

International Ocean Carbon Coordination Project

Progress Report for SCOR, July 2021



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PROJECTS & MAJOR ACTIVITIES

IOC Working Group on Integrated Ocean Carbon Research (IOC-R)

In April 2021, IOCCP was excited to announce that the IOC-UNESCO had published the "Integrated Ocean Carbon Research: A Summary of Ocean Carbon Knowledge and a Vision for Coordinated Ocean Carbon Research and Observations for the Next Decade", a report which sets out to accomplish the vital task of indicating the current gaps and future directions for the integrated ocean carbon cycle research. The report is available for download from [here](#).

IOCCP was one of the five international research and coordination programmes on ocean-climate interaction, which have been working together since 2018 in the IOC Working Group on Integrated Ocean Carbon Research (IOC-R). The other organizations are: the Integrated Marine Biosphere Research Project (IMBeR), the Surface Ocean Lower Atmosphere Study (SOLAS), the Climate and Ocean Variability, Predictability and Change (CLIVAR) project and the Global Carbon Project (GCP).

The report presents a synthesis of the state of knowledge about the oceans' role in the carbon cycle and points to the way ahead. Its objective is to provide decision-makers with the knowledge needed to develop climate change mitigation and adaptation policies for the coming decade. It also emphasizes the importance of scientific knowledge to the taking of informed decisions within the United Nations Framework Convention on Climate Change in order to achieve the goals of the Paris Agreement and build more resilient societies. Through continued collaboration amongst IOC-R WG co-conveners, we hope to develop an innovative joint programme of medium- and long-term integrated ocean carbon research to fill the gaps in this field.

In the Appendix A to the report, there are several pertinent research questions and recommendations in support of the integrated ocean carbon research which the IOC-R conveners and the observing community should be addressing in the next 10 years. These questions, which will also guide IOCCP when planning follow-up actions, include:

- Will the ocean uptake of anthropogenic CO₂ continue as primarily an abiotic process?
- What is the (changing) role of biology in the ocean carbon cycle?
- What are the exchanges of carbon between the land-ocean-ice continuum and how are they evolving over time?
- How are humans altering the ocean carbon cycle and resulting feedbacks?

Surface ocean observations of biogeochemical parameters

Integrated Ocean Carbon Observing System

In 2007, the IOCCP helped the community to start the development of the Surface Ocean CO₂ Atlas Project (SOCAT), which by now has pulled together 28 million quality-controlled surface water CO₂ observations spanning 50 years. The SOCAT database serves as the global basis for evaluating monthly fields of air-sea CO₂ flux. It has been operating for almost 15 years largely on a volunteer basis.

In 2018, IOCCP and US NOAA responded to long overdue need to formalize the coordination of surface ocean carbon observations and came together to develop the Surface Ocean CO₂ Reference Observing Network ([SOCONET](#)), a network of established operators who have developed a pilot

surface water and atmospheric CO₂ reference network that focuses on providing high-quality automated surface CO₂ measurements from multiple platforms from which global air-sea CO₂ fluxes and trends in surface water CO₂ levels may be determined.

During the last several months in response to international calls to operationalize the entire observing value chain allowing to observe, understand and quantify the ocean uptake of CO₂, and in anticipation of the UN Decade of Ocean Science for Sustainable Development, the IOCCP worked with international, regional, and national groups to establish an internationally-agreed strategy and implementation roadmap to convert these existing bottom-up efforts into a sustained global surface ocean CO₂ monitoring network. SOCAT and SOCONET have demonstrated the technological feasibility of implementing a global system. Now it is time to transition these volunteer activities into a global sustained observing network as part of the Global Ocean Observing System.

In June 2021, the leaders of the G7 published the G7 Nature Compact. In this Compact, G7 leaders have committed to supporting the UN Decade of Ocean Science for Sustainable Development by endorsing the G7 Ocean Decade Navigation Plan to drive developments in transformational ocean science to protect and further our sustainable relationship with the ocean.

