



# REPORT

from the XIII<sup>th</sup> Session of the

**International Ocean Carbon Coordination Project  
Scientific Steering Group**

**Global Ocean Observing System  
Biogeochemistry Panel of Experts**



*Japan Meteorological Agency (JMA), Tokyo, Japan, 24-26 October 2018*



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## SSG FOR 2018 AND PARTICIPANTS LIST

IOCCP SSG Co-Chairs Masao Ishii and Kim Currie extended their welcome to the SSG, noting that all SSG members were able to attend the annual meeting in person. The full list of attendees is provided in Tables 1 & 2 below.

**Table 1. 2018 SSG member composition and annual meeting attendance**

Name (Gender)	Home institution	Country of residence	Expertize	Attendance
Kim Currie (Co-Chair, F)	NIWA	New Zealand	Synthesis Activities: Surface ocean	attended
Masao Ishii (Co-Chair, M)	JMA-MRI	Japan	Ocean Interior Observations	attended
Richard Feely (M)	NOAA - PMEL	USA	Ocean Acidification	attended
Michio Aoyama (M)	U. Fukushima	Japan	Nutrients	attended
Björn Fiedler (M)	GEOMAR	Germany	Time Series	attended
Douglas Connelly (M)	NOCS	UK	Instruments and Sensors	attended
Siv Lauvset (F)	UiB	Norway	Synthesis Activities: Ocean Interior	attended
Benjamin Pfeil (M)	UiB	Norway	Data & Information Access Services	attended
Rik Wanninkhof (M)	NOAA - AOML	USA	Surface CO <sub>2</sub> Observations	attended
Cristian Vargas (M)	U. Concepcion	Chile	Ocean Acidification	attended
Veronique Garçon (F)	LEGOS	France	Oxygen	attended

**Table 2. Project Office staff and additional meeting participants**

Name (Gender)	Home institution	Country of residence	Role	Attendance
Maciej Telszewski (M)	IOCCP / IO PAS	Poland	IOCCP Director	attended
Artur Palacz (M)	IOCCP / IO PAS	Poland	IOCCP Project Officer	attended
Albert Fischer (M)	IOC-UNESCO	France	GOOS Director	remotely

## MEETING REPORT

On behalf of the IOCCP Executive, Kim proceeded to explain the structure of the meeting agenda (see Annex 1) in the light of the growing requirements of the marine biogeochemistry observing community and a responsibility taken up by the panel through adoption of the updated Terms of Reference in 2017. Kim thanked the SSG for contributing to the analysis of skills, roles and responsibilities ahead of the meeting. The meeting started with an overview of our accomplishments in the past 18 months, which was followed by a forward-looking overview of IOCCP's main responsibilities towards the community and the needs for specific activities stemming from these responsibilities. The SSG then discussed how to adjust the structure and functionality of the Panel in order to respond to those needs and plans. The proposed changes were then considered when individual themes were discussed and responsible SSG members proposed new action items for IOCCP to execute towards the end of 2018 and throughout 2019.

### Summary of 2017-2018 IOCCP accomplishments

The session was led by Maciej who provided a short summary of IOCCP accomplishments during the 2017-2018 period. The 18 months since the previous SSG meeting brought a lot of fruitful developments and interesting outcomes which are mentioned in the latter, thematic sections of this report.

The focus of this session was not only to briefly review these specific accomplishments but also to point at some of the challenges in executing the actions agreed upon during the previous SSG meeting. A few observations were made on how to improve the functioning of IOCCP with respect to activities taken up, executed (or for various reasons not executed) in the intersessional period. These points have laid foundation for the detailed discussions in the following sessions:

- 1) For a lot of activities (action items) coordination was performed without sufficient communication of the outcomes, both internally (Office & SSG) and externally, indicating a need for more frequent internal reporting on the status of action items.
- 2) Each action item needs to be assigned a named SSG leader, who would be responsible for stewardship and implementation of specific, action item-related activities such as planning, interaction with the community, developing relevant documentation, leading events, reporting and so on. Project Office will provide all the usual support to the leading SSG member.
- 3) A number of action items proposed during the previous SSG meeting was completed with little IOCCP involvement, not completed or even not initiated.
- 4) There is an occasional mismatch between proposed new IOCCP actions and the interest of the community (e.g. in case of Instruments and Sensors the key focus should still be on the technical capacity development rather than sensors development).
- 5) Several proposed action items described general, on-going activities which should be broken down into a more concrete, actionable tasks (e.g. Data and Information Access Services).

## **Future directions of IOCCP for the next 5-10 years**

After discussing successes and challenges of the past 18 months, the SSG spent a significant portion of the meeting discussing the main future directions of IOCCP anticipated for the next 5 to 10 years. Detailed discussions focused on individual themes held during the later part of the meeting were held in the context of these overarching directions. The initial list of key future activities was based on discussions held within the IOCCP Executive (Co-Chairs + Office) during approximately 6 months prior to the meeting with contributions from SSG members incorporated throughout that time. Below we summarize the main goals, challenges and decisions taken by SSG regarding each topic.

### **1. Surface Ocean Carbon Observing Network (SOCONET)**

The goal is to continue to support and expand on the activity of SOCONET. There is an apparent strong interest in having an organized activity for everyone involved in surface ocean observations. The question is whether the effort should be directed towards establishing the highest possible quality reference network or whether the effort should be directed towards coordination of the entire community interested in doing surface ocean measurements. There are good arguments for both approaches. If SOCONET remains, as originally intended, a reference network, then besides all the work required to achieve such a network globally, there are two challenges which need IOCCP's attention. First issue is regarding what to do with coordination of investigators working with sensors or less than optimal instruments which cannot meet the data quality requirements of the reference network. Second major issue concerns the inclusion of atmospheric measurements in SOCONET portfolio or otherwise. There are strong arguments suggesting that accurate atmospheric measurements (to within 0.2 ppm) above the ocean surface should be made in conjunction with surface water measurements (to improve the accuracy of air-sea CO<sub>2</sub> fluxes), and equally valid arguments rejecting the idea (logistics and cost based arguments).

An in-depth discussion on the accomplishments and future plans in this regard can be found under the Surface CO<sub>2</sub> Observations Theme section of the report.

### **2. Ocean Acidification through the Global OA Observing Network (GOA-ON)**

IOCCP's future work in the domain of ocean acidification observations will continue to be catalysed by a close collaboration with the GOA-ON. The 4<sup>th</sup> GOA-ON Science Workshop to be held in China in April 2019 will be co-funded by IOCCP and several IOCCP SSG members and other members of the community will be involved in preparing and running of this activity. IOCCP's role will continue to be related to specific issues regarding chemical and biological EOVS, to developing and updating relevant best practice documents and also providing a connection between the scientific community and high-level agendas such as UN SDG 14, WMO Indicators or GCOS Implementation Plan. Parallel to this, there is an ongoing interaction with the GOOS BioEco Panel through GOA-ON's panel on biological observations of OA, led by Sam Dupont.

An in-depth discussion on the accomplishments and future plans in this regard can be found under the Ocean Acidification Theme section of the report.

### **3. GOOS Biogeochemistry (BGC) Panel expansion**

As IOCCP has expanded its role as the GOOS BGC Panel, the IOCCP will gradually expand our coordination and communication activities in order to help the ocean observing community implement individual EOVS. Over the past 6 years we lead the community to establish a set of

biogeochemistry EOVs and we managed to provide a wide coordination support for three out of nine EOVs (inorganic carbon, nutrients, and oxygen). We now work to develop a careful strategy and conservative time plan to further expand our portfolio and perhaps add another three EOVs over the next 5-10 years.

IOCCP Executive selected three candidate EOVs to choose from for the implementation into the Panel's activities: nitrous oxide, dissolved organic carbon and particulate matter. Prior to the SSG discussion on priorities and strategies for these EOVs, it was noted that the Oxygen Theme has only been added to the IOCCP portfolio in 2018 and that the coordination and communication efforts related to oxygen observations have likely not yet reached their full capacity. With respect to the Ocean Colour EOV, any implementation activities will continue to be a joint venture of the International Ocean Colour Coordinating Group (IOCCG), IOCCP and GOOS BioEco Panel. IOCCP's main role is to curate the Ocean Colour EOV Specification Sheet – and not to lead all coordination and communication efforts related to this EOV.

Several criteria were put forward to judge the impact and feasibility of taking up new responsibilities with respect to EOVs: size and leadership in the observing community (if any), connection to observing networks (and satellite agencies), technological advancement, use of standards and best practices, data availability and quality, societal drivers and value for data users (scientific and non-scientific), importance for constraining mass balance of biogeochemical cycles. Estimates of personnel costs and volunteer hours will be made to verify feasibility of taking up the three EOVs. The final decision was left with the IOCCP Exec to determine the order and timing of adding new EOVs to IOCCP portfolio of activities. Below is a summary of the arguments for all three EOVs.

**Action #1:** Decide which from the selected EOVs (Nitrous Oxide, Dissolved Organic Carbon and Particulate Matter), will be added to the IOCCP portfolio of activities starting in 2019, and what will be the sequence and timeline for adding the remaining two EOVs.

Responsible: IOCCP Executive

Timeline: mid-2019

Financial implications: Low

**Action #2:** Issue an open call invitation for a new SSG expert to assume responsibility for the new EOV theme.

Responsible: IOCCP Exec, review by the entire SSG.

Timeline: 2019

Financial implications: None

### Nitrous oxide EOV

*Requirements:* IPCC stated the need for ocean observations of N<sub>2</sub>O as a greenhouse gas. In Europe, the EU Water Directive listed nitrous oxide as a needed waste water measurement.

*Observations:* There is a small open ocean community. Some platforms within ICOS also perform N<sub>2</sub>O measurements already. It is unlikely that this community is connected to those measuring N<sub>2</sub>O in waste water in the coastal regime. Observations might not be as mature as it seems. There is ongoing development of underway N<sub>2</sub>O sensors. There is need for reference materials.

*Data management:* There is already a functional database MEMENTO (MarinE MethanE and NiTrous Oxide; <https://memento.geomar.de/>), currently allowing access upon registration.

#### Particulate matter EOVS

*Requirements:* High importance of having wide array of high quality measurements for climate studies but mostly for interaction with the biology and ecosystem research. It is relevant for many BGC phenomena, including OA and ocean deoxygenation. Need to define clearly the scope of this EOVS: organic vs inorganic, total vs fractionated (physical, chemical, biological properties).

*Observations:* First order coordination efforts would need to be established. Challenging and demanding in terms of resources. Measurements taking place across many platforms, from ships (e.g. total particulates on GO-SHIP), Biogeochemical Argo (backscatter), satellites, etc.

*Data management:* Low readiness level.

#### Dissolved organic carbon EOVS

*Requirements:* High impact in terms of carbon budget and climate assessments. There is still controversy over replacing Dissolved Organic Matter with Dissolved Organic Carbon as EOVS. DOM is a Level-1 GO-SHIP measurement and a level 2 (international) GO-SHIP requirement.

*Observations:* There is potential for connection between in situ and satellite observing communities through the C-DOM component (though that fraction is ca. 1% of DOC). DOC is a challenging measurement for time series. The observing community is small and thus relatively easy to bring together and coordinate. Need for increased interoperability.

*Data management:* Data included in GLODAP but work on data management needed.

DOC observations are likely the most mature in terms of all three aspects of the Framework for Ocean Observing and would thus require least effort to increase in maturity level.

## **4. Standards and Best Practices**

With the onset of the idea to develop the Ocean Best Practices (OBP) repository (<https://www.oceanbestpractices.net/>), there has been a proliferation of activities related to promotion, availability and standardization of standards and best practices in all ocean domains. The BGC Panel was asked to make sure that marine biogeochemistry best practices are (i) visible, (ii) well documented, and (iii) searchable. For the benefit of our community, our work should take place via the OBP. The goal for IOCCP is to achieve standards and best practices for all EOVSs, all platforms and stages of the data cycle, from data acquisition to processing. To this end, IOCCP will continue to actively participate in relevant international meetings, first of which took place in December 2018 in Paris.

It was noted that so far all the activities related to requests related to best practices come through the Office and through individual requests to IOCCP SSG members as experts in their fields. The IOCCP Executive presented to the SSG an idea to establish Standards and Best Practices as a separate theme in the Panel's portfolio, with a dedicated SSG member responsible for related coordination and communication activities.

In response, the SSG argued that the theme of standards and best practices is intrinsic to the work of the entire Panel and that the responsibility for it should span across all of the SSG members. Thus, the SSG decided that we will not create a new theme dedicated to standards and best practices. The SSG also recommended that we do not take up an overwhelming amount of tasks related to the work of the OBP. Instead, we should offer our support to

activities otherwise led and executed by the very capable OBP working group, members of which are also on the IOCCP SSG.

## **5. IOC-UNESCO Working Group on Integrated Ocean Carbon Research (IOCR)**

The global ocean carbon research community is constituted by several initiatives carried out in the context of IOCCP, the Surface-Ocean Lower Atmosphere Study (SOLAS), the Integrated Marine Biosphere Research (IMBeR); the Global Carbon Project (GCP); WCRP's core project on Climate and Ocean Variability, Predictability and Change (CLIVAR), and numerous relevant activities of SCOR and IOC. Relevant national efforts on carbon research, as exemplified by the Ocean Carbon and Biogeochemistry program under the US Carbon Cycle Science Program, contribute directly to such global efforts on ocean carbon research.

The discontinuation in 2017 of the SOLAS-IMBeR Carbon working groups (1 and 2) which, 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, created the need for a new federating initiative on ocean carbon research. The focus of the group will be on identifying and recommending solutions for knowledge gaps in the integrated ocean carbon research. Initial issues proposed for discussions during the past 12 months when the group was being formed included decadal variability, meso and sub-meso scale processes, scientific requirements for optimal observing system design, integrating ocean carbon biology considerations, and the interaction of the fluxes of heat and carbon fluxes and their storage.

As one of the „founding programs” of the WG, IOCCP is asked to nominate two experts to join the Steering Committee of IOCR. Despite the fact that the IOCP SC members are nominated by individual programs, the IOCCP SSG expressed their hope that nominated experts will be completely free to interact unrestricted by the implementation plans and future strategies of those nominating them. It was agreed that one of IOCCP's roles will be to ensure that GOA-ON community is adequately represented in the process, though they are not formally part of the Steering Committee. As IOCR is an IOC Working Group, adequate geographical representation of its members is not a concern.

The SSG agreed that a science strategy for future marine carbon research was a needed outcome of this WG. Such a strategy would become an important asset for the community, used for example to lay out long-term planning for bodies such as the GOA-ON. However, in order to produce a strategy that is relevant for these structures, the structures need to be involved in the strategy design itself. There is a clear need to take into account the perspective of the coastal ocean and not just the open ocean in a strategy for future ocean carbon research.

The first meeting is planned for October 2019 as a scoping workshop.

## **6. Supporting current and developing new data synthesis products through the Global Data Assembly Centre for Marine Biogeochemistry (BGC GDAC)**

While the two flagship synthesis products supported by IOCCP: SOCAT and GLODAP have become standalone activities with significant accomplishments, it is important to note that both activities will continue to rely on and benefit from the support of IOCCP for funding and coordination of their activities (i.e. 1 meeting a year for SOCAT and for GLODAP). The SSG agreed that IOCCP needs to advocate for stable support to secure core funding for both the



SOCAT and GLODAP communities' efforts. IOCCP financial support would be focused on supporting specific activities.

A parallel goal for IOCCP is to determine what are the requirements for future synthesis products, and to anticipate how to advance their development. The SSG called for a pragmatic approach to designing and developing these products. The process ought to start with identifying end-users and opening a two-way dialog to tease out specific needs for such products. Equally critical is the identification of who will provide the actual product, what the specifications and limitations will be, and what is the long-term (10-years) goal for any given product. A specific example could be that of a synthesis product on ocean acidification and its impacts developed from time series observing efforts, including ship-based and moored observatories (for details on this specific topic please see the Time Series Efforts Theme part of the report). It was noted that anthropogenic CO<sub>2</sub> in the ocean could be a product if provided on decadal time scales, but not on monthly. The community has also expressed interest in developing oxygen-related synthesis products. It was apparent that any development of a product must start with organizing a workshop which would bring together expert observationalists and anticipated users. As new requirements for these products come up, IOCCP will need to have a strategy for engaging the right group of experts to join the effort to support various activities, such as data quality control, web-based GUI etc.

In order to best respond to the community's requests for new synthesis products, IOCCP Exec proposed to the SSG to re-structure the current themes of the panel. Apart from merging the 'Surface synthesis products' with 'Ocean interior synthesis products' themes, the SSG was asked to consider whether a separate theme for 'Data and information access services' was still necessary.

Central to these considerations was a discussion on the current status and future prospects of the Global Data Assembly Centre (GDAC) for Marine Biogeochemistry, as envisioned in the [IOCCP position paper on Global Ocean Biogeochemistry Data Management](#). The first important conclusion was that the community already has the capacity to have a GDAC functional for high quality Inorganic Carbon EOV measurements, thus sustaining data management for SOCAT and GLODAP products. However, more efforts and resources were needed in order for the GDAC to account for all biogeochemistry EOV data, regardless of the quality and intended applications. If the BGC GDAC was to support the development of new synthesis products based on time series observations, then there was a lot improvement to be made to bring management of these data onto the level of a GDAC.

Benjamin advocated strongly for pursuing the GDAC concept further. He mentioned that significant funds were collected so far to complete the implementation of the BGC GDAC. However, it was not reasonable to expect that central funding will be available to sponsor this activity entirely. Instead, it was recommended that IOCCP joins efforts with ICOS, NOAA OAP and PMEL, IODE and Copernicus in order to fully develop the GDAC. An important step in this direction was the meeting between Benjamin and Peter Pissierssens (Head of IOC Project Office for IODE) related to the requirements of IODE Associate Data Units (ADUs) – contributing to the objectives of National Oceanographic Data Centres (NODCs), and about adding visibility to the contribution of ADUs into the GDAC. With respect to supporting time series-based synthesis products, it would be beneficial to establish a stronger connection with OceanSITES who already have two GDACs of their own in place (). This connection would not only highlight the outstanding issues preventing time series data synthesis, but also likely help secure additional funding for the BGC GDAC.

