO}_2$  measurements without much additional effort. This results in data sets that have  $\text{CO}_2$  and  $\text{N}_2\text{O}$  and/or  $\text{CH}_4$  measurements combined. There is interest from the observational and modelling community to combine these data streams. Discussions are held with MEMENTO (MarinE MethanE and NiTrous Oxide) scientists regarding the strategy and procedures for such a combined effort to become more globally implemented.

You can read the full description of what was discussed at:

<https://www.socat.info/index.php/meetings/>.

## GLODAP – Update and road ahead

Two issues presented and discussed during the GLODAP session are highlighted here.

First is related to data quality control, specifically the pH measurements. Historical potentiometric pH measurements have not been included in GLODAPv2 and this was queried during the discussion. There are at least two challenges related to this issue: (i) often unknown accuracy of the potentiometric pH measurements and (ii) unsatisfactory consistency of seawater  $\text{CO}_2$  system calculations. For (i) the group decided to form a 'pH task force' within GLODAP, to focus on determining the quality of existing

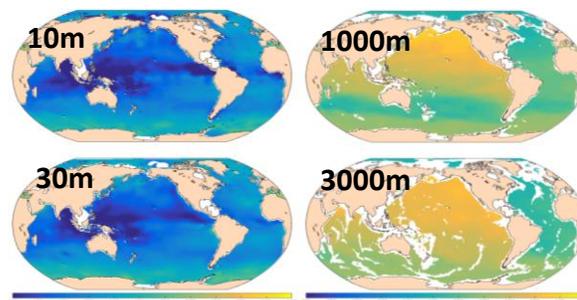


Figure 3. Total inorganic carbon ( $\text{TCO}_2$ ) in year 2002 at four different depth levels. Source: GLODAPv2.

potentiometric pH data and work on their inclusion in the GLODAP data product. For (ii) there is a need for a working group on the improvement of the seawater  $\text{CO}_2$  chemistry dissociation constants. Possibly a SCOR working group application should be considered.

The second theme extensively discussed during the GLODAP session was the inclusion of sensors-based data from biogeochemical profiling floats in the future releases of the data product. The current global network consists of ca. 300 active floats and still needs to undergo a transition to an operational observing system with sustained funding allowing to maintain a network of around 1000 biogeochemical Argo floats, which would need 250 deployments per year. However, data are already being produced in large quantities and global data collections like GLODAP need to start taking advantage of the new technologies allowing to increase the spatial and temporal data coverage. Best practices manuals for data quality assessment need to be updated so that the existing, high accuracy bench-top instrument-based data products could benefit from the ever-increasing sensors-based data stream.

## Time Series – Data coverage and availability

The entire discussion that followed the initial presentation was held in the context of the need for the time series community to get somewhat organized in order for coordination efforts of IOCCP, OCB, OceanSITES and others to take place. Whether it's measurements and data treatment protocols, funding, building capacity through training and otherwise, or developing data synthesis products for various parameters, it's impossible to coordinate amongst several hundreds of stations on an individual basis. A strong push in this direction was given by the

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coordination bodies in 2012, when the Global Intercomparability in a Changing Ocean: An International Time-Series Methods Workshop was organized. One of the goals there, was to establish an international network of ship-based time series. The initial steps were taken, but the community needs to capitalize on this effort and formalize the network structure so that at least communication amongst all interested parties is maintained.



Development of a global, time-series based data synthesis product was proposed as an activity promising to attract interest

from most sites and therefore serving as an axis for coordination. Such a product would have to serve a (set of) specific science goal(s), that in turn would have to be within scientific interest of participating sites. The ability to observe long term variability in physical, biogeochemical and biological phenomena and short- to long-term interconnectivity between the processes governing this variability, puts time series in a unique position within the global ocean observing system and makes the potential synthesis product(s) an extremely valuable perspective.

Comments from participants were very positive, however it was cautioned that such an effort would require a number of very dedicated champions across disciplines and some dedicated funding for coordination and technical infrastructure.

## ***Autonomous Sensors – What happens between unpacking the box and providing a useful information product***

This session looked at almost revolutionary change in requirements, specific needs and capabilities for biogeochemical measurements made with sensors. Widening the scope of sensor measurements beyond the traditional IOCCP-focus centred around carbonate system requires careful assessment of sensors' capabilities to provide measurements with required accuracy and precision. The development of international standards for sensor operation and data management is critical to assure the quality of the data output in order for the community to be able to develop confidence in the same way we have

confidence in the traditional methods of analysing the variables of interest.