As part of this work, the G7 will convene scientific and policy experts to discuss "the carbon absorption function of the ocean, furthering targeted and effective ocean action". The IOCCP will work with the G7 Future of the Seas and Oceans Initiative (FSOI) and other international and regional programmes such as the Global Carbon Project, the EU Integrated Carbon Observing System (ICOS) Ocean Thematic Centre (OTC) and others to help deliver the system capable of delivering the information required.

Involvement in OASIS

IOCCP continues its engagement with the SCOR WG #162 "Observing Air-Sea Interactions Strategy" (OASIS) approved by SCOR in 2020, led by Meghan Cronin (NOAA PMEL, USA) and Sebastian Swart (Univ. Gothenburg, Sweden). OASIS is a community working to harmonize observational strategies and develop a practical, integrated approach to observing air-sea interactions through capacity development, leveraging of multi-disciplinary activities, and advancement of understanding.

While no IOCCP SSG members are formally part of the effort, there are four OASIS WG members who are closely linked to IOCCP activities and who provide marine chemistry and biogeochemistry expertise: Ute Schuster, Christa Marandino, Warren Joubert and Shuangling Chen. In addition, Rik Wanninkhof (rotated off IOCCP SSG in December 2020) and two new IOCCP SSG members, Adrienne Sutton (NOAA PMEL, USA) and Richard Sanders (NORCE Research, Norway), are members of the broader OASIS community and they have been tasked with ensuring synergies between OASIS and IOCCP activities.

OASIS presents an opportunity for advancing both research and sustained observations of air-sea fluxes of biogeochemical and other EOVs. In a joint discussion between IOCCP and SOLAS during the 15th Session of IOCCP SSG, the two "sibling projects" recognized OASIS as an opportunity to strengthen the collaboration and jointly support the work of OASIS in light of their own work plans. In particular, the discussions considered the development of a network of integrated air-sea observatories pursued by SOLAS, and how this aligns with IOCCP's plan to revive and expand the operations of SOCONET, developed under IOCCP's Surface Ocean Biogeochemistry Observations theme, and strongly reliant on the EU Research Infrastructure ICOS OTC.

IOCCP's involvement in endorsed programmes of the UN Decade of Ocean Science for Sustainable Development

In order to start implementing a set of observing strategies for biogeochemical EOVs indicated as our ambition in the previous annual report, IOCCP decided to get significantly involved in a number of effective partnerships with relevant interested players and include several identified community needs in bids formulated for submission to the UN Decade of Ocean Science for Sustainable Development (the Decade).

In early June 2021, IOC-UNESCO announced the endorsement of the first programmes and contributions submitted under the Decade. IOCCP has played an active role in preparing five bids which were all successful:

- **Observing and Predicting the Global Coastal Ocean (CoastPredict)** which will “integrate observations with numerical models to produce predictions with uncertainties from extreme events to climate, for the coastal marine ecosystems (their services), biodiversity, co-designing transformative response to science and societal needs.”
- **Observing Together: Meeting Stakeholder Needs and Making Every Observation Count** which will “transform ocean data access and availability by connecting ocean observers and the communities they serve, through enhanced support to both new and existing community-scale projects.”
- **Ocean Observing Co-Design: evolving ocean observing for a sustainable future** which will “build the process, infrastructure and tools for co-design, creating an international capacity to evolve a truly integrated ocean observing system, matching agile observing and modelling capability with requirements.”
- **Global Ocean Oxygen Decade (GOOD)** which will “raise global awareness about ocean deoxygenation, provide knowledge for action and develop mitigation and adaptation strategies and solutions to ensure continued provision of ecosystem services, and minimize impacts on the ocean economy through local, regional, and global efforts, including transdisciplinary research, innovative outreach, and ocean education and literacy.”
- **Ocean Acidification Research for Sustainability (OARS)** which will “foster the development of the science of ocean acidification including the impacts on marine life and sustainability of marine ecosystems in estuarine-coastal-open ocean environments.”