The SSG also discussed to what extent the BGC GDAC should focus on facilitating data synthesis products and support data management on the level of national DACs. While the

intention is not to interfere with how countries deal with original data management as part of their NODCs, it was recognized that many countries do not have national data management centres and researchers submit data to regional and international databases in an often uncoordinated manner, or oftentimes, receive no clear guidelines on what to do with the data at all. Therefore, it cannot be expected that IODE's network of NODCs accounts for the integration of all oceanographic data. It was emphasized that in order to respond to the needs of users, actions need to be taken on a larger scale, integrating data from across the NODCs. IOCCP is in position to play such a role through the development of the BGC GDAC.

Regarding restructuring of the Panel Themes, the SSG decided that there will be one SSG member responsible for both synthesis activities, surface ocean and interior ocean. It was noted that this SSG member would be responsible not only for SOCAT and GLODAP but also for future synthesis products. Siv agreed to be responsible for this merged Synthesis Products theme. Regarding collaboration with SOCAT and GLODAP, the SSG recommended close interaction with Dorothee Bakker and the GLODAP Reference Group, respectively.

However, the SSG also decided that the 'synthesis activities' theme will not be combined with the 'data access and information services' theme. This decision was dictated by the recognition of the fact that specific expertise is needed to understand the complex realm of oceanographic data flow which is different from knowledge of quality control procedures and synthesis production.

**Action #3:** Merge the Surface Ocean Synthesis Activities with Interior Ocean Synthesis Activities into a single new theme on Synthesis Activities, under the responsibility of Siv Lauvset. This theme will consider the work of SOCAT and GLODAP as well as any new synthesis products supported by IOCCP. Changes are to be reflected on the IOCCP website.

Responsible: IOCCP Office

Timeline: Early 2019

Financial implications: None

## **7. Technical capacity development as part of the Instruments and Sensors theme**

The SSG agreed to retain a strong focus in the next 5-10 years on IOCCP's involvement in technical capacity development initiatives. Following on the success of the 2015 IOCCP International Sensors Summer Course, IOCCP responded to the large demand for a repeated offer of this course. Complete funding has been secured for the 2019 Training Course on a Suite of Biogeochemical Sensors (<http://www.ioccp.org/2019-training-course>), which will be co-organized by IOCCP and EU BONUS INTEGRAL project, with co-sponsorship from US OCB, ICOS-OTC and RINGO, and H2020 AtlantOS project. The course will take place on 10-19 June 2019 at the Sven Lovén Center for Marine Sciences, in Kristineberg, Sweden. First announcement was released shortly after the IOCCP SSG meeting, and applications were opened just before the end of 2018. Also in 2019, IOCCP is contributing to and co-sponsoring the [GO<sub>2</sub>NE Summer School](#), to be held in Xiamen, China.

The SSG decided that the SSG member(s) responsible for the Instruments and Sensors theme will also be responsible for the technical capacity development activities. Doug Connelly and Cristian Vargas have accepted to share the role of SSG members responsible for this theme.

The decision to re-focus the activities under this theme was based on the analysis of the past several years of IOCCP's services performed under the Instruments and Sensors theme. Doug pointed at the futile efforts of addressing marine sensor developers as a community. The developers tend to interact loosely through short-term research and development projects, and have little incentive to form a strong community. In the offshore domain, the market is small and competition is the only force for further development.

In the coastal domain however, the observers' community have a strong interest in the services offered by IOCCP. While well aware of the requirements for measurements (i.e. what to measure and why), they lack the capacity and knowledge on how to perform measurements. And that is especially true outside of Academia, where most of coastal measurements for management purposes are taken. They thus appreciate having a central repository with a sensors and instruments hardware directory, Alliance for Coastal Technologies (ACT) evaluation reports, technical workshop reports, or standards and best practices documents. Therefore, complementing these existing services with comprehensive training courses was deemed as the most efficient use of IOCCP's resources with regard to this theme.

The SSG discussed the optimal 5-10-year strategy for providing technical capacity training to the community. It was clear that IOCCP's role is in the international development which is critical in enabling specific capacity building efforts to be tied in with existing regional and national projects. The goal is then for IOCCP's services to be relevant for large observing systems in the US and in the EU (e.g. to support the implementation of Marine Strategy Framework Directive monitoring), but also for observations in developing countries keen on rolling out the technical capacity development. The SSG recommended that a partnership model be developed, akin to the one successfully used in ocean acidification research where joint capacity building efforts by GOA-ON, IOCCP, IAEA and others led to the rapid expansion of OA-related observing capacity.

Quality control of sensor measurements was suggested as a key aspect of capacity development that IOCCP could provide. This is important not only because of the growing use of sensors, but also in the context of generating data that is of sufficient quality to support the development of thematic synthesis products, such as on ocean acidification and its impacts. IOCCP recognized this need and during the 2019 training course will devote 1.5 days to quality control issues alone. In addition, as part of the AtlantOS project, the Office will most probably organize a dedicated workshop on quality control of pCO<sub>2</sub> sensors in April 2019.

The SSG agreed that perhaps the most effective means of improving quality of data is through follow-up activities, such as providing access to reference materials, after introducing new technology in a given environment. The issue of maintaining technology and its proper application is widespread among countries which do not have local manufacturers.

**Action #4:** Include technical capacity development activities under the Instruments and Sensors Theme, under joint responsibility of SSG members Doug Connelly and Cristian Vargas, and reflect these changes on the website.

Responsible: Doug Connelly, Cristian Vargas and the Office

Timeline: Early 2019

Financial implications: None

## 8. GOOS Strategic Objectives

This topic was presented remotely by Albert Fischer, Director of GOOS. Albert introduced GOOS as driven by the Framework for Ocean Observing, explained the GOOS structures and introduced the 2030 Strategy which was being finalized in October 2018, to be launched by the end of 2018. In particular, Albert talked about the 11 GOOS Strategic Objectives. Based on the stakeholder survey, GOOS identified top five priority strategic objectives: (i) strengthening partnerships for delivery; (ii) advocacy and communications, (iii) observing system implementation, standards and best practices and metrics of success; (iv) FAIR, open and quality controlled data; (v) guiding capacity development for a broader range of stakeholders.

### *(i) strengthening partnerships for delivery*

With respect to partnerships for delivery, based on a partner mapping exercise, it was determined that UN Environment would be the most appropriate partner for GOOS Biogeochemistry Panel in meeting the strategic objectives of GOOS. Therefore, GOOS recommends that the GOOS Biogeochemistry Panel seeks relevant partnership(s) with appropriate sections of UN Environment to jointly support the delivery of information for climate but also for marine ecosystem health applications, both main themes of GOOS. In this context, Albert explained the intended GOOS value chain, from research and innovation through observations, data managements, analysis/forecasts/models to applications and end users. Users should be actors involved in designing the observing system, as well as advocates of the observing system. By working with UN Environment, we want to engage those users to provide feedback on all elements of the value chain.

Also, a partnership with the Global Climate Observing System (GCOS) was discussed. Since 2015 the interaction between IOCCP and the GCOS was focused on delivery to the scientific assessment branch of the GOOS value chain, with data going through IPCC assessments to global policy and also by pro-active contribution to the GCOS Implementation Plan. At the same time, IOCCP (GOOS Biogeochemistry) is pulled in the direction of delivering information on the marine ecosystem health theme, where strong interaction with GOOS Biology and Ecosystem Panel is required. It was mentioned that while GOOS and GCOS are global observing systems, the challenge is to connect the global perspective to support efforts on regional and national levels mainly focused on coastal domain.

### *(iii) observing system implementation, standards and best practices and metrics of success*

Currently, GOOS does not have the capacity to set requirements for human pressure variables, although the importance of their monitoring is clearly recognized. The partnership with UN Environment would help identify actors in the human pressure space. Marine plastic contamination is one example of such a pressure. GOOS Steering Committee suggested in 2017 that BGC Panel be the main partner for UN Environment and other relevant bodies involved in marine plastics observations in the ocean.

### *(iv) FAIR, open and quality controlled data*

It was noted that GOOS is aware of the need to bridge the gap between the global data management approach, to which IOCCP contributes, and national data management approach based on the structure and functioning of IODE and National Oceanographic Data Centres (NODCs). As IODE considers expanding its nationally-focused data delivery, partnerships between the global and national structures should be facilitated. The need for both operational (near-real time) and delayed-mode availability and quality control of data was mentioned as another incentive for bridging the gap between operational services and academics.

*(ii) advocacy and communications*

With regard to prospects for greater intake of BGC data into operational models, GOOS will strengthen its partnership with GODAE OceanView (now OceanPredict). In particular, GOOS will ask the partners to act as advocates of sustained ocean observations to the users of OceanPredict.

## **9. Sustained observations of marine plastics**

During the 7<sup>th</sup> Session of the GOOS Steering Committee (June 2018), it was recommended that GOOS Biogeochemistry Panel takes charge of scoping the community needs for international coordinating of sustained ocean observations of marine plastics.

The IOCCP Executive presented this idea to the SSG opening this up for discussion with the main initial question being: whether or not IOCCP was willing and capable to get involved in coordination of sustained observations of marine plastics, and if so, in what capacity and to what extent? The Exec proposed two modes of operation in case of an affirmative. First, was to outsource these tasks to external groups with IOCCP acting as liaison with GOOS, similar to how we responded to the request to curate the Ocean Colour EO; or second, to handle the matter internally. It was noted that as part of initiating the scoping exercise, Maciej was going to attend the Micro2018 conference (November, 2018) to present the GOOS perspective on the requirements for marine plastics monitoring (NB: the meeting took place a few weeks after the SSG meeting).

The Panel discussed the issues from a number of perspectives. The SSG agreed that the issues of marine plastics monitoring are vital from the societal perspective, as recognized by the regional and global conventions (e.g. EU MSFD, UN Agenda 2030) and as reflected in the GOOS strategic objectives (see discussion above). The SSG also recognized the challenges related to even identifying what part of this highly complex variable should and could be measured. Aspects such as monitoring various species of plastic, various fractions (micro vs macro), and whether in situ or space-borne observations are more feasible and why, are just a few examples of fundamental questions which need addressing as soon as possible. Recognizing these challenges, the group suggested that it is likely premature to establish standard operating procedures for monitoring marine microplastics. However, developing common methodology would be a priority for the global community involved in plastics monitoring efforts. It was also mentioned that IOCCP, in its form, could not comfortably advise on data management issues related to marine plastics. Biogeochemistry GDAC could potentially be considered but it is pre-mature to make any recommendations as data management practices in marine plastics community have very low maturity level.

The group argued on the extent to which marine plastics were in fact part of biochemical cycles and therefore to what extent this theme falls with the IOCCP/GOOS Biogeochemistry mission. There was no consensus on the role of biogeochemical breakdown of these compounds, perhaps reflecting both the lack of sufficient knowledge on the topic and the lack of sufficient expertise on our panel. It was recognized that GESAMP, UN Environment and lately also SCOR have expert working groups dedicated to this topic and they would be more suited to herding the relevant members of the community.

The group exchanged information on the known marine plastics monitoring efforts. Very simple observing by the Ocean Cleanup Foundation was mentioned. From remote sensing, the name of Craig Donlon from the European Space Agency was mentioned as having a library of

reflectance of different fractions of plastics to aid remote sensing observations. It was recommended that as part of our informed response to GOOS-SC, we investigate the ongoing monitoring efforts as part of GESAMP activities.

In conclusion, the SSG decided that in the short-term IOCCP will be involved in collecting information on the status and needs of marine plastics monitoring, acting as a conduit for some other organizations on behalf of GOOS and not assuming any leadership role in the process. The SSG further recommended that a long-term solution would be to create a dedicated expert panel of GOOS, keep the activity under aegis of GESAMP, or a development program aiming towards calling such a panel which would in partnership with the relevant organizations and expert working groups take up the challenge of coordinating ocean observations of marine plastics. This Panel need not be limited to marine plastics, but would account for all Human Pressure Variables, as per original idea put forward by GOOS in 2016. As a side note, the SSG noted that CO<sub>2</sub> concentration and fluxes (Inorganic Carbon EOV) have a substantial anthropogenic pressure component which could be subject to such Panel's scope of work as well.

**Action #5:** Scope the needs for marine plastics monitoring through consultation with relevant organizations and expert working groups (UN Environment, GESAMP, SCOR and others) and to report back to GOOS SC with recommendations.

Responsible: Project Office

Timeline: Initial response to GOOS-SC-8 in May 2019 followed by longer term coordination efforts.

## 10. Fulfilling Global Climate Observing System (GCOS) requirements

Historically, GCOS was almost entirely focused on physical observations in the ocean. In fact even today, GOOS is formally working with GCOS via GOOS Physics Panel, which acts as GCOS's Ocean Observations panel for Physics and Climate (OOPC) – and is co-sponsored by GOOS, GCOS and WCRP.

In recent years GCOS has placed more attention onto biogeochemistry and biology, as expressed in the expanded number of Essential Climate Variables (ECVs). This triggered a need for a GOOS-wide input into GCOS processes and activities so that the relevant expertise is utilized when necessary. IOCCP as GOOS Biogeochemistry Panel is therefore frequently asked to provide input into GCOS. Currently, there are two types of requests that GCOS is directing towards IOCCP. One request is related to the input to the GCOS Implementation Plan and Status Report which set and summarize the implementation of the requirements for ocean observations for climate. Second request is related to participation in ocean observing system review activities proposed by OOPC, such as on storage and air-sea fluxes, and which would benefit considering carbon and oxygen alongside heat and freshwater pools and fluxes. The latter request undoubtedly carries along the need for significant resources for attending meetings and workshops, and document writing. The SSG noted that these efforts are important and that IOCCP is interested in cross-interactions. However, our involvement in this particular case will be best executed through the wider activity of RECCAP2 as well as the IOCR WG of IOC.

In the past, Toste Tanhua was almost solely responsible for the interaction between IOCCP and GCOS. After Toste had rotated off, Masao took over those responsibilities. However, Masao is over-committed and cannot fulfil the obligations towards GCOS to the extent needed. Masao asked the SSG to cooperate with him on the GCOS process, especially in light of requests related to ECVs which require input from all of our panel. SSG expressed

their concern at spreading our panel's attention too thin by taking upon still new tasks and responsibilities.

Nevertheless, several arguments in favour of supporting GCOS requests were put forward:

- There is a need for accurately representing the biogeochemistry flow of data which is very different from that of physics. This will not be achieved via OOPC.
- Increase our visibility in the climate observing space is important to attract funders.
- Without IOCCP's involvement, the ocean component of the carbon budget theme of GCOS will not be represented as well as the atmospheric and terrestrial components.
- IOCCP is in a unique position to respond to GCOS requests for new products based on climate observing system data, and to provide rationale and specifications for developing these products.

IOCCP Exec has recommended that we add an expert whose responsibility would be to ensure that IOCCP is well positioned to the future needs of GCOS. This is particularly important considering our intended advisory role in the IPCC assessments and other UNFCCC activities.

In order to be able to respond to these requests, the SSG agreed that IOCCP can neither do this alone nor do that without additional dedicated funding source. Providing advice on product development is a challenge and an opportunity for closer partnership with the modelling community. This important connection has not been established yet by the Panel. The creation of the products must also receive dedicated funding which however will not flow until it is clear who is responsible and in what capacity.

The SSG decided that we will invite an additional SSG member whose responsibilities will include acting as a GCOS liaison. Several suitable candidates were mentioned by the SSG. IOCCP Exec will consider these suggestions when reviewing the results of open call applications for this role. The SSG also agreed that the long-term strategy is to have a permanent sit at GCOS meetings, but for now we will send Masao and Maciej as biogeochemistry representation to the join the OOPC delegation to the GCOS All Panels Summit in March 2019 in Marrakesh, Morocco.

**Action #6:** Issue an open call invitation for a new SSG expert to primarily act as a GCOS liaison.

Responsible: Office

Timeline: 2019

**Action #7:** Request a permanent sit for GOOS Biogeochemistry Panel representative at GCOS meetings as a long-term solution to an efficient GOOS-GCOS interactions. As a short-term solution, IOCCP representative(s) will join the OOPC delegation to the GCOS All Panels Summit.

Responsible: IOCCP Executive

Timeline: March 2019

**Action #8:** Propose to the IOC-UNESCO Working Group on Integrated Ocean Carbon Research (IOCR) that one of their activities could be the participation in OOPC-led observing system reviews of storage and air-sea fluxes, both of which would benefit from including the ocean carbon components.

Responsible: IOCCP Director (as member of the IOCR SC)

Timeline: early 2019

## **Roles and responsibilities of the SSG based on a skill assessment**

Prior to this year's meeting, each SSG member was requested to self-assess their skills with respect to a number of roles and responsibilities that IOCCP SSG members are asked to perform. The need for this exercise was driven primarily by the continued expansion of IOCCP onto the GOOS Biogeochemistry Panel, and the entailed need for larger in-house expertise and capacity for partnership building.

One of the applications of the analysis of our skill assessment exercise is to make better informed decisions on SSG members' rotations, so that in the future we will not only try to replace the key expertise of an outgoing member but will make sure that new members have additional set of skills needed.

The results of this exercise were discussed in plenary and were instrumental in taking some of the key decisions regarding how IOCCP will approach the execution of action items in 2019 and prepare for achieving its goals on the longer, 5 to 10-year time frame.

Below is a summary of key conclusions derived from the combined assessment of skills, role and responsibilities:

- The information regarding the level of expertise relevant to individual EOVs and platform-specific observations, modelling, policy interaction and other dimensions will be used by the Office to call upon relevant SSG members when dealing with requests for IOCCP action.
- In its current composition, the SSG has a strong expertise in all observing platforms. However, in many cases this strong expertise might be limited to carbon parameters, and be significantly weaker with respect to other Biogeochemistry EOVs.
- There are a few gaps in expertise that IOCCP SSG should be alerted to, considering our terms of reference and obligations towards GOOS. These include the interaction with GCOS, and implementation of Transient Tracer and Nitrous Oxide EOVs.
- It was noted that when appointing a new member onto the Panel, the person should have interest and some expertise in most aspects of IOCCP's portfolio, especially various observing platforms.
- There are strong programmatic connections to national agencies leading the global sustained observing efforts, with the exception of China which is expected to play a growing role in the system, particularly in the development of the Biogeochemical Argo network.
- The SSG is well positioned to act at the science-policy interface but only within the countries we are residents of.
- All SSG members indicated a similar level of time commitment to IOCCP activities, with several looking forward to invest more time in 2019 compared to the 2017-2018 period.
- It must be noted that any changes to the SSG should additionally consider the recommendation from SCOR to further increase the ratio of female members, and to maintain a wide geographical coverage among the members.