The role of the IOCCP and wider GOOS community was discussed in the context of focussing the requirements for sensor measurements of most biogeochemical EOVs.

This requires active coordination efforts between sensor manufacturers, the wider scientific community and funding bodies.

A couple of major challenges were highlighted and discussed. The first is the fact that marine biogeochemistry measurements represent a relatively small market for sensor developers and therefore relatively small effort is made by the developers to improve the overall usefulness of any given sensor for individual applications after the product is brought to the market. It is therefore very important that the scientific community gets involved in funding of sensors development so that continued hardware testing and improvement is made possible regardless of perhaps unsatisfying financial gain for the industry. Such active involvement will also help the manufacturer community gain awareness of the requirements we have in terms of accuracy, precision or even the environment we need to work in.

The second major challenge is related to the large gap that exists between the technology already available or being developed and the capacity to use this technology around the world. Besides the financial challenges that need to be overcome in order to acquire the technology, still too many institutions lack the appropriate training in operating the sensors properly. Inter-calibration exercises, user training and development of field guides around sensor operation, data quality control and data management is badly needed. IOCCP with partners tries to fill some of this gap by organizing international training courses on sensor operation but this effort has to be multiplied in order to build global capacity for sensor operation. Several European and USA-funded national and regional projects provide funding for training but the scope is often limited to national/regional personnel. We hope for these efforts to allow participation by a wider, international community in the future.

## Carbon Data Management – Challenges and solutions

The entire session was based on issues highlighted and discussed in IOCCP's position paper on Global Ocean Biogeochemistry Data Management. Progress achieved over the past 2 years and remaining challenges were presented and discussed.

Discussions regarding data interoperability and therefore integration of the community-wide data management efforts filled a considerable part of the session. Currently, data exchange in our community is predominantly based on exchanging physical copies of individual data sets. As a result, seemingly endless number of versions of a given data set reside at various repositories, creating considerable confusion amongst users and making data curation a daunting task. Examples of interoperable data exchange systems working in other communities were briefly described and a schematic solution designed for use in marine biogeochemistry was proposed. When implemented, these services will not only address the version control challenges but, perhaps more importantly, will allow our community to instantly aggregate data from various sources moving our community to the age of Big Data.

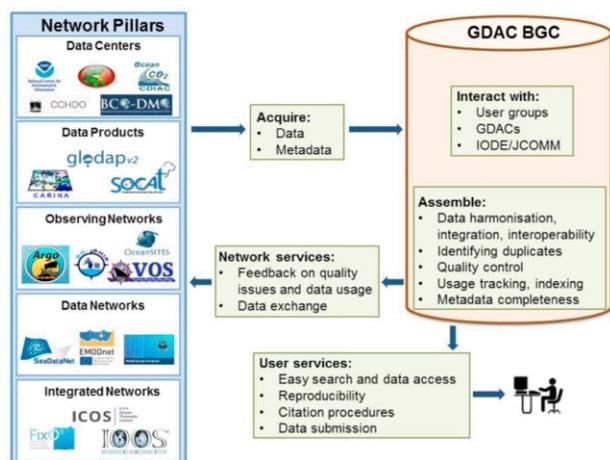


Figure 4. Anticipated structure of the Global Data Assembly Centre for Marine Biogeochemistry.

Within our community, an illustration of the implementation of the integrated data management was provided based on the European Research Infrastructure Integrated Carbon Observing System (ICOS).

During discussions following the ICOS presentation, it was emphasized that collaboration amongst elements of data management within our community must overcome the currently predominant competition. The key to success seems to be a community-wide agreement allowing individual data centres to focus and specialize in specific services for the community. In such a landscape, a combination of interconnected services provided by highly specialized elements (with modest digital overlap) would provide to the community needs. Each element would clearly communicate its function and funding needs, and therefore funding streams would not be directed to support efforts duplicating existing service-providers as it is often the case today.

Finally, it's important to state that in a truly interoperable data management system, each nationally or regionally funded data set would be submitted to a data archive designated by a funding agency supporting data collection. The data will be automatically made available throughout the system or public availability will be held for certain period requested by national/regional agreements.