Beyond being directly involved in 5 endorsed programmes, IOCCP has been involved in discussions about contributing to at least 3 further successful submissions:

- **Ocean Practices for the Decade** which will engage diverse communities of practice and interlink them through FAIR digital technologies to secure, equitably share and advance the cultural and natural methodological heritage related to the ocean.
- **Digital Twins of the Ocean (DITTO)** which will “establish and advance a digital framework on which all marine data, modelling and simulation along with [artificial intelligence] algorithms and specialized tools including best practice will enable shared capacity to access, manipulate, analyse, and visualise marine information.”
- **Observing Air-Sea Interactions Strategy (OASIS)** which will “provide observational-based knowledge to fundamentally improve weather, climate and ocean prediction, promote healthy

oceans, the blue economy, and sustainable food and energy.” This programme is driven by members of the SCOR WG#162 of the same name, OASIS.

Global data synthesis activities

New release of Global Ocean Data Analysis Project (GLODAP)

In June 2020, on behalf of the [GLODAP Reference Group](#) and hundreds of seagoing oceanographers that tirelessly have collected data all over the ocean, IOCCP announced the publication of GLODAPv2.2020 and the accompanying paper published ([Olsen et al., 2020](#)). The GLODAP data product provides access to quality controlled surface to bottom ocean biogeochemical data, with an emphasis on seawater inorganic carbon. GLODAPv2.2020 is an update of the previous version, with 106 additional cruises, extension of time coverage until 2019, and the inclusion of available discrete fCO₂ values in the merged product files. GLODAPv2.2020 includes measurements from more than 1.2 million water samples from the global ocean collected on 946 cruises, with data for the 12 core variables that had undergone extensive quality control, especially systematic evaluation of bias. The original data, their documentation and doi codes are available at the Ocean Carbon Data System (OCADS) of [NOAA NCEI](#). This site also provides access to the merged data product, which is provided as a single global file and as four regional ones.

Four IOCCP SSG members contributed as co-authors of the GLODAPv2.2020 release. For a more detailed summary of the product see the [release poster](#).

Towards GLODAP as a sustained effort

In 2020, IOCCP SSG member Siv Lauvset who is also a member of the GLODAP Reference Group (RG), was appointed as the new Co-Chair of GLODAP RG, along with GOOS Co-Chair Toste Tanhua (GEOMAR, Germany). In her role, Siv has maintained the responsibility for guiding IOCCP on how to support GLODAP in becoming a sustained effort.

GLODAP remains a volunteer, community effort, with regular updates and refinements supported by short-term project funding raised by the members of the RG. This presents a significant vulnerability of a product which alongside SOCAT has become a cornerstone of data-based knowledge used for climate model scenario evaluation and assessment, among a growing number of other applications. In order to address the issue, IOCCP and GLODAP RG have initiated discussions and performed a preliminary analysis of the budget required to maintain, update and upgrade the GLODAP effort on a regular basis. Initial results of the calculations were presented and discussed during the 15th Session of the IOCCP SSG (IOCCP-SSG-15), and can be found on page 20 of [that meeting report](#). This preliminary budget is needed to constrain and rationalize the fund raising efforts towards a much needed GLODAP version 3.

In order to highlight the vulnerability of GLODAP and similar ocean data products among the broad scientific community, funders and other stakeholders, the so-called “GLODAP Manifesto” was prepared by the GLODAP community. On 30 June 2021, we were proud to announce that a commentary in Nature Communications titled “A vision for FAIR ocean data products” was published by [Tanhua et al.](#) A number of IOCCP SSG members and IOCCP Project Director were among the co-authors of this milestone publication which will hopefully help raise awareness of the value of GLODAP for quantifying and monitoring the ocean carbon sink.

New release of Surface Ocean CO₂ Atlas (SOCAT)

Also in June this year, we were proud to announce the release of Surface Ocean CO₂ Atlas (SOCAT) version 2021 available via www.socat.info. Quality-controlled, synthesis and gridded products in SOCAT version 2021 contain 30.6 million in situ surface ocean fCO₂ measurements with an estimated accuracy of < 5 µatm. A further 2.1 million fCO₂ values with an accuracy of < 10 µatm are also available. Data collection has continued during the pandemic, albeit at a reduced rate.