## **2018 IOCCP Review commissioned by sponsors**

The Review Report was submitted by the Office in October 2018. It is currently still being considered by the Review Panel. Maciej asked the SSG for support in responding to comments from the review panel once they are made. The timeframe for this activity has not been determined and is beyond our control. The SSG agreed that the Review Report should be made available online if the Review Panel will agree.



## 2<sup>nd</sup> Regional Carbon Cycle Assessment and Processes (RECCAP2)

Masao and Maciej briefly introduced the plans of the Global Carbon Project (GCP) to hold the second Regional Carbon Cycle Assessment and Processes (RECCAP2). This would be the second exercise to evaluate regional and global carbon budgets being organized by Global Carbon Project. Nicolas Gruber (ETH, Switzerland) and Masao initially accepted to lead the ocean component of RECCAP2. The first official meeting of RECCAP2 is planned for March 2019 in Japan. It is anticipated that the meeting will bring 45-50 participants representing all domains, which means there is around 15 open spots to be filled in by ocean carbon experts. Following a few months of discussions on how to engage the ocean community in RECCAP2, Masao asked the SSG to comment on a number of suggestions that he would put forward to GCP:

1. RECCAP2 planning needs to be consulted with the ocean carbon community. This is fundamental to obtain the support of the community, to gather good ideas, and thus lead to a successful exercise.
2. Compared to the time of RECCAP1, IOCCP is better recognized in the community as a coordinating body for ocean carbon observations and data synthesis. Therefore, IOCCP could play a leading role in linking the ocean carbon community with the RECCAP2 effort, perhaps also via the Integrated Ocean Carbon Research (IOCR) WG of IOC-UNESCO.
3. Among core members engaged in RECCAP2-ocean might be a group of participants of SOCOMv2 (Second Surface Ocean CO<sub>2</sub> Mapping Intercomparison) led by Peter Landschuetzer (MPI-M, Germany) and Christian Roedenbeck (MPI-B, Germany). Although their 2018 [proposal to form a SCOR WG](#) was not accepted, they tentatively indicated their intention to interact with IOCCP on RECCAP2. They plan to meet during SOLAS Open Science Conference held in April 2019, in Sapporo, Japan.

The SSG welcomed the news on the RECCAP2 initiative but expressed their concerns about the process of selecting participants and the apparent lack of proper consideration to the ocean component of the carbon cycle. The SSG recalled that the first RECCAP had a very strong observational focus and expressed their hope that the modelling component will not become the dominant one in RECCAP2. However, many of the contributors to RECCAP1 had not been approached in relation to RECCAP2 at the time of the meeting.

The SSG agreed that RECCAP2 would be a large effort requiring substantial amount of resources. In order to discuss and agree on the exact scope and approach to ocean carbon review, an in-person meeting of the ocean community would be needed. The suggestion to involve the IOCR WG of IOC was deemed unsuitable due to the relative immaturity of the IOCR and the apparent tight deadline to ensure adequate representation of the ocean community in the RECCAP2 effort.

The SSG concluded that RECCAP2 was both an opportunity for and a responsibility of IOCCP to provide a strong statement to the GCP that the ocean community needs to be openly involved to enable a successful RECCAP2, and to be proactive in reaching out to the ocean community on behalf of RECCAP.

**Action #9:** Lead the coordination of the ocean component of RECCAP2 to ensure adequate community support and representation during the kick-off meeting in March 2019 in Japan.

Responsible: Masao Ishii

Timeline: early 2019

## Oxygen Theme

Veronique Garçon gave an account of the coordination and communication activities that IOCCP has been involved in during 2018 and confirmed plans for 2019. Below we summarize the key points made by Veronique with synthesis of discussions that followed, focusing on the specific needs of the community with respect to oxygen observations and indicated proposed future directions.

### VOICE

As part of the VOICE initiative, we have submitted an abstract for OceanObs'19 Conference Community White Paper (CWP). The Programme Committee has accepted it and invited VOICE to submit a full review paper to be published in a peer-review journal of *Frontiers in Marine Science*. The core writing team consisting of VOICE Co-Chairs has been leading the process of drafting the CWP. The first draft was reviewed and expanded upon during the 2<sup>nd</sup> VOICE workshop in September 2018, in Kiel, Germany. Please see below for the original CWP abstract as submitted by the VOICE team.

#### ***VOICE OceanObs'19 CWP abstract:***

Providing critical ocean information to satisfy ever-changing socio-economic needs requires a coordinated implementation of multi-disciplinary ocean observing activities. Building on the Framework for Ocean Observing, we recommend readiness level (TRL) assessments for observing the oxycline in highly productive and economically important Eastern Boundary Upwelling systems (EBUS). The upper oxycline (transition between high and low oxygenated waters) is fundamentally important for the ecosystem structure. The VOICE initiative demonstrates how societal benefits drive the need for integration and optimization of physical, biogeochemical and biological components of regional ocean observing and modelling. Together with the Global Ocean Oxygen Network, VOICE creates a roadmap towards observation-model syntheses for a comprehensive understanding of oxycline dependent processes. Local to global effects, such as deoxygenation trends, prompt for a better observing of the oxycline, and for an increased awareness of their impacts onto ecosystem services. VOICE determines its observing design based on scientific and monitoring activities in selected EBUS regions: Canary, Benguela, Humboldt, California, and Indian Ocean. Regional champions aid in addressing the FOO design elements. An assessment of TRL for existing observing, data availability and integration is performed and synthesized to inform local to global stakeholders. An observing strategy for fisheries and ecosystem management exists in all EBUS regions but maturity levels differ. The TRL for the VOICE elements is derived for each region and shall point at system bottle-necks which prevent delivering information and products for end users with a goal of motivating consistency across regions. Identification of relevant stakeholders, developing strategies for readiness level improvements and building and sustaining hard capacity to implement these strategies are fundamental milestones for the next 2-5 years and beyond.

### Global Ocean Oxygen Network (GO<sub>2</sub>NE)

IOCCP SSG member Véronique Garçon and IOCCP Director Maciej Telszewski are members of the Global Ocean Oxygen Network (GO<sub>2</sub>NE, IOC-UNESCO Working Group) Executive Council since it was established in 2016. GO<sub>2</sub>NE is committed to providing a global and multidisciplinary view of deoxygenation, with a focus on understanding its multiple aspects and impacts. The Network offers scientific advice to policy makers to counter this concerning trend and to preserve marine resources in the presence of deoxygenation. Currently, the members of the core working group represent 21 institutions in 11 countries.

A major recent outcome of GO<sub>2</sub>NE was an article published in *Science* in January 2018 on "Declining oxygen in the global ocean and coastal waters." GO<sub>2</sub>NE Executive Council has recently held their annual meeting on September 2, 2018, in Kiel, Germany, just prior to the

Ocean Deoxygenation International Conference. To learn more about the current and planned activities of GO<sub>2</sub>NE, please visit their website at: <https://en.unesco.org/go2ne>

### International Ocean Deoxygenation Conference

The International Ocean Deoxygenation Conference (<https://conference.sfb754.de/event/1>) was held from 3-7 September 2018 in Kiel, Germany. The conference was organised by the Collaborative Research Center (SFB 754) which addresses the threat of ocean deoxygenation, its possible impact on tropical oxygen minimum zones and implications for the global climate-biogeochemistry system. The conference brought together the global scientific community working on Ocean Deoxygenation and aimed to identify drivers and consequences of ocean deoxygenation in the past, present and future. IOCCP was represented by Véronique Garçon and Maciej Telszewski.

One outcome of the conference is the 'Kiel Declaration', in which the scientists call for more marine and climate protection and more international awareness of oxygen depletion. The declaration can be signed [HERE](#). Also, a technical brief for policy makers entitled "The Ocean is Losing Its Breath" was released by GO<sub>2</sub>NE during the conference (access [HERE](#)).



Fig 1. Kiel Declaration on Ocean Deoxygenation.

### Discussion

A matter that was discussed by the SSG in more detail was the request to support a workshop which would aim to prepare a roadmap towards an oxygen data synthesis product. Veronique explained that such a product would be very welcome by the community and if done well, would be a valuable addition to the World Ocean Atlas oxygen climatologies – currently the only global oxygen data product. Veronique proposed to gather ca. 15 experts representing different observing networks performing O<sub>2</sub> measurements. The workshop was tentatively planned for 2019 and would cost ca. 15k EUR. Apart from IOCCP sponsorships, there could

be opportunities for support from Future Earth – Belmont Forum Collaborative Research Action – Oceans and possibly NOAA.

The group agreed that it would be worth to support such an effort but also discussed the many challenges. It was recommended that the workshop organizers look very broadly across the community and in order to ensure optimal, bottom-up community engagement and endorsement. Communication should be established not only between GO2NE, IOCCP and the observing networks, but also with members of GOA-ON, GLODAP and NOAA among others.

**Action #10:** Co-organize a workshop aiming to prepare a roadmap towards oxygen data synthesis product(s). The workshop would gather experts (ca. 15) representing different observing networks and other partners (e.g. GO2NE, GLODAP, NOAA, GOA-ON) involved in dissolved oxygen measurements in the ocean.

Responsible: Véronique Garçon

Timeline: 2019

Financial implications: Medium

## Nutrients Theme

The group applauded Michio for his tireless efforts to increase the comparability of nutrient samples in the ocean. When summarizing the results of the 2018 inter-laboratory comparison study, Michio reminded the group that as many as 28 laboratories out of the 69 participating still did not use Certified Reference Materials (CRMs) for nutrients in seawater. He added that JAMSTEC committed to continue providing CRMs until 2023. It was noted that JAMSTEC provides the CRMs at a preferential price of 6,700 JPN only to academic/research communities who share their data. Commercially-available CRMs, at a price of 10,000 JPN, are sold by KANSO. There is a trend towards increase purchase of CRMs from both JAMSTEC and KANSO, thus satisfying both retailers and justifying the use of both in the community. IOCCP was asked to further advocate for wide-spread use of CRMs.

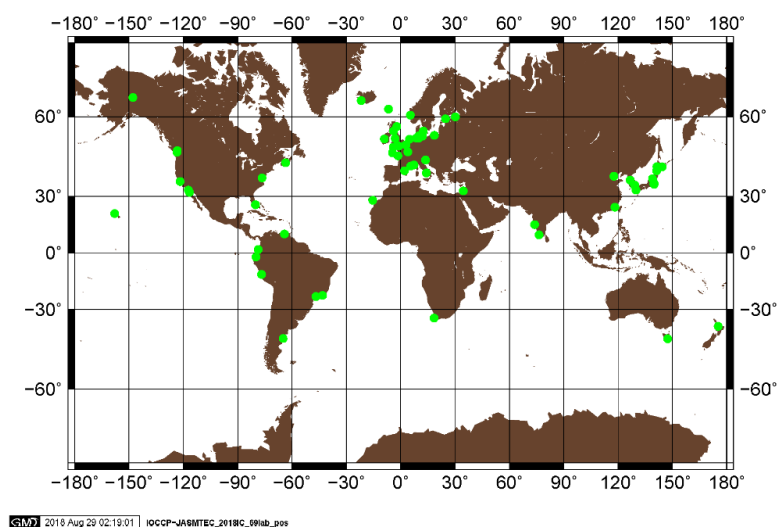


Fig. 2: Geographical distribution of the laboratories participating in the 2018 inter-laboratory comparison study.

Michio presented three recommendations to improve comparability of oceanic nutrients data:

- Continue “Inter-laboratory Calibration Exercises” to regularly assess the level of comparability of oceanic nutrients data.
- Develop a community own standard solution to establish silicon traceability.
- Publish a scientific manuscript detailing the results of the 2014/2015 and 2017/2018 IOCCP-JAMSTEC Interlaboratory calibration exercises.

There was a question whether the current level of comparability is sufficient to detect possible increases in nutrient concentration corresponding to biologically induced decreasing trends in oxygen content. Michio commented on the fact that more work is needed on reproducibility of measurements in order to detect changes in phosphate concentration. Only then can changes in N and P concentrations be used to infer information about the role of deoxygenation in the process.

Michio also informed the group about the completion of the draft of the revised Nutrients chapter for the GO-SHIP Manual, prepared by SCOR WG 147 COMPONUT. IOCCP Office was asked to distribute the draft for community expert review via IOCCP communication channels. Once published, the document will be published in a peer-review journal and submitted to the Ocean Best Practices repository.

The SSG thanked Michio for his dedicated work for the community and expert guidance as he concluded his 6-years of service as IOCCP SSG member responsible for the Nutrients Theme. The group ensured that regardless of who the new member responsible for the Nutrients Theme will be, IOCCP will support future inter-laboratory comparison studies and the equally-important follow-up activities in 2-3 year cycles. In 2019, a new SSG member will need to be recruited via an open call.

**Action #11:** Request community expert review of the draft revised nutrients chapter for the GO-SHIP manual.

Responsible: Office

Timeline: November 2018

Financial implications: none

**Action #12:** Appoint a new SSG member responsible for the Nutrients Theme through an open call application.

Responsible: SSG Exec

Timeline: Early 2019

Financial implications: none

## Framework for Ocean Observing Theme

The past and proposed future activities under the Framework for Ocean Observing (FOO) Theme were presented by Masao Ishii and Artur Palacz. Much of the discussion related to this theme is described elsewhere in this report, especially in the sections devoted to Marine Plastics observing and the expansion of GOOS BGC Panel onto the remaining EOVs.

A significant accomplishment related to the implementation of the FOO was the publication of the Ocean Colour EOVS Specification Sheet, which is available for viewing and download from: [http://www.ioccp.org/images/10FOO/BGC-EOV-Spec-Sheets\\_Aug-2017/EOV\\_Ocean-Colour\\_20180924.pdf](http://www.ioccp.org/images/10FOO/BGC-EOV-Spec-Sheets_Aug-2017/EOV_Ocean-Colour_20180924.pdf). The document has been prepared as a joint effort by the International Ocean Colour Coordination Group (IOCCG) and GOOS Panels.

The challenge of describing the multidisciplinary requirements and applications of ocean colour measurements was met by a task team of dedicated experts from IOCCG Committee and GOOS Expert Panels: Emmanuel Boss (University of Maine, USA), Frank Muller-Karger (University of South Florida, USA), Rosalia Santoleri (Consiglio Nazionale delle Ricerche, Italy), Simon Bélanger (Université du Québec à Rimouski, Canada) and Taka Hirata (Hokkaido University, Japan). Extensive feedback was obtained through two rounds of review provided by the IOCCG Committee, which consists of members drawn from national space agencies and the ocean colour community. We hope that the observing community will find this document useful in the process of implementing the vision for multi-disciplinary and multi-platform sustained ocean observing system.

Although IOCCP as GOOS Biogeochemistry Panel is formally responsible for curation of the document, the Ocean Colour EOVS should be seen as equally owned by and applicable to the work of all three Expert Panels of GOOS: Physics & Climate, Biogeochemistry and Biology & Ecosystems. As in the case of other EOVSs, GOOS in consultation with IOCCG will ensure that the document remains up to date in the future.

Moreover, IOCCP played a leading role in the efforts to better harmonize the three panels of GOOS. This took place through ongoing, regular virtual meetings and a dedicated cross-panel meeting that took place in Hobart, Australia in early 2018. As an outcome of the meeting, the three panels of GOOS managed to reconcile the operational & scientific branches of the value chain adopted by GOOS, harmonize the list of applications and phenomena, agreed on a pragmatic approach to a functional GOOS Strategic Mapping. The full report is available at: <http://www.goosocean.org/cross-panel-2018>

Finally, the IOCCP Executive attended the GOOS Steering Committee meeting in Santa Marta, Colombia, in June 2018. We reported on the BGC Panel activities in 2017 and early 2018. Majority of discussions focused around final acceptance of GOOS Strategy, development of the GOOS Implementation Plan and specifically on building partnerships. Specific requests for our Panel included the issue of Marine Plastics, BGC input into GCOS requirements and input into the GCOS IP. Reports and presentations from the meeting are available at: [goosocean.org/goos-sc-7](http://goosocean.org/goos-sc-7)

Below is a summary of the SSG discussions focused around three other issues pertaining to the implementation of the FOO.

Masao introduced the concept of GOOS Strategic Mapping as a tool promoted by GOOS central office to facilitate external communication between GOOS and its partners and sponsors. The Strategic Mapping has been under development for several years now and there are a number of potential applications envisioned and tested. The SSG had a number of critical comments on the structure and usefulness of this tool and recommended against relying on this tool to implement the FOO. The group pointed at a number of inconsistencies and errors in the presented links between elements of the observing system and the entire GOOS value chain. The SSG agreed that GOOS needed to strengthen the reasoning for the terminology used in the Mapping in order to apply the tool as a communication means. In general, the SSG decided it will not be involved in advancing this particular project further.

The Office also presented a proposed timeline and procedure for curation and regular update of the Biogeochemistry EOVS Specification Sheets. The timeline and procedure were approved by the SSG except for the responsibility for the curation process. It was agreed that it is the IOCCP Office role to perform the curation and if needed, request specific expert input of SSG members and/or external experts. The SSG made a commitment to respond diligently to these requests. It was also agreed that the Office will carefully analyse the results of the Skills and Responsibilities Matrix to identify which SSG member has the greatest level of expertise allowing them to provide relevant input to EOVS documentation.

Finally, the Office proposed to take over the responsibility for the FOO Theme from the co-Chair. In the past, the co-Chair has assumed this role. However, based on the past 6-years experience, it is clear that the majority of tasks and responsibilities fall onto the shoulders of the Office. Recognizing the increased workload taken up by the co-Chairs, the SSG agreed that the Office will be responsible for actions related to the FOO, under close supervision of one of the co-Chairs. At the same time, the SSG agreed that both co-Chairs still need to attend the GOOS SC and Executive meetings.