*Maciej Telszewski, Dorothee Bakker, Are Olsen, Björn Fiedler, Doug Connelly and Benjamin Pfeil*

## SOLAS-IMBER-IOCCP-GCP-CLIVAR-WCRP meeting on future ocean carbon cycle research

IOCCP was also very active in preparing for and participating in a scoping meeting aimed at developing a community-wide consensus on the future needs of the marine carbon research. In April 2017, SOLAS and IMBER have disbanded their two carbon working groups that, based on the Joint SOLAS/IMBER Carbon Implementation Plan, were charged with coordination and synthesis of ocean



carbon research related to both: ocean surface and ocean interior. Seeking new science directions, SOLAS and IMBER proposed an open discussion amongst all and any programs interested in ocean carbon research. IOCCP, GCP, CLIVAR, WCRP C-challenge and SOLAS and IMBER representatives expressed interest in such discussion and an initial, scoping side-meeting during the ICDC10 in Interlaken was organized. The meeting was attended by 13 participants representing the above mentioned programs and was chaired by Nicolas Gruber, a former chair of the SOLAS/IMBER Carbon Working Group 2.

It was positively noted that most major international programs dealing with the ocean carbon cycle were represented at this meeting. The following questions were discussed: 1) is there a need for an international coordination in ocean carbon cycle research that goes beyond what is currently done? 2) If the answer to 1 is yes, then (i) how broad should such an activity be, (ii) what are the key questions that should guide this activity, and (iii) what kind of organizational setup do we envisage/is possible?

The answer to the first question was a clear yes, perhaps most strongly expressed by IOCCP, who is currently lacking a scientific partner to develop and implement a science-based strategy related to marine carbon cycle. But the gap left after disbanding of the SOLAS-IMBER Carbon working groups 1 and 2 is felt by the other organisations, too. For example, the lack of coordinated ocean carbon cycle simulations was mentioned both with regard to CMIP6 and in the context of GCP's efforts to establish annual carbon budgets. Many programs are currently including ocean carbon related activities in their science plans, but in none of these organizations the ocean carbon cycle obtains adequate attention. This is neither efficient nor effective.

There was a less clear consensus with regard to the question of how broad such a new initiative ought to be. A good fraction of the participants were of the opinion that any new initiative would have to go beyond the (inorganic) carbon cycle, and include other related biogeochemical properties such as nutrients, oxygen, and  $N_2O$ , i.e., very much in the spirit of the biogeochemical suite of Essential Ocean Variables that were developed through the GOOS

Biogeochemistry Panel (IOCCP). At the highest level, delineating an initiative from the perspective of ocean health was mentioned as a way forward, particularly since such a line of argument would be attractive for potential funders and FutureEarth. A somewhat smaller fraction was arguing more in favour of a rather focused approach, staying mostly with inorganic carbon, i.e., within the scope of the past SOLAS/IMBER working groups 1 and 2.

In terms of the key scientific questions that would drive such a new initiative, most mentioned issues at the interface between biogeochemistry and physical oceanography, while biological processes were not identified. This might have been due to the lack of relevant expertise in the room. Concrete examples included decadal variability, meso- and submesoscale processes, optimal observing system design, multiple stressors considerations, and the interaction of the fluxes of heat and carbon fluxes and their storage. There was also a clear consensus that there should be a single entity dealing with surface and interior ocean carbon issues of interest.

On an organizational level, no clear consensus has emerged yet, although it was strongly stated that a clear narrative about what this organization represents and what its goals and ambitions are is needed. Particularly since the current view from e.g., the Belmont Forum, is that this community is rather fragmented. Associating a carbon-focused activity with CLIVAR was viewed as not feasible/desirable, although the large benefits of a close collaboration were uniformly recognized. RECCAP2 was identified as a potential seed project. Furthermore, a couple of options for structuring of this new entity were proposed. On one hand there was a proposal that such an organization needs at its core people who run the office and are responsible for coordination who provide scientific leadership. The emerging Ocean Knowledge-Action Network (Ocean KAN) framework was identified as a potential avenue to move forward. The approach offers the stability of a project office and a clear organizational status. Challenges with such an approach include the need for fund-raising related to staff and operations of the program as well as the need to overcome potentially adverse reactions of the community to creating yet another layer of coordination.