SOCAT documents the increase in surface ocean CO₂ for the global oceans and coastal seas, and similar to GLODAP, presents a unique value for various stakeholders. constraining changes in the carbon budgets and climate assessments. SOCAT-based data products are used for quantification of ocean CO₂ uptake and ocean acidification, and for evaluation of sensor data and climate models. The community-led SOCAT synthesis products are a key step in the value chain based on in situ inorganic carbon measurements of the oceans, which provides policymakers in climate negotiations with essential information on ocean CO₂ uptake. Some regional data collection is variable and at risk for lack of long-term funding. The global need for accurate knowledge of ocean CO₂ uptake and its (future) variation makes sustained funding for in situ surface ocean CO₂ observations imperative.

Annual releases of SOCAT are made possible by more than 100 data contributors, quality controllers and other contributors; and under continued leadership of Dorothee Bakker (UEA, UK). Several IOCCP SSG members have been contributing as data providers as well as data quality controllers. SOCAT remains a volunteer, community-based effort which the SOCAT Global Group and IOCCP are keen to make more operational and sustained. To this end, initial discussions towards a SOCAT business plan, akin to that being prepared for GLODAP, have taken place. The next step is likely to perform a preliminary budget analysis for the annual SOCAT release. IOCCP has been working towards aligning SOCAT and GLODAP efforts towards sustainability, through Siv Lauvset who is a member of both the GLODAP RG and the SOCAT Global Group.

Development of a Global Ocean Oxygen Database and Atlas (GO₂DAT)

As reported previously, in 2019 IOCCP engaged with several international partners to develop a roadmap towards creating a “SOCAT-like” synthesis data product for oxygen observations. The need for a standardized, well-documented, high-quality, and comprehensive database, integrating data from multiple sources is growing rapidly with the increasing threat of ocean deoxygenation for marine ecosystems and their associated services to society.

In November 2020 a second workshop was organized (virtually) to follow up with the progress of several task teams convened in the aftermath of the initial scoping workshop held in Sopot, in November 2019. As a result of both workshops and extensive intersessional communication, in June 2021 the group submitted a manuscript entitled “A global ocean oxygen database and atlas for assessing and predicting deoxygenation and ocean health in the open and coastal ocean” to the journal of *Frontiers in Marine Science*, as a review article to the Observing section. This paper outlines the need for a coordinated international effort towards the building of an open-access Global Ocean Oxygen Database and Atlas (GO₂DAT) complying with the FAIR principles (Findable, Accessible, Interoperable, and Reusable). GO₂DAT will combine data from the coastal and open ocean, as measured by the chemical Winkler titration method or by sensors from Eulerian and Lagrangian platforms. GO₂DAT will further adopt a community-agreed, fully documented metadata format and a consistent quality control (QC) procedure and quality flagging (QF) system.

GO₂DAT will serve to support the development of advanced data analysis and biogeochemical models for improving our mapping, understanding and forecasting capabilities for ocean O₂ changes and deoxygenation trends. It will offer the opportunity to develop quality-controlled data synthesis

products with unprecedented spatial (vertical and horizontal) and temporal (sub-seasonal to multi-decadal) resolution. These products will support model assessment, improvement and evaluation as well as the development of climate and ocean health indicators. They will further support the decision-making processes associated with the emerging blue economy, the conservation of marine resources and their associated ecosystem services and the development of management tools required by a diverse community of users (e.g., environmental agencies, aquaculture and fishing sectors).

An international agreement on a common, cross-platform roadmap for GO₂DAT is a major achievement for IOCCP and its partners. This effort, which addresses several of the IOCCP Terms of Reference, attracted significant input from among the IOCCP as exhibited by the fact that seven IOCCP SSG members (of whom three have rotated off by January 2021) and IOCCP Director have co-authored this paper. Future work of IOCCP will focus on gradually implementing the steps identified in the Roadmap, and work towards synergies with potential new or previously unidentified regional developments which might be complementary to GO₂DAT.