Below is the list of action items approved by SSG members in relation to the Framework for Ocean Observing Theme.

**Action #13:** Update Biogeochemistry EOVS Specification Sheets according to the new curation procedure and timeline.

Responsible: Office

Timeline: September 2019

Financial implications: none

**Action #14:** Officially take up the responsibility for the FOO Theme and update relevant information on the IOCCP website.

Responsible: Office

Timeline: early 2019

Financial implications: none

**Action #15:** Provide input to the GOOS Implementation Plan.

Responsible: IOCCP Executive

Timeline: 2019

Financial implications: none

**Action #16:** Represent GOOS Biogeochemistry Panel at the 8<sup>th</sup> Meeting of the GOOS Steering Committee (GOOS-SC-8).

Responsible: IOCCP Executive

Timeline: May 2019

Financial implications: Low

## **Ocean Interior Observations Theme**

Based on intersessional discussions, the IOCCP page for Ocean Interior Observations was enriched to include information on Biogeochemical-Argo in addition to the information and link to GO-SHIP. See the website at: <http://www.ioccp.org/index.php/ocean-interior-measurements>

This is not only because both GO-SHIP and BGC-Argo are ocean interior observation networks but also because their cooperation is becoming more important in the evolution of biogeochemical observation in the ocean interior in general. This will be particularly true when BGC-Argo develops from current pilot phase into the future global operation phase.

IOCCP will continue contributing to the development of all ocean interior observations in many aspects such as dissemination, preparation of best practices, capacity building and negotiation with intergovernmental organizations through our work with GO-SHIP Committee, BGC-Argo Steering Committee, JCOMM-OCG, GOOS Steering Committee and others.

### GO-SHIP

In 2017-2018, eleven reference sections (3 in the Atlantic, 1 in the Indian, 3 in the Pacific, 3 in the Southern Ocean, and 1 in the Mediterranean Sea) have been completed in addition to the total of ten high-frequency and associated sections. Ireland completed their first cruise at the zonal section at A02 in the northern North Atlantic in 2017. The section I07N in the western Indian Ocean, which had not been occupied lately because of the piracy, has been completed by US in 2018 for the first time after its last occupation in 1995.

For the years 2019-2022, ten cruises have been planned (nine funded) for reference sections. Among these, five cruises have been funded for the sections in the Indian Ocean and Indian sector of the Southern Ocean, including zonal section I05 by US and meridional sections I06S, I07S, I08N and I09S by Australia, Japan and US.

A review of US GO-SHIP (significant conclusions for international GO-SHIP) is planned for 2019. Topics to be discussed include: expanding onto more biogeochemistry and biology; and relationship between GO-SHIP and BGC Argo. IOCCP's advise in the process will be instrumental. GO-SHIP is also keen on obtaining advice from IOCCP on which EOVs should be included in the expansion of the network's capacity.



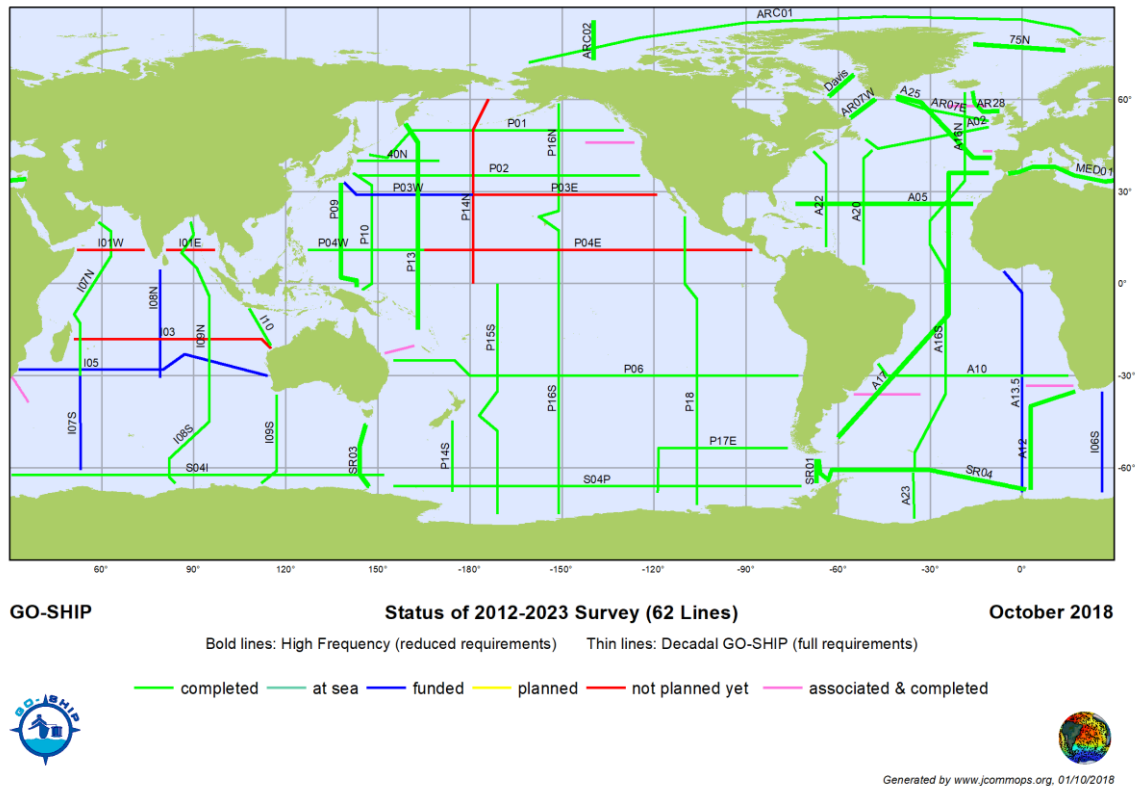


Fig.3 Status of GO-SHIP 2012-2023 survey.

GO-SHIP Repeat Hydrography Manual (“Hydro Manual”) (<http://www.go-ship.org/HydroMan.html>) has been under considerations for the update. In its current edition (V1), a document for the measurements of dissolved organic matter (DOM) is missing. The Hydro Manual also does not comprise Standard Operation Protocols for fluorescence or backscattering in spite that Biogeochemical Argo (BGC Argo) carry these sensors and operators often rely on GO-SHIP data for Calibration/Validation. Underway measurements also require better documentation. GO-SHIP’s Community White Paper for OceanObs’19 will include a table summarizing several elements of the Manual for which updated information is already compiled. These include: documentation for previously not included measurements methodology, description of newly available standards, data depository information summarized for physical, biogeochemical, and biological variables measured on GO-SHIP cruises by sensors on CTD frame, underway, and from water samples taken from Niskin bottles.

GO-SHIP is an affiliated program of JCOMM and one of the GO-SHIP co-chairs attends the annual JCOMM-OCG meetings. In addition, GO-SHIP, through national contributions, supports 3-mo of technical coordinator time at JCOMMOPS for metadata tracker and organization.

### Biogeochemical Argo

In September 2018, a total of 329 BGC-Argo floats were in operation. Although number of these floats is growing, it is still approximately one-third of the target number indicated in the Biogeochemical Argo Implementation Plan. Also the number of floats equipped with sensors

for all six parameters [oxygen, nitrate, pH, chlorophyll a, suspended particles (back scattering) and downwelling irradiance] was zero as of end of 2018 (2 such deployments made in March 2019). Oxygen sensor is the most mature sensor in the BGC collection. It has been installed on all BGC-Argo floats currently in operation. On the other hand, numbers of floats with nitrate sensors (131) and pH sensors (117) remain about less than half to one-third of that with oxygen sensors.

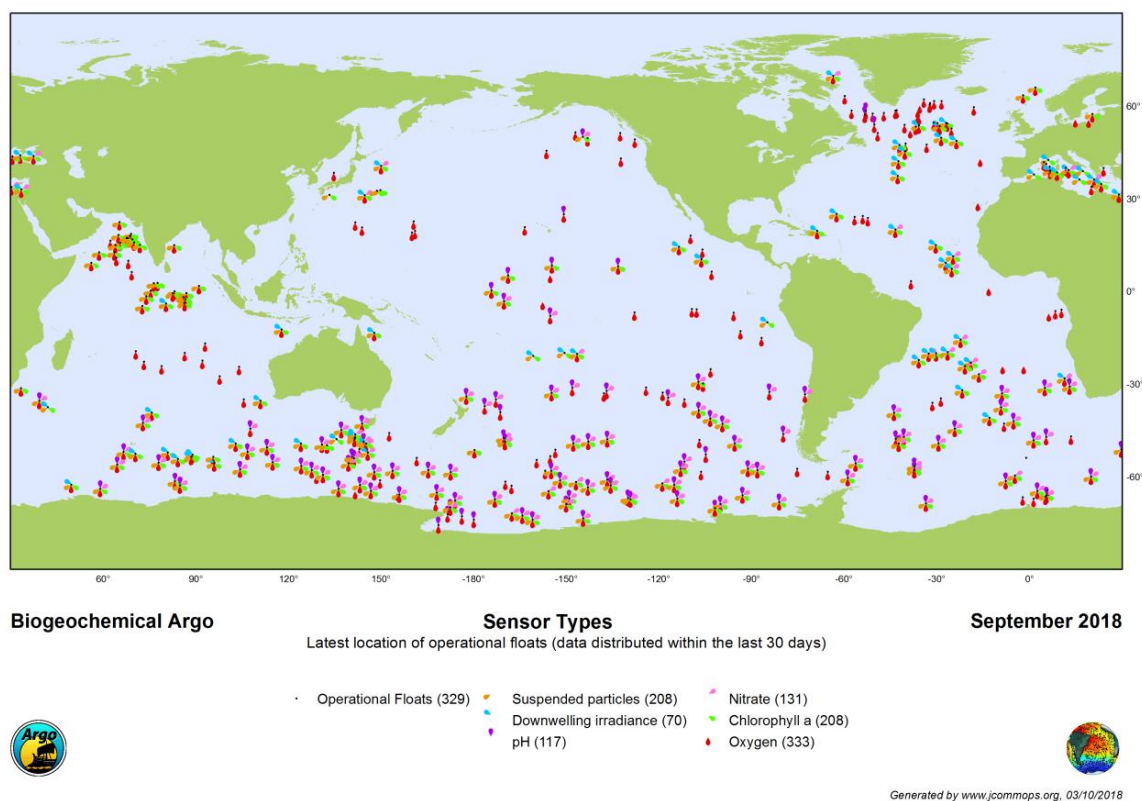


Fig.4: Status of BGC-Argo as of September 2018.

During the 51<sup>th</sup> session of the Executive Council of the IOC of UNESCOs held in Paris on 3-6 July 2018, unanimous support from Member States was given to the proposal to incorporate biogeochemical sensors in the Argo array. Toste Tanhua, the former IOCCP chair and now the co-chair of GOOS, played an important role in obtaining the support.

Details can be found on page 23 of the provisional action paper from that meeting at: [http://ioc-unesco.org/index.php?option=com\\_oa&task=viewDocumentRecord&docID=21550](http://ioc-unesco.org/index.php?option=com_oa&task=viewDocumentRecord&docID=21550)

### Coordination among BGC-Argo, GO-SHIP and IOCCP

Calibration/validation of data collected by BGC-Argo sensors is fundamental in order for these very large sets of data to be used in the context of long-term trends quantification as required when discussing climate variability. This argument is specifically highlighted in OceanObs'19 CWPs submitted by both GO-SHIP and Argo. This argument is as valid for calibration/validation of data from other autonomous ocean observing networks such as that of gliders with BGC sensors.

To facilitate the communication between BGC-Argo Steering Committee, GO-SHIP Committee and IOCCP, local organizers of 6<sup>th</sup> Argo Science Workshop (Toshio Suga and Shigeki Hosoda, JAMSTEC) and that of 13<sup>th</sup> session of IOCCP SSG (Masao Ishii) cooperated and planned each of these meetings in the adjacent dates (22-24 October and 24-26 October, respectively) and venues in the central Tokyo.

The majority of the discussion among the SSG revolved around the growing importance of Biogeochemical Argo in ocean interior observations and the extent to which IOCCP should support it alongside the current support given to GO-SHIP.

The SSG exchanged information on the prospects for future funding of the ongoing components of the BGC-Argo float array and for the expansion of the fleet towards the goal of 1000 floats with all six biogeochemical sensors as detailed in the BGC-ARGO implementation plan (<http://biogeochemical-argo.org/>). The group agreed on the importance of supporting the program on the international level, recognizing the fact that current support is mostly national and project-based, with a growing number of countries committing to create national operational Biogeochemical Argo programs (China, Canada, Japan, Norway).

The SSG remarked on a number of open issues regarding the strategy and implementation of BGC Argo from an international perspective. One such issue is the possibility and cost-benefit analysis of having additional oxygen sensor measurements on core Argo floats, implemented on top of the Biogeochemical Argo float array with a full-blown suite of sensors. Veronique advocated for additional oxygen sensors on Core Argo floats during the Argo workshop in Tokyo.

While the 6<sup>th</sup> Argo Workshop held just prior to the IOCCP SSG meeting was intended to approach some of these issues, it did so only to a very limited extent. Hence, there was a suggestion to organize an international workshop on Biogeochemical Argo but with IOCCP's role as facilitators and with a clear strategy and implementation plan published. Further progress was made at the Argo Science Team meeting in China, March 2019. In particular, the establishment of Argo Mission 2020, or Argo-2020 for short. Dick Feely will scope the need and possibility for pursuing this activity further.

**Action #17:** Share contact information of Biogeochemical Argo PIs with Dick Feely who would inquire about the potential for an international workshop on implementation of Biogeochemical Argo into the future.

Responsible: Office

Timeline: immediate

Financial implications: none

## Surface CO<sub>2</sub> Observations Theme

The international coordination of underway CO<sub>2</sub> measurements from ships under auspices of IOCCP has made major progress and transformation during the intersessional period. The focus of the activity has changed from platform- to variable-based, and the groups performing high quality measurement are currently being united as a network, called SOCONET (surface ocean carbon observing network, <http://www.aoml.noaa.gov/ocd/gcc/SOCONET/>). The SOCAT effort remains the central focal point of data collation and quality control efforts for surface water CO<sub>2</sub> measurements. The SOCAT data requirements are used to establish further coordination and cooperation between measurement groups. As part of SOCONET we are

establishing protocols to quality control air xCO<sub>2</sub> measurements, and we are improving quality control procedures of temperature and conductivity/salinity measurements.

Below we provide an overview of action items that include new items along with updates on the standing items.

#### Continued development of SOCONET

At a meeting, co-sponsored by IOCCP and the NOAA/OOMD/Ocean Carbon Program, in Portland on 9 February, 2018 a reference surface water CO<sub>2</sub> project was proposed to facilitate sustained reference quality surface water CO<sub>2</sub> observations. The effort was enthusiastically endorsed by 35 participants at the meeting, and subsequently the surface water CO<sub>2</sub> community in general. A prospectus of SOCONET is available online at a skeleton webpage: <http://www.aoml.noaa.gov/ocd/gcc/SOCONET/>, and a conference paper is being prepared for the OceanObs'19 that covers SOCONET and the associated Marine Boundary Layer CO<sub>2</sub> ("air CO<sub>2</sub>") measurements. The development will proceed as outlined in the prospectus. Implementation of SOCONET is slower than anticipated in large part because the regional construct were consortia (EU, USA, Japan, Southern Ocean (Australia, New Zealand, and South Africa)) would comprise SOCONET was not embraced. Rather the individual participants wanted to be directly acknowledged and engaged in the SOCONET effort. The readiness level of several participants to accomplish some of the goals (telemetry, near real-time distribution of data) was such that full implementation will likely take several years. The first steps of registering the different ships is well underway with over 40 platforms that appear to meet SOCONET criteria. The next step will be establishing protocols for air CO<sub>2</sub> measurements and QC.

**Action #18:** Highlight/link SOCONET effort to IOCCP Surface CO<sub>2</sub> Observations website & harness external web support for the dedicated SOCONET website.

Responsible: Rik Wanninkhof, Office

Timeline: immediate

Financial implications: none

#### Establishing protocols for Marine Boundary Layer Air CO<sub>2</sub> measurements and QC

To determine air-sea fluxes currently the NOAA Boulder product GlobalView is being used. A quasi-assimilation product CarbonTracker CT2017 is also available. As air measurements of CO<sub>2</sub> are becoming increasingly important, details of how to develop a high quality product without regional bias need to be worked out. It was recommended to carry out an investigation into the feasibility and the need for comparison/validation of products.

Furthermore, the SSG talked about collaboration with the atmospheric observationalists who as a community are also gathered in Global Atmospheric Watch (GAW). GAW requirements cannot be currently met with our ship measurements. However, these ship-based measurements could be of value if the uncertainty is better constrained. Otherwise a special sensor for atmospheric CO<sub>2</sub> measurements would be needed. A useful application could be the validation of satellite retrievals of column CO<sub>2</sub>.

**Action #19:** Attend the Biennial WMO/IAEA meeting on Carbon Dioxide, other greenhouse gases and related tracer measurement techniques (GGMT-19), Korea, Jeju Island, 1-6 September 2019.

Responsible: Rik Wanninkhof

Timeline: 2019

Financial implications: Low

#### Coordination with JCOMM-SOT-SOOP-CO<sub>2</sub>

As part of JCOMM-SOT, key performance indicators (KPIs) and specification sheets have been developed for SOOP-CO<sub>2</sub> and a template is in place for SOOP-BGC. Efforts are underway with JCOMMOPS to list all platforms in their appropriate program. Active discussions are ongoing how to incorporate SOCONET, which is an EOVB-based approach, to the platform based structure of JCOMM. As an interim, all SOCONET pCO<sub>2</sub> sensors will be listed in JCOMM under its relevant platform-based program (e.g. mooring under OceanSITES and DBCP; SOOP-CO<sub>2</sub> under SOOP-SOT).