An alternative proposed approach was to form an explicitly cross-program group (ocean carbon think-tank) that would be supported jointly by some or all programs with links to but no direct focus on ocean carbon (CLIVAR and/or IMBER and/or SOLAS and/or GCP) and IOCCP. Such a group would include interested members of the member organization SCs as well as others. The approach offers potentially immediate activity and clear and direct connection to all existing interested programs. Challenges with this approach include the need for all involved existing programs to agree to co-sponsor the activities of such a cross-program ocean carbon think-tank and to jointly agree on details of the implementation of developed future activities.

In response, the individual representatives were asked to bring these issues as a discussion items back to their respective organizations to further explore proposed options, while considering others as well.

In conclusion, the need for a science development-focused, international ocean carbon/biogeochemistry program was clearly articulated and supported by all present. As the issue is considered pressing, it's our intention to continue this scoping activity until the community will arrive at a feasible solution.

*Maciej Telszewski*

## IOCCP SSG member profile: Doug Connelly



*Photo 2. Doug Connelly.*

Doug is a Principal Scientist at the National Oceanography Centre in the UK, and holds an Honorary Professorship at the University of Southampton. He has been serving on IOCCP SSG since January 2016.

A geochemist by training, initially working on redox speciation of elements, Doug has moved into developing and using marine sensors to determine important biogeochemical tracers. He is involved in the development and application of a variety of sensor

technologies to address global biogeochemical and societal questions.

Applying these sensors to marine systems as diverse as cold-seeps, hydrothermal vents, and reducing lochs, Doug has worked in all of the world's oceans. He coordinated a Marie Curie ITN (<http://www.eu-sensenet.net>) aimed at training a cohort of PhD students to develop a number of novel sensor technologies. He is also the coordinator of an ambitious EC project SenseOCEAN (<http://www.senseocean.eu>) that has developed a new family of sensors, at or close to, the market place, which involves collaboration with academics, engineers and a number of small and medium-sized enterprises (SMEs) across Europe.

His latest coordination role is for a large EU project focused on questions associated with the development of Carbon Capture and Storage (CCS) as a technique to mitigate anthropogenic climate change, and the development of monitoring procedures for CCS in marine environments, STEMM-CCS ([www.stemm-ccs.eu](http://www.stemm-ccs.eu)). This work involves collaboration with the research community, with commercial organisations in the oil and gas sector and applied marine engineering companies. Doug is also involved in the EC project AtlantOS (<https://www.atlantos-h2020.eu/>), focused on optimizing and enhancing the integrated Atlantic observing system, with a task focusing on identifying and promoting emerging observing networks.

Doug manages a large laboratory facility with a suite of sensors and instruments valued in excess of US\$ 1 million and supervises numerous technical staff and a number of PhD students investigating a range of more focused studies such as the role of organic complexes in the stabilization of iron in the marine environment, through to studies of the role of a warming Arctic in the release of geologically stored methane.

The field of sensor development directed towards biogeochemical measurements is expanding year by year, and commitments by national and international agencies to fund this work demonstrate the importance of technology developments in ocean observing. As Doug says himself: "This is an exciting time to be working at the cutting edge of the field and my involvement in the IOCCP is personally rewarding

as I want to highlight the new developments which are the future off-the-shelf sensors for wider use."

*Maciej Telszewski*

## Sensors and Instrumentation Roadmap produced by the EU AtlantOS project



An overview of the current state of the art and roadmap for biogeochemical sensors

for observing systems has been published as part of the EU Horizon2020 AtlantOS project.

The report - Sensors and Instrumentation Roadmap provides a review of the instruments currently available in the marketplace, and importantly looks at those sensors in development and assesses their current TRL (Technology Readiness Level) as a guide to the most promising candidates for commercialisation and hence wider availability for the community in the near future. The roadmap captures data from a number of sources including commercial entities and research groups across the world.