Time-series Biogeochemistry Data Product

The development of a ship-based time-series (TS) biogeochemistry data product is an important IOCCP initiative which contributes to Terms of Reference 4, 5, 8 and 9. Over the past 12 months, significant progress has been made in this effort led by Björn Fiedler, IOCCP SSG member until December 2020, in collaboration with other international bodies coordinating time series observing and data dissemination efforts, primarily [US OCB](#) and [IGMETS](#).

The overall goals of this undertaking are to:

- Establish common best practices among ship-based biogeochemical time-series sites by finding commonality of different methods and implementing existing recommendations;
- Provide comparable biogeochemical time-series data to international communities by having a prominent access point to all TS-data in a consistent and uniform format;
- Establish ship-based time-series as a recognized, coordinated global observing network, meeting the criteria of the GOOS Observations Coordination Group (OCG).

During the past year data from 12 ship-based biogeochemical time-series were collected and transferred into a harmonized data set for further development of QC routines. The next step was to discuss with time-series PIs and external experts the development and application of QC routines in order to ensure inter-comparability of time-series data.

Due to the SARS-CoV-2 pandemic the planned in-person community workshop had to be transformed into a virtual event which took place on 23-25 November 2021 (see details on page 18 of this report).

The workshop built upon the two most recent workshops focusing on BGC ship-based time series:

- IOCCP & US OCB Time-Series workshop (2012): Methodology of individual TS sites (“TS at a glance”) → TS-Selection, Basis for method sheet, Sources for offsets
- NSF Earth Cube TS workshop, Honolulu (2019): One of the actionable outcomes was to develop an inorganic carbon-focused TS pilot product

Furthermore, the workshop was closely tied to the long-term EarthCube RCN for Marine Ecological Time-Series (METS) project, funded recently by NSF and which aims at developing a community-agreed FAIR METS data model.

The central outcome of the workshop was the agreed way forward. All participating sites agreed to be on-board for a first pilot product and committed to first immediate steps. These steps include the

formation of four working groups: (i) concept/head, (ii) commonality of methods, (iii) data handling, and (iv) data policy.

The first ongoing action focuses on producing a concept note with a clearly articulated mission statement, outlined benefits for the sites and time-series community, envisioned work- and dataflow and detailed task descriptions of the other working groups. IOCCP SSG members Kim Currie and Adrienne Sutton are both contributing to the effort.

Integrated Marine Debris Observing System (IMDOS)

Since November 2019, IOCCP has led a task in EU H2020 Project EuroSea on establishing global coordination of sustained observations of plastics in the ocean. Following months of in-person and remote consultations, a draft Action Plan to establish global coordination of an Integrated Marine Debris Observing System (IMDOS) was delivered as an internal project milestone report in October 2020. The report was also circulated for further feedback to members of GOOS structures and members of various organisations who will be instrumental in implementing the Action Plan. Moreover, the Action Plan on Establishing a Global Coordination of IMDOS was presented at various fora, including during the Ocean Best Practices System IV Annual Workshop, the EuroSea 2nd General Assembly, or during the 15th Session of the IOCCP SSG in November 2020.

Key to the realization of the objectives of the Action Plan on IMDOS was to convene a Marine Litter Working Group at the [Ocean Best Practices IV Annual Workshop](#) in September 2020. The WG was co-led by IOCCP Project Officer Artur Palacz and by René Garello (IEEE France). It brought together 17 experts on different aspects of marine litter, from monitoring and data management to remote sensing, through modelling and citizen science, to policy and requirement setting. The WG recommendations set priorities and next steps towards harmonisation and standardisation of methods and approaches, as well as on establishing global coordination towards IMDOS. It was recognized that the Marine Litter WG will constitute the main body of experts who will develop the Marine Plastics Debris as a new EOVS of GOOS, to set observing requirements complementing the existing set of indicators informing SDG target 14.1 on marine pollution. See page 15 of this report for more information on the workshop and Marine Litter Working Group proceedings.