**Action #20:** Support fundraising efforts to secure a part-time position of a SOCONET coordinator at JCOMMOPS.

Responsible: Rik Wanninkhof

Timeline: 2019

Financial implications: None

#### Investigating utility of SOCONET data for surface water and profiling float pH measurements

Autonomous pH sensors are reaching a maturity level where they are low maintenance, precise, and with minimal drift. There is strong interest to use these sensors to determine surface water pH. As the accuracy of the sensors and conversion of pH to pCO<sub>2</sub> is not well known, the SOCONET quality data will be of great utility to validate or calibrate these units. If successful, this will greatly augment the current surface pCO<sub>2</sub> dataset.

It was proposed that a technical workshop to explore this utility in detail could be organized and supported by IOCCP.

**Action #21:** Organize a technical workshop to explore the utility of SOCONET data for surface water and profiling float pH measurements.

Responsible: Rik Wanninkhof

Timeline: 2019

Financial implications: Low to Medium

#### Outcomes from and updates on the action items developed during the 12<sup>th</sup> session of the IOCCP SSG (February 2017)

##### **1. Constraining uncertainty, accuracy and performance of new generation pCO<sub>2</sub> sensors**

*There should be a concerted community effort to fully constrain the uncertainty, accuracy and performance characteristics of the new generation pCO<sub>2</sub> sensors that can be placed inline without need for gravity drain. As a contribution to this effort, NOAA/AOML will allocate space on the OA cruise in the Gulf of Mexico for concurrent measurements using some of the new sensors. A particular focus will be on characterizing the accuracy and precision of the data of all underway pCO<sub>2</sub> system. A full characterization of the inorganic carbon system will occur*

*during the cruise with measurements following SOP protocols of pCO<sub>2</sub>(20), DIC, Talk, and pH to facilitate comparisons. IOCCP is asked to advertise this opportunity. Based on these results of these side-by-side checks, the criteria for appropriate sensors and standardization should be changed in the SOCAT manual.*

There was limited interest in this activity in part due to limited resources available and short time between announcement and cruise. Of note was the one manufacturer felt that sufficient comparison had been made with predictable outcomes.

Instead of comparison of underway pCO<sub>2</sub>, the General Oceanics (GO) underway pCO<sub>2</sub> sensor was used to test and compare underway pH sensors. Two DuraFED sensors were tested and data is currently analysed. One sensor showed a noisy signal that appears to be a grounding problems which is a common issue for high impedance instruments on ships. The GOMECC-3 cruise referenced above was fully successful with quality inorganic carbon measurements of all four parameters plus, underway pCO<sub>2</sub>, and pH.

During GO-SHIP cruise (A02) in the North Atlantic a thorough comparison was undertaken between the community designed "gold standard" underway pCO<sub>2</sub> system manufactured by General Oceanics Ltd and a Pro-Oceanus membrane sensor. The results are being worked up will appear of a peer reviewed article (D. Wallace pers. com)

ICOS/OTC had plans to host an intercomparison exercise but due to re-organization of the OTC this effort is currently on hold.

## **2. Shift in theme scope from platform to EOY-based**

*There is a change in mindset of the community from platform based to location based assets. This is in part because of new platforms coming online for surface water CO<sub>2</sub> measurements. In addition to ships of opportunity and mooring based CO<sub>2</sub> sensors there are new autonomous platforms such as drifters, wave gliders, and autonomous sailing vessels. The duties in IOCCP SSC members should be adjusted to focus on surface water CO<sub>2</sub> irrespective of platform rather than underway CO<sub>2</sub> observations.*

The re-assignment of SSC member from "underway" measurements to more comprehensive "surface water" measurements has occurred. The coordination of moorings and ships has been accomplished as part of SOCONET. The pCO<sub>2</sub> measurements from other platforms (sail drones) are currently undergoing validation tests (NOAA/PMEL, A. Sutton PI)

## **3. Quality control procedures and information exchange needs to occur between operational groups to further increase uniformity quality and documentation of surface water CO<sub>2</sub> data.**

This will be part of SOCONET and we are working closely with the ICOS OTC for uniformity of procedures. A successful workshop organized by ICOS/OTC was held in Bergen in March 2018 covering this topic. Ongoing discussions within SOCAT Global Group are facilitating improved metadata submission and accommodating of SOCONET (MBL air CO<sub>2</sub>) data.

No further IOCCP action is required with respect to this activity.

## **4. Support developments (inter-comparison experiment, workshop) leading to higher quality atmospheric observations from SOOP-CO<sub>2</sub> (2017 Action Item #9)**

*xCO<sub>2</sub> air measurements that are often done with the underway pCO<sub>2</sub> systems need to be checked independently for quality. A quality check procedure needs to be put in place. Note that, most (all?) of the in-line pCO<sub>2</sub> sensors do not measure air which could limit their applicability to determined high accuracy air-sea CO<sub>2</sub> fluxes.*

This is one of the focal areas of SOCONET. The ocean carbon group at NOAA/ AOML, the atmospheric carbon group at NOAA/CMDL/GMT, and investigators at U. East Anglia (P. Pickers) are currently assessing shipboard MBL-CO<sub>2</sub> data and processing historical data to determine its accuracy and utility. This activity is ongoing.

### **5. Recruiting of ships**

*Recruiting of ships for SOOP-CO<sub>2</sub> remain a challenge despite several groups dedicating effort to doing so (e.g. WOC, Oceanscope, ICOS, JCOMMOPS).*

No concrete actions on recruiting ships has taken place and this remains a major issue in establishing a global network. Related issues of EEZ clearances and permission to install on ships are being investigated.

In particular, EEZ clearance for SOOP are being discussed in JCOMM-SOT and a procedure similar to what is currently established for ARGO through WMO and IOC is advocated. This process entails nations being notified rather than securing permission. Some companies require "DNV GL Maritime" approval for installation of systems. This was successfully completed for a recent install on Eimskip line Sellfoss and basically required detailed description of installation and materials. The shipboard installation manual by Pierrot and Steinhoff proved very useful for this.

## **Ocean Acidification Theme: Global Ocean Acidification Observing Network (GOA-ON)**

The Global Ocean Acidification Observing Network (GOA-ON) is designed to disseminate information global carbon and acidification data sets and assets for management while also delivering scientific knowledge: to improve our understanding of global ocean acidification conditions; to improve our understanding of ecosystem response to ocean acidification; and to acquire and exchange the data and knowledge necessary to optimize the modelling of ocean acidification and its impacts. The observing network is an ongoing effort to continue the international design and coordination strategy; define ecosystem and goal-specific variables; spatial and temporal coverage needs; observing platform-specific recommendations; data quality objectives and requirements; and develop GOA-ON synthesis products.

The GOA-ON Executive Council (EC) held their 5<sup>th</sup> annual meeting in Sopot Poland in May 2018. This meeting served as an opportunity to welcome the new GOA-ON Distributed Secretariat, which includes members from the IAEA, IOC-UNESCO, and the NOAA OAP. These new members will help in supporting GOA-ON's various activities.



*Fig.5: Attendants of the 5th GOA-ON Executive Council meeting in Sopot, Poland.*

The GOA-ON Executive Council has contributed to the development of the methodology for the UN Sustainable Development Goal 14.3.1. The methodology, which is led by IOC-UNESCO, was presented at the IOC Executive Council meeting in July 2018 and was approved.

An Implementation Strategy for the GOA-ON is currently under review, and should be accessible on the GOA-ON website in the coming months. This document will outline the concrete actions GOA-ON will take in achieving its goals, which are laid out in its Governance Plan.

Among the future activities of GOA-ON in which IOCCP will or could be involved are:

- The 4<sup>th</sup> GOA-ON International Workshop to be held in Hangzhou, China on 14 – 18 April 2019. The focus of this workshop will be to allow further development of coordinated networks for monitoring and forecasting of ocean and coastal acidification, and ecosystem responses.
- The GOA-ON Executive Council is collectively writing an OceanObs'19 Community White Paper. This will be an opportunity to communicate GOA-ON's major goals and vision for the future to the wider scientific community.
- The OA-ICC/GOA-ON organized a workshop on data QA/QC and management at the IAEA in Monaco, 22-26 October 2018. Participants from various regions used their own data sets to work on. This was an opportunity to test the newly developed SDG 14.3.1 methodology and associated data and metadata files. IOCCP might be asked/interested in helping with follow-up activities.
- Ocean Acidification will be included as a World Meteorological Organization (WMO) Global Climate Indicator. GOA-ON will produce figures of pCO<sub>2</sub> and pH from various time-series around the world, to be used in the future WMO reports for this purpose.

IOCCP was asked to support GOA-ON with leadership and vision on future carbon science which would help steer the long-term strategy for ocean acidification observation and research. Continued IOCCP support for ongoing and planned GOA-ON activities will be important as the network continues to grow. These include the next international workshop, further development of the data portal and web site, capacity building, Pier2Peer mentoring program, and ongoing



support to developing countries. IOCCP SSG has committed to co-sponsoring the 4<sup>th</sup> GOA-ON workshop.

With Dick Feely rotating off from the IOCCP SSG at the end of 2018, it was decided that IOCCP will request Kim Currie to be appointed as member of GOA-ON EC representing IOCCP. If appointed, Kim would join Cristian Vargas and Maciej Telszewski (representing a wider GOOS perspective at the GOA-ON EC) to ensure close collaboration between IOCCP and GOA-ON on both the global and regional level.

**Action #22:** Appoint Kim Currie as responsible for the Ocean Acidification Theme starting January 2019, and make relevant changes on the IOCCP website.

Responsible: Office

Timeline: immediate

Financial implications: none

**Action #23:** Advocate for Kim Currie to join as a member of GOA-ON Executive Council.

Responsible: Dick Feely, Maciej Telszewski

Timeline: immediate

Financial implications: none

Access to affordable certified reference material for researchers in countries setting up OA monitoring and research continues to be a challenge and the IOCCP should assist the process to the extent possible. A couple of recently discussed partial solutions include exploring the development of IAEA-produced reference material and centralizing shipments which account for a very significant portion of the overall cost. Another ongoing issue, which could benefit from a more centralized solution backed by IOCCP is related to safety issues with mercuric chloride.

#### Discussion:

The discussion among the SSG members was centred around the development of the OA data synthesis products and the potential IOCCP contribution. The need for such products was presented in the context of SDG14.3 and the new WMO OA indicator among others. A wide community consultation in partnership with GOA-ON and other interested coordinating bodies was suggested to identify the most pressing needs for such products and to assess the current and needed capabilities in the community.

A global map of ocean acidification with temporal variability visualized over various relevant timescales was considered as the most effective tool for “upward” communication with local and regional governmental managers and policy makers. Biology and ecosystem scientists rely on the availability of such information in order to examine and project future impacts of OA on ecosystems. For instance, if you know what the carbonate system thresholds for oyster larvae are, and know how often this threshold was/is/will be crossed depending on the current atmospheric CO<sub>2</sub> levels and related marine levels, then you could design an interactive decision support tool for stakeholders interested in assessing risks related to oysters’ farming.

It was agreed that better coordination of time series observations and data management is a critical step towards developing the OA-related products. This includes developing standards and operating procedures for better quality and inter-comparability of data. ICOS OTC has been working towards those goals for fixed ocean stations. ICOS and GOA-ON are learning from each other’s experiences and are natural partners in the process.

Moreover, it was noted that there is a need for agreed procedures for discerning anthropogenic signal from the data – a task that is challenging recognizing the difficulty in de-seasonalizing the signal in coastal time series stations. It was mentioned that US NOAA is working on solutions to these issues and they are open to invite a wider group of scientists to the process.

**Action #24:** Organize a workshop on the procedure for discerning anthropogenic signal in time series data, organized by NOAA by inviting the international community and link to ICOS efforts. *[Possibly to be combined with Action Item 26.]*

**Responsible:** Kim Currie, Cristian Vargas, Rik Wanninkhof, in close collaboration with GOA-ON.

**Timeline:** 2019

**Financial implications:** Low

The SSG agreed that there are strong links between several themes of IOCCP: OA, Time Series Efforts, Synthesis Activities and Data & Information Access Services. For the purpose of developing OA-related information products, IOCCP should ensure close cooperation across all these themes.

Ultimately, the IOCCP SSG, in partnership with relevant organizations, will try to design and organize a workshop for all experts in time series data. The exact scope will be determined by relevant SSG members in consultation with the community. Therefore, there is a potential for combining the workshop described in Action Item 24 with the one on the needs for data product(s) based on input from the time series community (Action Item 26).

## **Ocean Acidification Theme: Latin American Ocean Acidification Observing Network (LAOCA)**

All the different IOCCP tasks focused on the global observing system for ocean acidification have benefited the local needs of the Latin-American community. During 2017-2018 this community has continued to focus on formalizing agreements and defining protocols for  $p\text{CO}_2$  measurements in the region under the auspices of the Latin-American Ocean Acidification Network (LAOCA). LAOCA was designed to synthesize the information about ocean acidification impacts in and around Latin-America, to encourage the implementation, maintenance, and calibration of long-term data-sets of carbonate chemistry, to standardize chemical analytical techniques and protocols for experimentation in order to enhance data quality, to establish a regional node for the articulation and communication between local, regional, and global research programs (e.g. BrOA, IMO, GOA-ON and IOCCP), to design an outreach strategy for communication of this emerging challenge with the society, to promote the development of cooperation projects between member countries of LAOCA, and to promote the inclusion of Ocean Acidification on the political agenda of member countries, and even through the pursuit of cooperation agreements among LAOCA members.

LAOCA carries out significant capacity development in the region, and since 2014 more than 50 researchers have been trained through actions managed within the framework of LAOCA, and the support of a variety of international programs including the OA-ICC (IAEA; <https://www.iaea.org/ocean-acidification/page.php?page=2181>), IOCCP, GOOS, IOC-UNESCO, as well as the Chilean Millennium Institute of Oceanography (IMO; [34](http://en.imo-</a></p></div><div data-bbox=)

[chile.cl/](http://chile.cl/)) and the Center for the Study of Multiple-Drivers on Marine Socio-Ecological Systems (MUSELS; <http://www.eula.cl/musels/english/>).

Nevertheless, some relevant issues are far from being addressed and need continuous reinforcement in the following years. For example a dramatic improvement of data availability (i.e. most data associated to specific projects in each country) is needed, as is standardization of data quality (i.e. protocols and training) procedures and data management structures across and within individual countries.

Status report on the 2017 Action Items:

**1. To help design the components and locations of the global ocean acidification-observing network including existing observing networks wherever possible.**

- *New member countries:* A new achievement this year has been the formal inclusion of new members from the Caribbean region including Costa Rica, Panamá, and Cuba. All those countries have been invited to sign data-sharing agreements in the framework of LAOCA, which is relevant for IOCCP as the surface data will be submitted to SOCAT.
- *1<sup>st</sup> Latin-American Symposium on Ocean Acidification (Red LAOCA 2017; <http://laoca.cl/congreso2017/>)* took place on 24-26 October 2017 at the Cultural Centre for the Sciences of CONICET in Buenos Aires, Argentina. The symposium convoked researchers, students, government and industries representatives from Latin America, but was open to the global community, interested in acquiring a regionally and globally relevant knowledge about the impacts of OA on marine resources and ecosystems. Although LAOCA Symposium was not directly supported by IOCCP, the symposium was an opportunity to share the research results and to explore new opportunities of collaborative research and data sharing in the region. Cristian presented the main objectives of IOCCP, as well as the importance of data quality control and data sharing for the international marine carbon research community (including SOCAT). This meeting demonstrated the need to strengthen observation systems in carbon chemistry on the coasts of Latin America. The next LAOCA symposium will be held in Lima, Peru, in 2020, and will be organized by the Instituto del Mar del Peru.

**2. To help identify measurement parameters and performance metrics for each major component of the observing system.**

There has not been any new advances on this task during the previous 18 months.

**3. To help develop strategy for data quality assurance, storage and distribution.**

This has been one of the aspects of larger development during the last two years. Within the regional community, there is a clear consensus that the information generated by the different research groups should be freely and publicly available for in order for the data to be used for the production of global data syntheses products. At the moment, only Argentina and Brazil are providing  $p\text{CO}_2$  data from research cruises and buoys.

Recently, Chile is including  $p\text{CO}_2$  data from an array located off central Chile (36°S – POSAR Buoy, CR2 Center) through GOA-ON data portal. Validation and calibration of  $p\text{CO}_2$  is carried out by the MUSELS Center in Chile.

Based on the discussion during LAOCA-2017 Meeting in Buenos Aires, the need for quality control procedures to further increase uniformity quality and documentation of carbon chemistry data was also recognized. This issue was already approached and partially addressed in the past (December 2016) through actions under the strong support of IOCCP

(*Technical Workshop on Carbonate System Measurements*). Nevertheless, there is a general mis-information in the region about the protocols for data management, and data sharing in international carbon community programs. The need for a similar workshop on data management at the regional level is still highly relevant.

#### Future Directions:

**Regional capacities for development of new sensors** – Dr. Martin Henández-Ayon at the Universidad Autónoma de Baja California (UABC), México is working on the development of a new sensor for pH measurements. The design of this sensor is relatively similar to Satlantic's SeaFET, but with alternative electronics and associated software. This technological challenge is undertaken to test the relative performance of a lower cost equipment. Also the in-house engineering expertise would allow for a less costly and more timely maintenance over time. One of the main limitations at a regional level is the calibration and maintenance of pH and  $p\text{CO}_2$  sensors that have been acquired through different initiatives (e.g., institutional projects, The Ocean Foundation, IAEA, etc.)

**Data Management Workshop** – To date there are several initiatives aimed at implementing local observing systems in some of the Latin America and the Caribbean countries, through provision of sensors and associated labware as well as the necessary technical training. However, there is no policy on quality control and data management for the region, and therefore in many, if not most, cases the data is not made available to the international community. Also the "know-how" on linking the local observing systems with global observing networks is missing. From this point of view, the organization of a *Regional Meeting on Data Quality Control and Data Management for Ocean Acidification Research* could be a valuable action to be supported by IOCCP.

#### Discussion:

The majority of the discussions among the SSG focused around the issue of data availability and quality control. In some Latin American countries, there is an issue of government restrictions being placed on sharing the data, e.g. Mexico, Peru. However, willingness to share the data is a requirement for LAOCA membership.