The roadmap is available online both as a PDF:  
<http://oceanrep.geomar.de/39477/1/6.1%20Sensors%20and%20Instrumentation%20Roadmap.pdf>,  
and as a spreadsheet:

[http://noc.ac.uk/files/documents/science/WP6\\_Roadmaps\\_\(S%2BI\\_and\\_Emerging\\_networks\)V4.xlsx](http://noc.ac.uk/files/documents/science/WP6_Roadmaps_(S%2BI_and_Emerging_networks)V4.xlsx)

What is clear from the roadmap, perhaps not unexpectedly, is that we have a range of existing sensors for the physical measurements in the oceans (temperature, salinity, depth). However, we are still restricted in sensors available for a wide range of biogeochemical species of interest. There are a number of sensors in late stage development, at least at TRL7, with a prototype having been tested and demonstrated in a real-world environment. Sensors at this stage of development include those for the partial pressure of CO<sub>2</sub>, nitrite, pH and dissolved oxygen. We are still lacking sensors for some of the key biogeochemistry EOVS in the market place but it

is hoped that through on going sensor development projects that these gaps can be filled.

The roadmap is a living document and will be updated periodically. For those with comments, suggestions or who would like to highlight sensor development not captured by the report please contact Douglas Connelly (dpc[at]noc.ac.uk).

*Doug Connelly*

## GOOS Biogeochemistry EOVS version 2.0 released



Towards the end of August, IOCCP as Global Ocean Observing System (GOOS) Biogeochemistry Expert Panel was happy to announce the release of **GOOS**

**Biogeochemistry Essential Ocean Variable (EOV) Specification Sheets version 2.0.** The 2017 revision is the result of GOOS-wide dedicated efforts to better harmonize the EOVS and associated concepts across all disciplines: physics & climate, biogeochemistry, biology & ecosystems; and to align the EOVS closer with the corresponding Essential Climate Variables (ECVs) developed by the Global Climate Observing System (GCOS - see the 2016 GCOS Implementation Plan for details).

You can download the updated Biogeochemistry EOVS Specification Sheets from our site [HERE](#), and access the most recent versions of all GOOS EOVS from this site: [www.goosocean.org/eov](http://www.goosocean.org/eov)

The Specification Sheets were updated in terms of their structure and content in response to recommendations from GOOS expert panel members and thanks to feedback obtained from the community over the 18 months since the Specification Sheets were first published online in February 2016. These changes include revisions of several of the Biogeochemistry EOVS names: Inorganic Carbon (formerly Carbonate System), Nutrients (formerly Inorganic Macronutrients), Oxygen (formerly Dissolved Oxygen) and Particulate Matter (formerly Suspended Particulates).

Though significantly updated, the 2017 Biogeochemistry EOVS Specification Sheets should still be considered 'work in progress.' Acknowledging all the input already provided, we kindly invite the community to contact the IOCCP Office with any questions, comments and suggestions, which we will carefully consider prior to future updates. We anticipate that the continuing revision process will result in annual or bi-annual updates over the next few years, with the frequency of the updates gradually decreasing as the Specification Sheets and their application mature.

Through this 2017 update to the Biogeochemistry EOVSs, performed alongside similar efforts on the Physics & Climate and Biology & Ecosystems EOVSs, we contribute to furthering the implementation of the  Framework for Ocean Observing, and we hope that this effort will trigger our community to become even more engaged in building the multidisciplinary, fit-for-purpose global ocean observing system.

*Artur Palacz*

## Implementation of Multi-disciplinary Sustained Ocean Observations (IMS00)

### IMS00 workshop and report

On 8-10 February 2017, Global Ocean Observing System (GOOS) Panels for Physics & Climate (OOPC), Biology & Ecosystems and Biogeochemistry (IOCCP), and the Ocean Research Coordination Network (Ocean RCN) co-organized a workshop on "Implementation of Multi-disciplinary Sustained Ocean Observations (IMS00)".

The 3-day workshop took place at the Florida International University campus, just north of Miami, FL, USA. 49 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, chosen as so-called demonstration themes:

-  Changes in plankton communities
-  Oxygen minimum zones (OMZ)
-  Open ocean - shelf interactions



Implementation of Multi-Disciplinary Sustained Ocean Observations (IMS00) Workshop  
February 8 - 10, 2017, Miami, FL, USA



Photo 3. Participants of the IMS00 workshop.