A critical issue identified during the discussion is that of quality of available data coming from sensors used in developing countries and distributed by the Ocean Foundation. It was noted that SAMI  $p\text{CO}_2$  sensor data are not included in the SOCAT gridded product. These data received flag E. In situ calibration is not possible for these sensors, and so they cannot be included in the gridded product under current SOCAT rules. In more advanced regions, these sensors are only used for short-term variability studies but not for long-term monitoring.

The SSG agreed on the need for developing best practices (for data collection and data management), and including Latin American colleagues in any intercalibration efforts in the future. Best practices would help the community evaluate whether the sensor calibration was performed accurately, and would allow the regional and global data analyses which would further assess whether the given data uncertainty is within an acceptable range. Regarding intercalibration of pH and  $p\text{CO}_2$  sensors, Dick Feely mentioned a small testbed off the coast of Washington which could be used for this purpose.

The SSG decided to support the organization of a regional meeting on data quality control and management for OA research in Latin America and beyond. Numerous activities of IAEA in the region were mentioned in this context. This workshop would aim to produce a strategy for adequate quality control and thus help connect regional observationalists to the global synthesis products. It was recommended that for this purpose IOCCP, led by Cristian, would

connect with the Ocean Teacher Global Academy (OTGA), GOA-ON, IAEA and potentially the EU H2020 AtlantOS project.

**Action #25:** Organize a regional workshop on data quality control and data management for ocean acidification research in Latin America and other regions.

Responsible: Cristian Vargas

Timeline: immediate

Financial implications: Low to Medium

## Time Series Efforts Theme

Time-series coordination efforts within IOCCP were presented during the IOCCP-organized side event at ICDC10 in Interlaken, Switzerland (August 2017) and at the 12<sup>th</sup> OceanSITES Steering Group meeting in Kiel, Germany (July 2018). During both events shipboard biogeochemical (bgc) time-series sites were promoted and the discrepancy between their scientific value on one side and the lack of data availability and synthesis on the other side, was emphasized. To overcome this situation, the development of a dedicated bgc time-series data synthesis product has been proposed. During the ICDC10 side event, the carbon community – many persons in the room have had experiences with GLODAP and SOCAT synthesis efforts – was consulted about the potential impact of such a synthesis effort and how such a process could be developed. The main outcome of this session was that (i) such a product needs to be driven by a specific scientific question, (ii) the set of variables (EOVs) need to be well defined due to the heterogeneity of time-series sites, (iii) existing data infrastructures would benefit from the technical development and (iv) the envisioned data product would have a high scientific value and impact.

The audience at the OceanSITES meeting was dominated by physical oceanographers (for historical reasons). Coordination activities by IOCCP, OCB and IGMETS were presented and the idea of a ship-based bgc time-series data product was formulated. It turned out that within OceanSITES, no explicit bgc expertise exists and that bgc bottle data only sporadically exists in the OceanSITES data format. OceanSITES would welcome any bgc expertise to improve this situation within OceanSITES. OceanSITES decided to establish some task teams, one on biogeochemistry and one on ecology. There is a recognition of the potential of OceanSITES to deliver information relevant for bgc questions, and there is willingness to engage more with the different science communities, such as IGMETS and GOA-ON. Currently, three topics were identified for the OceanSITES BGC Task Team (composed of Richard Lampitt, Doug Wallace and Tom Trull): CO<sub>2</sub> air-sea gas exchange, OA and change in ocean productivity.

### OCB liaison intensification

The collaboration between OCB and IOCCP was intensified during the past year by regular information exchange. During regular OCB Ocean Time-Series Committee (OTC) virtual meetings, the IOCCP time-series representative was present and reported from the international GOOS perspective in relation to time-series. IGMETS was also present during these meetings. One outcome of this exchange was the concerted presentation of ship-based bgc time series coordination efforts during the OceanSITES meeting, and the development of a 10-year time-series strategy (see below).

### 10-year time-series strategy

A white paper for the OceanObs19 conference with the title “Ocean Time Series Observations of Changing Marine Ecosystems: An Era of Integration, Synthesis, and Societal Applications”

was submitted in 2018. Representatives from the OCB OTC, IOCCP and IGMETS were involved in this process. This 10-year strategy describes the current state of biogeochemical and ecological time-series with a clear focus on ship-based assets. It also discusses the future role of long-term time-series in connection with other (emerging) autonomous observational networks such as the BGC-Argo program or other autonomous platforms, as well as data integration needs and capacity building aspects.

#### Time-Series OceanObs 19 CWP abstract:

Sustained ocean time series from shipboard, autonomous, and remote sensing platforms are critical for characterizing marine ecosystem shifts in a time of accelerating and often unpredictable changes. They represent the only means to distinguish between natural and anthropogenic forcings, and are the best tools to explore causal links and implications for human communities that depend on ocean resources. Here, we highlight important challenges and opportunities for sustained multi-platform ocean time series observations over the next decade. Recent advances in imaging technology, biooptical and acoustic methods, molecular sampling, and remote sensing technology and platforms represent an opportunity to build unprecedented biological and ecological monitoring capacity that will enable us to more effectively address important questions about how marine ecosystems function, how they are changing, and their links to our climate system. Other important tenets of this decadal vision for ocean time series include developing capacity to manage increasingly complex multi-platform data streams, diversifying funding sources to ensure sustained support for these valuable ocean observing resources, and developing synthesis products to serve both science and society. The implementation of this vision will require increased coordination and communication across individual time series programs in the form of a cohesive international time series network to collectively address challenges and develop tools and numerical methods to facilitate more routine data integration. Furthermore, these sustained observations not only enable important scientific discoveries, but they directly support applied research, management, education, and technology development. Strengthening links and facilitating an ongoing dialog with a broader end-user community is an essential step to optimize the regional and global knowledge gained from sustained ocean time series measurements.

### **Future Activities**

#### **Time-series data synthesis product**

In order to initiate the development of a bgc time-series data product two main challenges need to be overcome: (i) Establishing a community-based working group that defines requirements and steers the process and (ii) funds need to be raised to enable the work on a pilot data product.

To achieve the first objective, an international scoping workshop for a bgc time-series data synthesis product is envisioned which involves representatives of shipboard time-series sites, other programs like IGMETS, GOA-ON, etc. and experts with background in GLODAP. The workshop would formulate a roadmap for the development of a pilot data product which should form the basis for a more sustained product in the end. Such a workshop (1.5 days) could be held in Sept. 2019 back to back with the OceanObs19 conference in Hawaii. The workshop could be co-sponsored by IOCCP and OCB as a follow-up initiative of the 2012 time-series workshop in Bermuda. OCB just released a call for 2019 activities to be proposed by early December 2018 which would be a good opportunity to raise external funds for such an effort.

The second objective could be implemented by incorporating this topic into a national or international research proposal to acquire funds for a dedicated postdoctoral researcher who would work on the implementation of a first pilot product. A first attempt has been made recently as part of the EU proposal COMFORT (lead Uni Bergen; H2020-LC-CLA-2018-2019-2020) but due to very limited resources this topic didn't make it into the submitted proposal. Currently, another EU proposal is being prepared (EUROSEA) to be submitted in January 2019 (BG-07-2019-2020: The Future of Seas and Oceans Flagship Initiative, Scope [B] 2019 Observations and forecasting). This provides another opportunity to secure funds for the envisioned pilot product. The idea has been positively discussed with the coordinator (GEOMAR, T. Tanhua) and will be proposed to the respective WP leader soon. NB: Meanwhile, the proposal was submitted which includes a dedicated task to develop a pilot bgc time-series data product.

### Discussion

It was noted that due to lack of demand, the US OCB decided not to reinvigorate the website and mailing list of the international time series network established after the 2012 methods workshop in Bermuda. However, US OCB is actively pursuing better integration of bottled bgc data on the US side. They are very interested in partnering with IOCCP to support the coordination of bgc time series observing efforts and information product development on the global level.

The SSG welcomed the idea of building a coordinated time series community through the development of a time series synthesis product, mimicking the successful bottom-up approach of SOCAT. It was clarified that IGMETS is not working towards any data synthesis products that makes quality-controlled data available for the community, but instead focuses entirely on visualization of metadata and data from time series. What's more, their focus is stronger on ecological variables and the reported status of selected biogeochemistry EOVs is far from complete.

Community coordination from time series synthesis products would help alleviate the major issue that ship-based observing platforms from time-series are not recognized as an observing network, as opposed to moored platforms coordinated through OceanSITES, and thus also not part of JCOMM OCG. Also as noted above, there is only very limited dedicated bgc expertise and data handling in OceanSITES.

Hence, the SSG decided to proceed with gathering a community of practice with the goal of making a ship-based time-series observing network.

The SSG then discussed the issue of quality control of time series data. The QC discussion at future workshop should be based on the outcomes of the 2012 methods workshop held in Bermuda. If the time series data are to be ingested into existing data synthesis products, their quality control needs to undergo a different process than that of e.g. pCO<sub>2</sub> from underway systems. In September, SOCAT group had a workshop in Seattle during which ingestion of data from other platforms was discussed. However, this work is pending the availability of funding for SOCAT. Once available, the report from that meeting will provide more details on the challenges stemming from this issue.

Issues with data availability for BGC EOVs were noted. In general, the less mature the EOV, the less data there would be available from time series stations.

The SSG agreed that the time series product development cannot be done on an ad hoc basis and requires a strategy for establishing the requirements for products, and for securing the adequate resources. It was agreed that the scale of the project must be communicated clearly

in the sense that a map of biogeochemical EOVs from time series is just a final product which is based on a very significant effort that involves financial and human resources needed to collate, process, quality control, analyse and visualize the data.

The SSG thus welcomed the proposal to kick start the process with a brain-storming activity / scoping workshop to be held some time in 2019. The SSG requested that a clear objective be set for the workshop, considering any potential overlap with another proposed workshop on OA products specifically. It was noted that this workshop should aim for getting the community's feedback on what the pressing issues were. These will be related to OA but other SDG targets as well as knowledge gaps identified by IPCC will likely be the drivers for future synthesis product development.

The workshop would not be fully supported by IOCCP and an application for US OCB funds should be prepared. Regarding the timing, it was proposed to hold the workshop as a side meeting to the OceanObs'19 Conference in September 2019. While logistically very appealing, there was a concern about getting a critical mass of participants in a period and place with many parallel meetings going on. Alternatively, there was a suggestion to consider running a time series product workshop back to back with the 2019 IOCCP SSG meeting, for instance in Cape Verde.

**Action #26:** Organize a scoping workshop focused on the needs, capacities and development strategy for time series data product(s). *[Possibly to be combined with Action Item 24.]*

Responsible: Bjoern Fiedler

Timeline: September-November 2019 *[Update: postponed until 2020]*

Financial implications: Medium

In parallel, efforts will be pursued to obtain financial support for a small demonstration project on a limited number of sites, as outlined in two EU proposals. It was agreed that a task team involving IOCCP will be needed to develop a pilot product.

#### Discussion:

In response to a question on the status of OA Africa, Bjorn remarked that there has been a slowdown in OA Africa's activities, and in consequence, its maturity is less than that of the LAOCA network (likely 2-3 years lag time). A white paper on regional observational and training needs in Africa is being prepared and the community would look forward to the lessons learnt from the LAOCA experience.

## **Instruments and Sensors Theme**

An update of relevant activities spanning the intersessional period was presented. Doug mentioned the efforts to communicate the role of the IOCCP in collating information on sensors and other technologies.

Two important outcomes from the AtlantOS project were mentioned. The roadmap for technology development ([http://noc.ac.uk/files/documents/science/WP6\\_Roadmaps\\_\(S+I\\_and\\_Emerging\\_networks\)V4.xlsx](http://noc.ac.uk/files/documents/science/WP6_Roadmaps_(S+I_and_Emerging_networks)V4.xlsx)) will now be maintained by JCOMMOPS. There is also a new deliverable report on the



roadmap for emerging networks ([https://www.atlantosh2020.eu/download/deliverables/AtlantOS\\_D6.2\\_reworked.pdf](https://www.atlantosh2020.eu/download/deliverables/AtlantOS_D6.2_reworked.pdf)). It was agreed that this list will also be rolled onto the IOCCP website.

It was mentioned that while the AUV technology is evolving rapidly, there is a gap on handling data from these platforms. Doug gave a short summary of the results from lab-on-chip on Kongsberg Seaglider, pointing for example at the large variability in the organic nutrients signal detected in the nearshore.

A short discussion ensued about the potential to use the presented sensor on saildrones which in some cases could be used to close the gaps in the observing system, gaps not covered by either ships, floats or gliders.

The SSG also recommended that the hardware directory on the IOCCP website becomes equipped with examples of DOs and DONTs of calibration and validation. It was stressed that in general we need to target institutional and program managers as much as individual observationalists in order to ensure proper consideration of standards and best practices among those investing in sensors and instruments.

A short discussion regarding IOCCP's role in informing the community about newly developed sensors and platforms as they emerge and are applied for short-term and sustained observations. The SSG recommended that we showcase emerging platforms and sensors on our Instruments and Sensors website.

**Action #27:** Expand the Instruments and Sensors website services onto emerging technologies and to highlight the importance of calibration and validation for each instrument and sensor in the hardware directory.

Responsible: Doug Connelly

Timeline: 2019

Due to the fact that there is no sense of community per se around sensor development and based on our experience over the past several years indicating that competition amongst ad-hoc and established developers is stronger than the need to collaborate, the SSG agreed to shift the scope of this theme to focus on technical capacity development combined with updated and perhaps expanded hardware directory. SSG's discussion on that topic in the context of the IOCCP 5-10 year strategy, please see the first section of this report on technical capacity development.

In 2019, IOCCP will commit many of its human and financial resources to organize the IOCCP-BONUS Integral training course on a suite of biogeochemical sensors. More information on the course can be found on a dedicated page of the IOCCP website at: <http://www.ioccp.org/index.php/2019-training-course>. Applications are due by 1 February 2019 and the course will be held from 10-19 June 2019.

**Action #28:** Organize the 2019 IOCCP - BONUS INTEGRAL training course on a suite of biogeochemical sensors.

Responsible: Office

Timeline: 2019

Financial implications: High



Fig. 6: The second announcement for the IOCCP-BONUS INTEGRAL 2019 training course.

## Synthesis Activities Theme: Ocean Interior

Siv gave an overview of the relevant activities that took place between 2017 and 2018. Below is their summary followed by a discussion on planned future actions and IOCCP's role in their execution.

### GLODAP Reference Group and Terms of Reference

The GLODAP Reference Group was formally initiated in April 2017 after finalizing the terms of reference. At the first meeting one additional member (Marta Álvarez) was suggested, who was shortly after invited and accepted to the group.

The first meeting was a virtual meeting held on May 29, 2017. During this meeting the group members were introduced, and the future plans for GLODAP were presented by the group chairs (Toste Tanhua and Are Olsen). Most of the meeting was then spent on a tutorial of the adjustment table (led by Carsten Schirnick) and the concrete plans for the next release (GLODAPv2.2018).

A person was hired at GEOMAR (Nico Lange, with AtlantOS funding) to do the secondary QC on all new cruises and populate the online adjustment table with adjustments, explanatory comments, and figures.

### GLODAP side event at ICDC10 in Interlaken

It was suggested at the first Reference Group meeting that an in person meeting of the new GLODAP team be convened in 2017. One suggested arena was the ICDC10 conference in late August. It turned out not be fisible to gather the entire group in Interlaken, but the IOCCP organized a side event, part of which was focused on GLODAPv2 and future GLODAP issues.

The side event had the following agenda points, and ample time for discussion on these topics:

- Introduction (A. Olsen)
- Quality control (Toste Tanhua)
- Mapped products (Siv K. Lauvset)
- Biogeochemical Argo - GLODAP and GO-SHIP (Henry Bittig)

The new GLODAP website, [www.glodap.info](http://www.glodap.info), is up and running as of April 2018. The website hosts the cruise summary table, and have updated links to the data products, the adjustment table, the publications, and the Reference Group. The site also offers a download of a set of useful figures showing the data. [www.glodap.info](http://www.glodap.info) is not a data archive, but provides links to the data.

### **QC and automation meeting in Seattle, USA, September 24-25, 2018**

Major follow up on discussions held at the XII IOCCP SSG meeting in Miami relates to Jonas Henriksen at UiB, who is currently developing an online QC tool, based on the Lauvset and Tanhua (2015) Matlab code. Such an online tool will reduce the work effort needed to QC new cruises and determine adjustments.

Jonas' work is part of a larger QC automation effort that was discussed in Seattle Sep 24-25, 2018, among discussions about QC routines and how to harmonize methods for different platforms. This relates to a point that was raised at the XII IOCCP SSG meeting about whether we, in the future, want to move towards a system similar to SOCAT with raw files (submitted by each PI), enhanced files (QC-ed, adjusted), and final product files (all cruises combined) all available and archived in the same place. It seems that the community would benefit from such development (possibly without archiving the enhanced files, but rather document the "enhancements" in new metadata). Efforts are now being made to create a data ingestion system that can handle data from different platforms and perform primary QC on them. Such a system will be build based on several basic principles agreed upon by the group:

- independent of people, so people can rotate in and out
- ingestion -> sanity check -> primary QC -> secondary QC -> adjustment
- only submit data once
- must be able to recognize our own data
- able to recognize other's data
- data set based, not variable based - data from same cruise/line should stay together
- salinity, oxygen, DIC, TA, discrete pCO<sub>2</sub>, pH, nutrients, transient tracers, temperature (without QC?), (isotopes)
- PI must be acknowledged, don't anonymize data providers
- relevant papers must be tracked
- must nourish data communities
- need to distinguish between data and data products
- have to recognize that all data have different uncertainties associated and when combined it needs to be easy to account for all

This is a collaborative effort between NOAA PMEL and UiB. The timeline is a year for a data ingestion tool that can perform sanity checks and basic primary QC.

### **GLODAP reference group meeting in Seattle, USA, September 26-28, 2018**

A technical meeting of the GLODAP Reference Group was organized in order to make decisions on adjustments for new cruises, and prepare for the publication of an updated GLODAP version (GLODAPv2.2018)

Prior to this meeting Nico Lange ran all new cruises through the Lauvset and Tanhua QC toolbox, generated crossover figures, and populated the online adjustment table with suggested adjustments (and justification) for all new cruises. During the meeting, the Reference Group discussed all new cruises and made final decisions on adjustments. The online adjustment table was updated as necessary.