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 introducing a wider perspective and a more critical approach to fulfilling the workshop aims, which were to:

-  Building on the established societal and scientific requirements expressed in EOVSs, 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

The initial set of implementable recommendations has been formulated and is published as the GOOS Report No. 223, available for download from here:

 [IMSOO Workshop Final Report](#)

## Summary of Outcomes

The near term outcomes of the workshop are a series of suggested actions and recommended directions for the three demonstration themes including efforts of collaborations across disciplines, observation platforms and networks. The first steps are a series of planning and implementation meetings and workshops planned for 2017 and 2018. Only a few of the planned actions fall within currently funded activities; therefore, the groups have started to seek out required resources through funding avenues identified at the workshop. For details, please see the section below on IMSOO follow-up activities.

There was a recognition that new capabilities and new observation systems must be built on existing capabilities and this should be done with minimal impact on the current operations. Examples include the introduction of Biogeochemical Argo to the Argo network and the recommended addition of water sampling for biological measurements to repeat hydrography surveys.

The recommendations called for expanding the range of platforms available for observation including expanded use of autonomous sampling and fixed-point observatories for biogeochemical measurements.

Due to the complexity and widely varying scales of ocean dynamics, modelling plays a key role in addressing the three demonstration themes. Further expansion of models and closer coupling of models with observations was noted as a priority.

Capacity building was another common thread. This includes the use of existing standards and best practices for data management and could include the creation of best practices manuals and similar documentation.

The challenges discussed by the participants for each demonstration theme were not new, however, the emphasis on multi-disciplinary information and collaboration was a step forward in expanding traditional dialogues. The planning with a multi-year perspective offers the opportunity for advances that otherwise could take a decade of evolution.

## Sponsors

The organizers wish to kindly thank again the generous sponsors: US NSF, GOOS/IOC-UNESCO, NOAA, NASA.



## IMSOO follow-up activities

Details of planned actions summarized in the IMSOO workshop report are already being followed through by the organizers and demonstration theme co-chairs, and will continue over the next 2-5 years' time frame.

## OMZ Demo Theme

In the direct aftermath of the IMSOO workshop, the leaders of the IMSOO OMZ Demonstration Theme, supported by the GOOS Biogeochemistry Expert Panel coordinators, started planning for a workshop that would refine the proposed science plan for a project called 'Variability in the Oxycline and its Impacts on the Ecosystem (VOICE),' ambitiously laid out by the IMSOO OMZ participants.



As detailed in the IMSOO report, VOICE will assess the current readiness level of the observing requirements, existing observing capabilities and availability of data products to deliver information on the variability in the oxycline and its impacts on the ecosystem in selected OMZ regions around the globe: the Humboldt Current System, West Africa (Canary and Benguela Current Systems), Northern Indian Ocean, and the California Current System.

If successfully implemented, VOICE would result in 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, capable of informing the society about the variability in the oxycline and its impacts on the ecosystem, applicable within the global ocean observing system, and contributing to the overarching question: “How do changing OMZs affect the spatio-temporal distribution, productivity and trophic structure of the benthic and pelagic communities?”

The VOICE Science Plan Workshop was a three-day event, held back to back with the Global Ocean Oxygen Network (GO<sub>2</sub>NE) third annual meeting (11-13 September 2017, Monterey, CA, USA). The workshop was attended by 22 scientists from around the globe, and was the first opportunity to establish communication and initiate coordination of efforts leading up to the implementation of the VOICE project.

The workshop provided an excellent and in depth summary of the regional requirements, observing capability, data and information product management to form a basis for comprehensive observing system readiness level assessment in accordance with the FOO guidelines. The information conveyed through presentations and during discussions will be documented and expanded upon through a spreadsheet questionnaire distributed among the workshop participants, to be filled out towards the end of 2017.



Photo 4. Participants of the VOICE Science Plan Workshop in Monterey, CA, USA.

Detailed proceedings and outcomes of the workshop will be published in a report, which will be made accessible online in a couple of weeks.

The next VOICE meeting is planned for September 2018, around the SFB 754 International Conference on ‘Ocean Deoxygenation: Drivers and Consequences – Past, Present and Future’, 3-7 September 2018, Kiel, Germany. Stay tuned for more news on the exciting developments of VOICE.

## **Changes in Plankton Communities Demo Theme**

The IMSOO workshop provided a number of important recommendations for this theme. In 2017, the first, and perhaps the most significant one, was successfully followed through.

Just last month we were happy to inform you that SCOR approved three new working groups, among which was P-OBS: Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs. The P-OBS proposal was conceived under the strong influence of the recommendations stemming from the IMSOO workshop. The P-OBS WG is Co-Chaired by Emmanuel Boss (University of Maine, USA) and Anya Waite (Alfred Wegener Institute, Germany)

As stated in the proposal:

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

needed), and data collection, quality control (QC), and data archival protocols.”

We are looking forward to tracking the progress of P-OBS, for the benefit of implementing multi-disciplinary sustained ocean observations.

## Open Ocean - Shelf Interactions Demo Theme

The Open Ocean - Shelf Interactions Demonstration Theme group, also referred to as the Boundary Currents group, decided to split their efforts into two: Western Boundary Current Systems and Eastern Boundary Current Systems (EBUS). There is a potential for synergies between the EBUS group and VOICE with respect to many driving questions: e.g. what are the motivations for observations in EBUSes? What measurements are needed, what is the required temporal and spatial coverage, and what measurement techniques are most adequate? It should also be noted that an EBUS SCOR Working Group proposal was lately approved, co-led by Ivonne Montes, also a member of VOICE. Hence, as anticipated at the original IMSOO workshop, there is a growing tendency to identify synergies and opportunities for joint follow-up actions among the three IMSOO demonstration theme groups.

## On the road to OceanObs'19

We believe that the immediate outcomes of the IMSOO workshop will be instrumental in setting the stage for OceanObs'19, and thus open up new opportunities for long-term implementation of multi-disciplinary sustained ocean observations. To this end, the groups leading various IMSOO follow-up efforts aim to engage directly or indirectly in the shaping the directions as well as the actual organization of the OceanObs'19 Conference.

Currently, organizers of OceanObs'19 are forming its Program Committee (PC), which will shape the agenda and outcomes of the conference set for September 16-20, 2019 at the Honolulu Convention Center, in Honolulu, HI, USA.

In response to the call, IOCCP has nominated four members of the biogeochemistry community who were willing to take up the challenge, one of which

being a joint nomination with the Global Ocean Oxygen Network (GO<sub>2</sub>NE).

We look forward to seeing our community being actively represented in the development of the OceanObs'19 program. In order to keep track of the developments we recommend you subscribe to the mailing list through the link on the bottom of [www.oceanobs19.net](http://www.oceanobs19.net) site.

Artur Palacz

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## Two major reports on the status of the ocean published

This summer we witnessed the publication of two major reports describing the status of the world's ocean:

-  the “Global Ocean Science Report” presented by UNESCO's IOC, and
-  the “What are Marine Ecological Time Series telling us about the ocean? A status report” prepared by The International Group for Marine Ecological Time Series (IGMETS).

## The Global Ocean Science Report

On World Oceans Day, 8 June 2017, UNESCO's Intergovernmental Oceanographic Commission presented the first ever global stock-taking of marine science at the United Nations' Ocean Conference in New York. The *Global Ocean Science Report* identifies and quantifies the key elements of ocean science at the national, regional and global scales, including workforce, infrastructure and publications. It is the first collective attempt to systematically highlight opportunities as well as capacity gaps to advance international collaboration in ocean science and technology.



The Current Status of Ocean Science around the World

challenges, the Report makes a case for increased funding in view of the ocean's economic importance and key role in regulating the climate.

To be published every five years, the inaugural Report also serves as an instrument to assess progress in the accomplishment of Sustainable Development Goal (SDG) 14 on the conservation and use of the oceans, seas and marine resources.

The full Report, in English, as well as the Executive Summary, in the six official UN languages, are available online here.

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## What are Marine Ecological Time Series telling us about the ocean? A status report



The International Group for Marine Ecological Time Series (IGMETS) has released its report entitled "What are Marine Ecological Time Series telling us about the ocean? A status

report" (<http://igmets.net/2017> or  download). The report writing was generously supported by IOC-UNESCO, IOCCP, the Ocean Carbon and Biogeochemistry Program (OCB), and the Korea Institute of Ocean Science & Technology (KIOST).