Substantial time was dedicated to creating a detailed work plan endeavouring to finalize a new version of GLODAP. Nico Lange (GEOMAR, Germany) will be in charge of this work, with help from Bob Key (Princeton University, USA), a technical assistant from Benjamin Pfeil's group in Bergen, Norway, and several of the Reference Group members. The release is planned for 2019 (ideally before the final AtlantOS meeting in late March).

There will be 190 new cruises in GLODAPv2.2018. These have all been compared and made consistent with GLODAPv2. There are 80 additional cruises, mostly Japanese, which we did not have time to QC for GLODAPv2.2018 and which will be added to GLODAPv2.2019.

In addition to the discussion around and decision on adjustments, there was a discussion concerning a number of issues related to pH:

- There are not enough measured pH data in GLODAPv2 to do a proper crossover QC analysis. Therefore, in GLODAPv2 pH data were QC-ed using two alternative methods (as described in section 3.2.4 in Olsen et al., 2016): #2 interconsistency between measured pH and pH calculated from DIC and alkalinity (if both were present); #3 crossover of calculated DIC OR alkalinity if only one was present along with pH
- In GLODAPv2 the group set the QC-limit to 0.005 for pH (i.e., if differences are smaller than this no adjustment is applied)
- At the Seattle meeting in September 2018 it was agreed that this limit is too small. Given the uncertainties in calculating the carbon chemistry, and recent research highlighting all the known and understood issues related to the inter-consistency of ocean carbon chemistry, we are unable to claim that pH has an accuracy of  $\pm 0.005$  after secondary QC.
- The new limits are  $\pm 0.01$  if method #2 is used, and  $\pm 0.02$  if method #3 is used
- Therefore, for the new cruises in GLODAPv2.2018 no adjustment smaller than 0.01 has been applied to pH. However, the group decided not to apply the adjustments retrospectively.
- All the necessary metadata (scale, temperature, method, impure or pure dye, degree of automation, type of spectrophotometer, etc.) will be collected and collated for all pH measurements in GLODAPv2. In addition, an effort will be made to describe in more detail how the scale conversions, temperature conversions, and adjustments in GLODAPv2 (and subsequent updates) were performed. This will be made available, and will allow users to back-track data manipulations performed during the GLODAP adjustments process. This document will also make it easier for the Reference Group to track and potentially re-apply the QC procedures performed on pH.
- The sub-group dealing with pH in GLODAPv2 is led by Brendan Carter (NOAA/PMEL, USA), Anton Velo (CSIC, Spain), and Marta Alvarez (IEO, Spain).

**Action #29:** Publicize GLODAPv2.2018 through IOCCP channels, in collaboration with the GLODAP Reference Group.

Responsible: Siv Lauvset

Timeline: pending GLODAPv2.2018 release, planned for early 2019

Financial implications: None

The plan is to coincide the new release with the AtlantOS meeting in March 2019 so perhaps a GLODAP-themed event would be appropriate.

### **Support to GLODAP RG in preparations for GLODAPv2.2019 and GLODAPv2.2020.**

Given the goal of annual GLODAPv2 updates financial support for a GLODAP Reference Group meeting (similar to the one in Seattle, USA in September 2018) in 2019 is necessary.

**Action #30:** Organize a GLODAP Reference Group meeting in 2019.

Responsible: Siv Lauvset

Timeline: 2019

Financial implications: Low

Siv also informed the SSG about the retirement plans announced by Bob Key that will force changes in the workflow related to future updates of GLODAP products. The group already implements small adjustments to their procedures but most likely a gap will open between the time when Key retires and the time when the new system described above (automated data ingestion and QC) will be functional. Solutions need to be approved for this transition period with funding being one of the challenges.

#### Discussion:

The SSG recognized how successful the GLODAP effort has become. However, they also marked that one of the major GLODAP RG's obligations is to assure that the data collection process is expanded beyond the individuals dependent on the RG members. Similarly, the process of data ingestion or any other step in producing GLODAP should not rely on a single person, creating bottle-necks in the workflow.

While all acknowledged the benefits of automation in the process, including greater transparency and less reliance on individuals, Siv emphasized the very valuable role that a network of PIs plays in the process. It is currently very easy and efficient to communicate via email to clarify errors and implement fixes rapidly in response to any queries.

The discussion also pointed to the disparate level of confidence in inorganic carbon EOVS vs other EOVS data. GLODAP is also QC'ing and adjusting nutrients, oxygen and transient tracer data, but the confidence is much lower for these variables. Siv remarked that mistakes in the QC and adjustment are very likely, and that it is currently unlikely to eliminate mistakes assuming the short (annual) time line for the future GLODAP updates.

It was noted that the GLODAP format currently does not allow to specify an uncertainty field. In some cases, e.g. nutrients or oxygen, such values can be specified by data providers. Instead, qualitative uncertainty in form of QC flags is being used. There is also a push from the atmospheric community to replace QC flags with uncertainty values. In addition, in the EU there is a growing recognition of the need to provide rich metadata with uncertainty estimates

in order to ensure fitness for purpose of data collected. However, implementing this change from QC flags to uncertainty estimates would be a big step in the GLODAP development.

### **Long-term funding for the GLODAP effort**

Some brainstorming is necessary on how to sustain the GLODAP effort in the long-term. Currently there is some funding at UiB and NOAA PMEL, but this is limited to developing the necessary tools. There is currently no funding for the actual work on creating the final (annual) product.

#### Discussion:

The SSG had a number of ideas and suggestions on how to approach this issue. While in the EU there is now a requirement to state the needs for data archival, dissemination and exploitation in the proposals, the SSG agreed that raising funds through project proposals, and supporting salaries of individual people is not efficient or sustainable. Instead, one should approach mission agencies (e.g. NOAA, Copernicus) with requests and clear communication on the need to provide mandatory support for data synthesis through QC and archival activities written into the plans. Also, an idea was proposed to advocate for funding specific data infrastructures instead of putting aside funds for national archives which do not guarantee funds being allocated to projects such as GLODAP and SOCAT. To this end, the issue must be made visible and advocated for on the level of GOOS, or directly under its umbrella.

These efforts should take place in parallel to, or be preceded by, raising the issue widely among the scientific community. As a first concrete measure to achieve that, the SSG proposed to write a short commentary (e.g. published in Nature Commentary or other high impact journal) communicating the fact there is no sustained funding for data synthesis efforts.

**Action #31:** Write a short commentary (published e.g. in Nature Commentary) on the lack of sustained funding for ocean data synthesis efforts.

Responsible: Siv Lauvset

Timeline: 2019

Financial implications: None to Low

## **Synthesis Activities Theme: Surface Ocean**

Kim Currie gave an overview of the past and proposed future activities related to surface ocean synthesis activities. A brief summary below is followed by a discussion on the role of IOCCP in supporting the future activities.

The 10<sup>th</sup> Anniversary of SOCAT was celebrated with a workshop side-event held at ICDC10 in Switzerland in August 2017. The new look website was also launched at this event, and a celebratory dinner was held afterwards. Dorothee Bakker (UEA, Norwich, UK) and Kim Currie (NIWA, New Zealand) presented a webinar about SOCAT in November 2017 as part of the GOOS webinar series. The on-going annual release of SOCAT was pledged as a Voluntary Commitment at the 2017 UN Ocean Conference (#OceanAction20464).

Version 6 of the Surface Ocean CO<sub>2</sub> Atlas (SOCAT) was publicly released on 19 June 2018, and contains measurements from ships, moorings and other platforms. Version 6 contains 23.4 million quality-controlled surface ocean fCO<sub>2</sub> (fugacity of CO<sub>2</sub>) values with an accuracy of better

than 5  $\mu\text{atm}$ , plus 1.2 million calibrated sensor data points with an accuracy of better than 10  $\mu\text{atm}$ . These data cover the time frame 1957 – 2017.

SOCAT has been cited by more than 210 peer-reviewed scientific articles and reports, and continues to be utilised for the calculation of the Global Carbon Budget. SOCAT also starts to be used to evaluate Bio-Argo floats.

Dorothee Bakker leads the global SOCAT committee, which meets virtually several times per year, with more frequent meetings of the data management team. The implementation of several strategic issues is under discussion:

### **Inclusion of atmospheric CO<sub>2</sub> measurements in consultation with the atmospheric community**

Currently  $x\text{CO}_2^{\text{air}}$  is not included in the SOCAT QC process although several groups include these data in their submitted data-sets, often with a WOCE flag assigned. SOCAT will make these data available through the ERDAPP services, with a clear disclaimer that SOCAT has not QC'ed this parameter. This also applies to any other data submitted, as SOCAT only QC's  $f\text{CO}_2^{\text{rec}}$ . A sanity check will be added for  $x\text{CO}_2^{\text{air}}$  measurements during the data ingestion phase. In the future, the  $x\text{CO}_2^{\text{air}}$  data will be included in synthesis files, but probably not before SOCAT version 7.

#### Discussion:

The discussion focused on the need for translating QC flags into numeric uncertainty estimates, reiterating the points already raised during the discussion on future GLODAP releases. This comes as a strong recommendation from the SSG.

Specifically for SOCAT, the aim is currently to allow ingestion of data with maximum uncertainty level of +/- 10  $\mu\text{atm}$ .

It was clarified that although there is no secondary QC performed on atmospheric CO<sub>2</sub> measurements, this does not mean that the submitted data is without any primary QC.

It was agreed that SOCAT and SOCONET will work together and organize a joint workshop dedicated to the issues of QC outlined above. This workshop would be part of a larger SOCAT community event (see Action Item #34 below).

### **SOCAT QC Cookbook and ESSD article**

The SSG has expressed their support for the following two action items.

**Action #32:** Update the SOCAT QC Cookbook.

Responsible: Siv Lauvset

Timeline: 2019

Financial implications: None

**Action #33:** Update the 2016 ESSD article on SOCAT.

Responsible: Siv Lauvset (Dorothee Bakker leading the paper)

Timeline: 2019

Financial implications: None

### **Future SOCAT community event**

An event is planned for 2019. Several options are being considered, including a potential combined meeting with SOCONET and possibly SOCOM. IOCCP sponsorship is sought for this activity.

#### Discussion:

The SSG expressed their support for the meeting and will dedicate funds for the organization of the event. The SSG recommended that the event includes a technical workshop run jointly with SOCONET on the issues of QC described above.

**Action #34:** Organize a joint SOCAT-SOCONET community event (incl. technical workshop), possibly attached to a larger conference/meeting.

Responsible: Kim Currie, Siv Lauvset, Rik Wanninkhof

Timeline: 2019

Financial implications: Low to Medium

## **Data and Information Access Services Theme**

Benjamin Pfeil presented a summary of the past activities and proposed future actions related to this theme. Below is a short description of what was accomplished followed by a summary of the discussion among the SSG on the role of IOCCP in executing future actions.

### **Operational data flow developments**

Current activities in the USA, Australia and in Europe are moving forward to make the data flow for the EOVS that are of interest to IOCCP (e.g. Inorganic Carbon) operational and to speed up data availability. In Europe, the Research Infrastructure ICOS (Integrated Carbon Observing System), one of the flagships of the European Strategy Forum on Research Infrastructures Roadmap, aims at achieving an operational data flow including Near-Real Time data availability. One of the essential requirements to achieve this goal is to automate data reduction and initial first level quality control procedures.

#### Software development

Within ICOS, an online data reduction and quality control software QuinCe ([https://wiki.uib.no/quince/index.php/QuinCe\\_Wiki](https://wiki.uib.no/quince/index.php/QuinCe_Wiki)) is being developed. QuinCe performs all necessary data reduction calculations according to internationally agreed standards, and performs automatic quality control checks to identify potential inconsistencies in the data. QuinCe was released in 2018 and will be continuously upgraded and maintained. Within the USA and Australia similar approaches towards operational services are being developed e.g. metadata submission and activities are being aligned to ensure complimentary efforts and reduce redundancies.

#### Metadata editor

Current metadata schemes that are used in the community and which are used for data products like GLODAP and SOCAT are based upon the input from the scientific community. This input was gathered at a workshop co-hosted by NIES, PICES, IOC, SCOR and IOCCP in 2004 (<https://tinyurl.com/yaxjnbhb>). This metadata form has been continuously improved



especially by NOAA OAP and the latest version is used by the NOAA OAP, RI ICOS, SOCAT, GLODAP and is the baseline for the methodology for UN's Sustainable Development Goal target 14.3 'minimize and address the impacts of ocean acidification'. In order to ease metadata reporting this form has been modernized and an online editor has been developed by NOAA PMEL within OAP (<https://www.pmel.noaa.gov/sdig/oap/OAPMetadataEditor.html>). In Europe funding was granted through the H2020 ENVRI-FAIR project to upgrade this form and reduce the amount of free text and to ensure that data is FAIR.

#### ICOS OTC Workshop on General Oceanics (GO) – Contros

Within ICOS a dedicated user workshop including overseas participation of colleagues from USA and manufacturers of CO<sub>2</sub> systems was organized in March 2018 at the University of Bergen, Norway. The purpose of this workshop was to discuss experience with, and improvements of, three systems used by stations in the Integrated Carbon Observation System Ocean Thematic Center (ICOS OTC): the General Oceanics (GO) underway pCO<sub>2</sub> system, and Contros' HydroFIA TA and HydroC CO<sub>2</sub> systems. The goal was for participants to come away with a better understanding of the systems and for the manufacturers to receive feedback and ideas to improve their systems. The meeting also aimed at fostering a better communication between the vendors and customers. Topics discussed also included: improving atmospheric measurements and synergizing with the atmospheric community, new platforms and new sip recruitment, standardizing data processing and products, and alternative preserving methods for discrete samples. Minutes from the meeting are available at <https://tinyurl.com/y7nwnn3c>.

#### Quality Control workshop for biogeochemical data and developers workshop

In September 2018, NOAA OAP, IOCCP and RI ICOS Ocean Thematic Centre hosted a workshop at NOAA PMEL in Seattle, USA. The aim of this workshop was to evaluate the quality control methodologies for the biogeochemistry EOVS data measured on various platforms. A global group of 25 experts consisting of scientists, data managers and programmers attended and defined routines dealing with all kind of BGC data from Argo floats, RVs, VOS and moorings in the open ocean and coastal areas within the entire water column. A set of 13 QC routines was identified ranging from simple spike checking to advanced neural networking methods. A summary of the workshop will be published in the IOCCP Conveyor.

In order to guarantee progress, the QC workshop was followed-up with a developer group workshop. NOAA PMEL, with representation from NOAA OAP, and the Bjerknes Climate Data Centre representing ICOS identified the readiness level for the implementation of the suggested QC routines and ensured that both systems and developments are compatible and complimentary. A timeline was set and many routines will be implemented in the GLODAP automation that will be finalized in late 2019.

#### Data products

GLODAP and SOCAT were registered as voluntary contribution to the UN's Sustainable Development Goals in 2017. In addition, both are official IOC-UNESCO/Global Ocean Observing System (GOOS) data products and data is being made available to other communities using various methods to ease the availability, usage and to promote our community efforts. For more information on the developments related to GLODAP and SOCAT, please see the section on Synthesis Activities.

## **Global Data Assembly Centre for Marine Biogeochemistry**

Developments are ongoing and funding was secured in Europe and in the USA – future GDAC partners (NOAA PMEL and BCDC at the University of Bergen signed a Memorandum of Understanding and will apply to become IODE Associated Data Units (ADU) and a formal GDAC application will follow in 2019 or 2020.

### Discussion:

The SSG discussed briefly the complexity of the data management landscape, in particular the need for greater visibility of SOCAT and GLODAP activities among the myriad of infrastructures and initiatives with long-term support, e.g. SeaDataCloud, Copernicus, EMODnet. It was noted that these initiatives do not recognize SOCAT and GLODAP well enough since the communities gathered by these two projects bypassed the National Oceanographic Data Centres (NODCs).

The importance of including other sources of data in the BGC GDAC was noted by the SSG. Many developing countries with obligations towards SDGs and other conventions will use NODCs and not necessarily the data integrators. Thus, it is important to ensure that countries maintain their visibility in the GDAC through different regional hubs, as the obligations to share the data are often the responsibility of the country and not researchers. At the same time, we are aware of the fact that researchers want to be rewarded for their contributions to operational data delivery systems.

The importance of regional visibility is very well understood by the GDAC team. To this end, Benjamin presented the GDAC concept, for instance to the World Data Center for GHGs at their meeting in Japan. Moreover, a memorandum of understanding has been signed with all the partners from regions who agree to share the data. So the efforts reach well beyond Europe and the USA.

Although much of the presented actions and discussions were limited to the Inorganic Carbon EOVS, the SSG recognized the need to account for all other biogeochemistry EOVS in the GDAC planning. For example, harvesting data of dissolved oxygen could be done using the same framework. In case of nutrients, there is a totally different community and other mechanisms of data harvesting will need to be implemented.

Following up on the discussions related to merging several themes with overlapping scope of activities, Benjamin recommended that once the BGC GDAC is implemented, there is no need for an SSG member responsible for data management on the IOCCP Panel. Majority of the relevant actions will be handled by a person responsible for Synthesis Activities. However, considering that current development of the BGC GDAC will likely be limited to only selected EOVS (Inorganic Carbon, Oxygen), there will be a need for long-term support to ensure similarly adequate data management of all Biogeochemistry EOVS.

## **IOCCP Communication Services**

Artur Palacz presented a summary of accomplishments and issues related to IOCCP communication services. These were divided into internal and external.

### **Internal communication**

The following issues were identified with respect to communication on action item responsibility and status:

- No regular review of action item status in the intercessional period
- Progress is made on action items but the Office might not know about it
- Many action items untouched or overdue after 1 year

The Office presented several suggestions to overcome the problems in internal communication. These were discussed by the SSG and the following decisions have been taken:

- There will be regular, quarterly updates on the status of Action Items by SSG member assigned as lead responsible for a given action.
- Each action will have a clear due date.
- A document shared with the SSG will have a list of all action items with a dedicated comment field to update the status of each action.
- The action items status will be reviewed on each VMQ Call, preferably kept to 10-15 minutes.
- The Office will send an email a week ahead of each VMQ call with a reminder to update the status of relevant action items.
- Action Item status as a living document shared and updated by the Office
- All reports/notes from meetings attended will be shared with the SSG and the Office in a timely fashion.

With respect to the monthly IOCCP Executive meetings, which started in 2017, they have proved extremely helpful for boosting internal communication and decision making. The SSG recommended that the Exec consider inviting one of the SSG members on the call if and when this would be relevant for making progress on a given action item.

A separate issue was related to maintaining updated thematic pages on the IOCCP website. Currently, we do not have a regular check and update of the theme pages content. For some themes, we have frequent communication on the website content; for others there is none. There were major reviews of some sites discussed but not implemented (Surface CO<sub>2</sub> Observations, Instruments & Sensors). At the same time, a new template has been designed and implemented for Oxygen theme – and which will now be gradually copied onto other thematic pages. The new template should make the pages more attractive, complete and easier to navigate and update.

**Action #35:** Implement the new template on all thematic pages on ioccp.org, starting with Instruments and Sensor and Surface CO<sub>2</sub> observations.

Responsible: Office

Timeline: end of 2018 to mid-2019

Financial implications: None

SSG members also committed to having regular checks through the thematic pages and the Office will prompt them with occasional reminders if needed. These regular checks should also apply to the Calendar of Events as well as the pages with Standards and Methods, Meeting reports, etc.

The SSG also briefly discussed what is the most efficient format of virtual meetings that happen on a quarterly basis. It was agreed that the format must depend on the current agenda. However, in general it appears more efficient to focus on a relatively smaller number of issues during a single call. One suggestion was to spend the first half of the meeting on a major issue(s) and the remainder of the call on a number of smaller issues. Ultimately, the IOCCP Executive must optimize the agenda on a case

by case basis. The SSG also expressed their appreciation of the notes taken and distributed after each VMQ meeting. There was also a request to provide a reminder about each VMQ call 2-3 days in advance, and provide any background documents at the same time.

The SSG was also asked to set a fixed time in the year in which the annual in-person SSG meeting could take place on a regular basis in order to help anticipate the yearly event scheduling. After a quick poll, it was decided that in general the period 1-15 November would be a suitable time to meet.

## **External communication**

### The Conveyor

First, the SSG was asked to comment on the suitability of issuing the Conveyor on a quarterly basis. The frequency issue was discussed before (2 vs 4 issues in a year) and in 2017 we decided to stick with the quarterly issues. However, for several reasons, we were not able to keep up with that frequency and end up publishing no more than two issues a year.

Considering the workload that goes into each issue and the fact that the community is overloaded with frequent newsletters, the SSG decided to change the Conveyor status from a quarterly to a biannual newsletter. The newsletter was perceived as a useful archive of most important news in a given time period, being complementary to the more rapid communication service provided by the near-daily email news and website updates.

The SSG expressed their interest in knowing who the readers of the Conveyor are. It was agreed that the Office will explore new software solutions to better track the users, for example taking advantage of the experience of Cristian Vargas in that domain.

In response to a suggestion to include a new section on science highlights, the SSG recommended to turn to social media for this type of information dissemination.

### The website usage statistics

Artur presented some statistics from website usage, going back to March 2016. Bot attacks in 2016 were so frequent that we don't report on total usage statistics in that year. In 2017, our Jobs page was the most popular, with more than 1,200 unique page views (i.e. not counting repeated visit of same user during a single session) giving an average of ca. 100 per month. Most popular theme site was dedicated to Instruments and Sensors, and it had over 400 unique page views. Very popular were also sites dedicated to: Nutrients, Framework for Ocean Observing, Ocean Acidification and Surface CO<sub>2</sub> Measurements - each with over 300 unique page views. Other theme pages also received between 50 and 150 page views over that 12-month period.

As of mid-October 2018, Nutrients page received already over 600 unique page views. The instruments and Sensors page continues to attract a lot of attention (ca. 400) with Framework for Ocean Observing, Ocean Acidification and Surface CO<sub>2</sub> Observations next in line. The new Oxygen theme site has already attracted over 100 unique page views in less than 6 months since it went live.

The number of subscribers to IOCCP email newsletter has been growing slowly but steadily since 2016. As of mid-October, there were 530 confirmed subscribers. Regular email news distribution was picked up in early 2016. In 2016, we reached to the community almost 80

times, informing about news, events or job postings on average almost twice a week. In 2017, we sent out more than 60 announcements, and in 2018 already more than 40 announcements (status as of 1 October 2018).

Below is a list of the most popular news items sent in 2017, with number of unique page views in parenthesis:

- 2017 POGO-SCOR Visiting Fellowship Programme (312)
- POGO fellowship for on-board training on Fridge cruise in 2017 (226)
- SCOR-POGO nutrient analysis training workshop for developing countries (225)
- Marine biogeochemistry relevant sessions during 2018 Ocean Sciences Meeting (159)
- SOLAS-IMBeR-IOCCP-GCP-CLIVAR-WCRP meeting on future ocean carbon-cycle research (144)
- GOOS webinar on SOCAT (143)
- 2015 nutrients inter-comparison study report (136)

Figure 7 below shows the geographical distribution of our website users in the period April 2017-March 2018 (left) compared to the period April 2016-March 2017 (right). Please note that Russian users have been completely excluded from this analysis due to an overwhelming number of bots with IP addresses from that country. It can be concluded that there is a very broad geographical distribution of users, however with the majority coming from the USA, the EU and Japan.

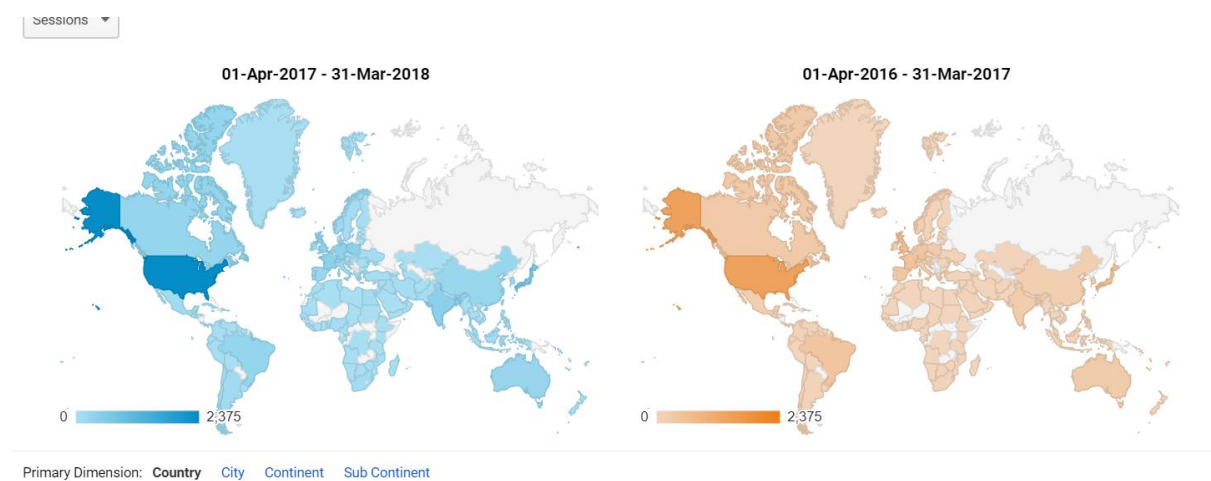


Table below gives a more detailed breakdown of the users by country, this time reported for 2018. Please note that the statistics cannot exclude users who visit the website while travelling abroad, thus perhaps skewing some statistics in case of countries that held large events related to marine biogeochemistry observations.

Country	Users	% Users
1. United States	2,209	36.25%
2. France	508	8.34%
3. India	356	5.84%
4. Japan	304	4.99%
5. Germany	229	3.76%
6. United Kingdom	209	3.43%
7. Italy	206	3.38%
8. China	204	3.35%
9. Canada	195	3.20%
10. Portugal	143	2.35%

We estimate that our website receives on average around 150 unique page views per week, with a minimum of ca. 80 in the boreal summer months and up to 800 in response to particularly important announcements.

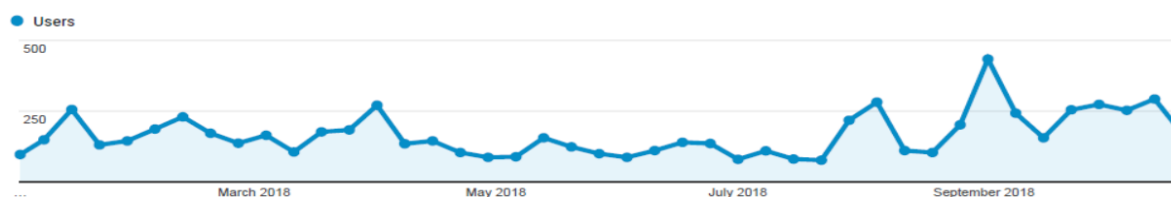


Fig. 8: Number of total website page views in 2018.

It is difficult to assess the value of these results as we do not have a long data record, nor can we compare our data with other coordinating programs. Still, we would like to attract more visitors, and more frequent updates to the thematic pages is one action that the Office and the responsible SSG members will undertake.

### Social media

The Office asked the SSG for their opinion on whether we should extend our communication service onto social media, in particular Twitter. In response, the SSG was overwhelmingly positive about this idea and shared a number of potential benefits based on their personal and programmatic experiences.

It was concluded that new IOCCP activity on Twitter should not be time consuming as most of the activity will focus on simple re-tweeting of the relevant content pasted by partner programs, projects and individuals. The hope is that through Twitter we will be able to reach out to an even greater pool of users and provide a very rapid news communication service.

**Action #36:** Open an IOCCP Twitter account.

**Responsible:** Office

**Timeline:** early 2019

**Financial implications:** None

## **Budget: current status and anticipated support for activities**

Maciej presented the status of the IOCCP budget and outlined what the anticipated spending for 2019 would be. The SSG commended the Office for maintaining a 'healthy' budget and a surplus of money available for activities. Much of the discussions on what the available funds would be spend for took place in relation to action items proposed under each Theme – these can be seen in sections above. Beyond the themes of IOCCP, the group agreed that some additional support could be devoted to the planned actions of IOCR and RECCAP2 in 2019.

In addition, the SSG discussed the unsatisfactory level of GOOS support for the project officer's salary anticipated for 2019 and beyond. Considering the substantial amount of new requests and responsibilities passed onto IOCCP from GOOS, it is expected that GOOS takes the responsibility for continued funding of the project officer beyond June 2019. Currently, fundraising efforts by the IOCCP Office secured additional funding for 3 months, but no resources have been secured beyond September 2019. As a short-term strategy the SSG suggested exploring the possibility of additional fundraising through private donors, national calls in relation to implementing SDG targets, or outreach activities.

**Action #37:** Ensure continued funding for project officer.

Responsible: Office and the SSG

Timeline: 2019

Financial implications: None

## **XIV Session of the IOCCP SSG in 2019**

The SSG decided not to organize the next SSG in-person meeting around the OceanObs'19 Conference in Honolulu. This was partly due to the expected large number of side meetings at that time, but also in line with the decision to fix the timing of the SSG in-person meetings to the first two weeks of November (nominally 1-15 November).

The final decision on where to hold the meeting was left to the IOCCP Exec. The group suggested that we might consider holding a meeting in Europe, to take advantage of one of the planned workshops which IOCCP would like to support in 2019. One particular suggestion to pursue is a back-to-back meeting of IOCCP SSG and a scoping workshop on time series synthesis product requirements, potentially to be held at the new Ocean Science Center Mindelo in Cape Verde Islands. Such a model of combing the SSG meeting with a regional workshop was adopted by GOOS and in 2018 appeared very successful in terms of engaging the local scientific community.

## Annex 1: Meeting Agenda

Headquarter of Japan Meteorological Agency  
Meeting Room on 5F 気象庁  
1-3-4 Otemachi, Chiyoda-ku, Tokyo 100-8122, Japan  
<https://www.jma.go.jp/jma/indexe.html>

### WEDNESDAY, 24 October 2018

08.30-09.00

*Arrival*

09.00-09.10

**Opening and welcome + local logistics** (Masao)

09.10-09.20

**Overview of the meeting agenda** (Kim)

09.20-09.50

**Summary of IOCCP accomplishments over 2017-2018** (Maciej)

09.50-10.30

**Presentation of IOCCP Future Directions – the next 5-10 Years – Overview**

*(In this session we will discuss the anticipated future directions of IOCCP for the next 5-10 years. These result from the continuous request from sponsors and the community and require from us that we do one or more of the following: (i) expand, (ii) assign specific roles and responsibilities to each SSG member, and (iii) update the expertise on the panel to fulfil our ToRs. Session will be introduced by Maciej, discussion moderated by Kim and Masao.)*

*General introduction followed by presentation of the following activities:*

- *Surface Ocean CO<sub>2</sub> observations*
- *Ocean Acidification through GOA-ON*
- *Global Data Assembly Centre for Marine Biogeochemistry*
- *Framework for Ocean Observing: increasing readiness level of BGC EOVs: Oxygen, Nitrous Oxide, Particulate Matter, Dissolved Organic Carbon*
- *Standards and Best Practices*
- *Participation in observing system design, e.g. via JCOMM OCG*
- *IOC-UNESCO WG on Integrated Ocean Carbon Research*
- *Synthesis products*
- *Technical capacity building*

10.30-11.00

*Coffee break*



- 11.00-12.00 **Presentation of IOCCP Future Directions - continued**
- *GOOS Strategic Objectives (15 min presentation by Albert Fischer + 15 min discussion)*
  - *Fulfilling GCOS requirements*
  - *Marine plastics*
- 12.00-12.30 **Roles and responsibilities of SSG members (Maciej)**
- (A review of the expectations towards IOCCP SSG members, including guidelines for feasible action item design and delivery, internal and external communication and fulfilling other responsibilities.)*
- 12.30-13.00 **Presentation of skills, roles and responsibilities matrix (Kim)**
- The presentation focuses on current SSG membership and self-assessed skills.*
- 13.00-14.00 **Lunch Break**
- 14:00-17:30 **IOCCP Themes restructuring and strategy for expansion (moderated by Kim & Masao)**
- This session is motivated by the needs for:*
- *theme restructuring,*
  - *SSG rotations,*
  - *theme and SSG expansion,*
  - *assignment of specific roles and responsibilities to realize IOCCP ToRs.*
  - *requirements and recommendations for new SSG members (with gender, geographic and budget considerations) to be appointed in January 2019*
- Anticipated issues for discussion and decision, based on the need to engage in approved future directions of IOCCP (morning session) and skills, roles and responsibilities matrix:*
- (i) *Responsibility for the Framework for Ocean Observing Theme*
  - (ii) *GCOS requirements*
  - (iii) *Strategy for adding next EOVs as themes: Dissolved Organic Carbon (low hanging fruit), Nitrous Oxide (high TRL), Particulate Matter (high Impact)*
  - (iv) *Data Synthesis Activities Theme combined with Data and Information Access Services Theme + new data synthesis products*
- 15.30-16.00 **Coffee Break**
- (v) *Time series coordination vs data synthesis based on time series efforts*
  - (vi) *Best Practices as a new Theme*
  - (vii) *Combining instruments and sensors with technical capacity development*
  - (viii) *Decision/strategy for handling (or not) the Marine Plastics issue*
- 18.30: **IOCCP dinner cruising in Odaiba-area in Tokyo Port (meet at KKR Hotel Tokyo at 18:00)**

## THURSDAY, 25 October 2018

08.30-09.00

*Arrival*

09.00-09.30

**SCOR & IOC-UNESCO Sponsors Review of IOCCP**

*(Toshio Suga, Co-Chair of the IOCCP Sponsors Review Panel)*

09.30-10.30

**IOCCP Communication Services** *(Artur)*

Internal:

- *Monthly updates on Action Items status and website*
- *Monthly Exec meetings*
- *VM Calls: frequency, structure – how to boost engagement?*
- *Fixed time in the year for IOCCP SSG meetings (e.g. October, February?)*

External:

- *Conveyor: frequency and new ideas (e.g. science highlights)*
- *Website*
- *News*
- *Social media: start a twitter account? (sharing SSG experiences)*
- *Meeting attendance as an opportunity to communicate and coordinate*

10.30-11.00

**Budget and fundraising** *(Maciej)*

11.00-11.30

*Coffee Break*

11.30-12.00

**EOV curation process** *(Artur)*

12.00-12.30

**Future engagement and future meetings** *(Maciej)*

12.30-13.30

*Lunch Break*

13.30-15.30

**Roles and responsibilities of SSG members** *(led by Kim & Maciej)*

*This session intends to discuss and assign key roles and responsibilities of individual SSG members with respect to the requirements identified in the matrix presented by Kim. Meeting the demands of IOCCP's mission might require revision of the currently played roles and responsibilities.*

15.30-16.00

*Coffee Break*

16.00-17.30

**Review of past and proposal for new actions** *(moderated by Masao)*

*(Presentations by SSG members responsible for themes followed by discussion moderated by Masao; ca. 10 min presentation + 20 min discussion for each theme.)*

- *Oxygen*
- *Nutrients*
- *Ocean Acidification*

18.30:

*Self-paid dinner and walk together through Asakusa district (optional)*

## FRIDAY, 26 October 2018

08.30-09.00

*Arrival*

09.00-10.30

**Review of past and proposal for new actions – continued**

- *Framework for Ocean Observing*
- *Ocean Interior Observations*
- *Surface Ocean CO<sub>2</sub> Observations*

10.30-11.00

*Coffee Break*

11.00-12.30

**Review of past and proposal for new actions – continued**

- *Instruments and Sensors*
- *Data Information and Access Services*
- *Time Series Efforts*

12.30-13.30

*Lunch Break*

13.30-14.30

**Review of past and proposal for new actions – continued**

- *Synthesis Activities: Ocean interior*
- *Synthesis Activities: Surface ocean*

14.30-15.00

**Summary of Action Items and final adjustments** (*Maciej & Artur*)

15.00-15.30

**Final review of the roles and responsibilities assigned** (*Kim & Masao*)

15.30

*Meeting adjourned*

17.00-18.30

**156<sup>th</sup> OPRI-SPF Ocean Forum “Deoxygenation”** including a talk by *Véronique Garçon*