This report presents an analysis and overview of oceanic trends through the end of 2012, based on a collection of over 340 in situ marine ecological time series, and supplemented with satellite-based spatio-temporal sea surface temperature and chlorophyll background fields. This report features electronic supplements in the form of a Metabase (<http://igmets.net/metabase>) and the IGMETS time series Explorer (<http://igmets.net/explorer>), which allow users to further expand on the information featured in the text. The information contained in the report and IGMETS metabase is relevant for a

number of Essential Ocean Variables (EOVs), including the biogeochemistry ones.

*Artur Palacz, Kirsten Isensee and Laura Lorenzoni*

## NCEI OCADS website

In August, we were pleased to announce that NOAA National Centers for Environmental Information (NCEI) has opened the new Ocean Carbon Data System (OCADS) Project web page for public use. The NCEI OCADS web site address is <https://www.nodc.noaa.gov/ocads/>.

OCADS is responsible for hosting and providing access for ocean carbon data collected from around the world, as previously performed by the Oceans component of the Carbon Dioxide Information Analysis Center (CDIAC-Oceans) at the Oak Ridge National Laboratory (ORNL). OCADS aims to be a customer-centric data management entity, and is keen on responding to the community's needs to provide stellar customer support as was done at CDIAC. The OCADS team values the importance of putting all ocean carbon data into one repository and welcomes data submissions from around the world.

In general, the OCADS web site is based on the former CDIAC Ocean web page with similar data exploring tools. However, the CDIAC-Oceans data discovery system Mercury has been replaced by the NCEI Ocean Carbon and Acidification Data Portal. Any DOI and EXPCODE that were issued by CDIAC-Oceans for a data set can still be used to search the Portal to locate that data set.

While some changes may take time for you to get used to, OCADS hopes to provide even better service by putting ocean carbon data into a long-term archive, creating stable data citations, and using terms from controlled vocabularies. The goal is to build an ocean carbon data service that is driven by the users and at the same time meets all U.S. Government data management requirements.

*Artur Palacz and Alex Kozyr*

## Upcoming Events

-  Simposio Latinoamericano en acidification del oceano, Red LAOCA 2017, 24-26 October 2017, Buenos Aires, Argentina, <http://laoca.cl/congreso2017/>; (in Spanish)
-  The fifth session of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM-5), 25-29 October 2017, Geneva, Switzerland, <http://meetings.wmo.int/JCOMM-5/SitePages/Session%20Information.aspx>; attendance by invitation
-  International Training Workshop for Nutrient Analysis, 5-9 November 2017, Texel, the Netherlands, <https://www.nioz.nl/en/education/marine-studies/scor-pogo-international-training-workshop-for-nutrient-analysis-2017/>; application closed.
-  3rd General Assembly of the EU Horizon2020 AtlantOS project, 21-23 November 2017, Las Palmas, Spain, <https://www.atlantosh2020.eu/events/3rd-general-assembly-meeting-21st-23rd-november-2017/>; registration closed.
-  AGU Fall Meeting, 11-15 December 2017, New Orleans, LA, USA, <https://fallmeeting.agu.org/2017/>; abstract submission closed.
-  2018 Ocean Sciences Meeting, 11-16 February 2018, Portland, OR, USA, <http://osm.agu.org/2018/>; abstract submission closed. For a subjective list of sessions relevant for marine biogeochemistry, see our site [HERE](#).
-  European Geosciences Union (EGU) General Assembly 2018, 8-13 April 2018, Vienna, Austria, <https://www.egu2018.eu/>; abstract submission deadline: 10 January 2018, or by 1 December 2017 if applying for Roland Schlich travel support.
-  4th International Symposium on the Effects of Climate Change on the World's Oceans, 4-8 June 2018, Washington D.C., USA, <http://meetings.pices.int/meetings/international/2018/climate-change/scope/>; abstract submission open.
-  7th SOLAS International SOLAS Summer School, 23 July-4 August 2018, Cargèse, Corsica, France, <http://www.solas-int.org/solas-summer-school-18.html>; application deadline: 15 November 2017.
-  2018 Ocean Carbon & Biogeochemistry Summer Workshop, 25-28 June 2018, Woods Hole, MA, USA, <http://web.whoi.edu/ocb-workshop/>; poster abstract submission will be available in May.
-  SFB 754 International Conference on 'Ocean Deoxygenation: Drivers and Consequences – Past, Present and Future', 3-7 September 2018, Kiel, Germany, <https://www.sfb754.de/o2conference2018>, call for submissions opens in December 2017.