The role of IOCCP in establishing global coordination of sustained observations of marine plastics has been recognized, resulting in invitations to provide feedback and expert advice on a growing number of relevant initiatives. In December 2020, IOCCP was invited by the International Ocean Colour Coordination Group (IOCCG) to provide feedback on the proposed Terms of Reference of the new [IOCCG Task Force on Remote Sensing of Marine Litter and Debris](#). After the Task Force was officially approved in January 2021, IOCCP attended its online kick-off meeting, and based on a subsequent meeting with the Task Force leads, further clarified future collaboration to strengthen the in situ-remote sensing interface of marine litter monitoring as a critical element of a future IMDOS. In February 2021, IOCCP Project Officer was invited to join the Standardisation and Stakeholder Advisory Board of a newly-funded EU H2020 Project [EUROqCHARM](#) which aims to analyze and evaluate existing methodologies for plastic pollution assessment, and harmonize them on a European level. Participation in a series of workshops organized by the Ministry of Environment, Government of Japan (MOEJ) is described on page 19 under the Meetings & Workshops section of this report.

Based on a comprehensive stakeholder analysis, summarized as a written internal report to GOOS, in February 2021 IOCCP and the leadership of GOOS took a strategic decision to submit a proposal for a joint GOOS-UNEP project on establishing global coordination of IMDOS. The decision was driven by the realisation that global coordination of integrated marine debris/litter observations would need to encompass a much broader set of activities, reaching beyond the oceanic realm (i.e. beach litter) and higher up the ocean value chain (i.e. coordination of data management activities, providing

scientific assessments). In 2019, the United Nations Environment Assembly (UNEA) asked for a coordination group and a technical platform dedicated to marine litter as a global challenge. The mandate to create such a coordination group was given to UNEP, leading the Global Partnership for Marine Litter (GPML; <https://www.gpmarinelitter.org/>). A high-level discussion between the leadership of GOOS and GPML/UNEP was therefore strongly recommended prior to establishing any new global coordinating body or project under the umbrella of GOOS. Expanding the scope of IMDOS coordination as led by GOOS but in partnership with UNEP and other actors to match the UNEA mandate could:

- help reconcile the EOVS observing framework with the SDG indicator framework which is used to set policy requirements for marine debris monitoring,
- prevent the need for establishing another parallel technical group/platform realizing the full UNEA mandate, and
- provide GOOS an opportunity for concrete transformative actions as part of its endorsed programmes under the UN Ocean Decade for Sustainable Development.

A joint GOOS-UNEP project proposal on IMDOS was sent to GPML/UNEP in April 2021, and subsequently discussed during a high-level meeting held online on 26 May 2021 between Hartwig Kremer, Heidi Savelli-Soderberg and Marta Ottogalli from UNEP, Toste Tanhua and Albert Fischer from GOOS, and Artur Palacz from IOCCP. The conversation was framed in the context of a broader collaboration between GOOS and UNEP on the Global Environmental Monitoring System (GEMS) Oceans, currently being developed. The parties expressed their enthusiasm at the proposal, and agreed that GOOS and UNEP will proceed to jointly refine the scope of IMDOS as a long-term project. IMDOS was pointed out as a clear demonstration of the benefits of strengthening the overall partnership between GOOS and UNEP - a key objective identified by GOOS in the Roadmap for Implementation of the GOOS 2030 Strategy.

During a follow-up technical meeting in June, IOCCP and UNEP identified a number of opportunities and near term actions to demonstrate the capacity of IMDOS as a backbone observing system behind the GPML Digital Platform which is aimed at informing stakeholders on marine litter pollution as a global challenge. Much attention was paid to the capacity of GOOS to monitor the capacity and status of observing networks tracked by OceanOPS, and how such a technological solution and coordination service could be extended onto marine litter monitoring in the future.

Setting requirements for EOVS and ECVs

GOOS Implementation Plan

Following the publication of the GOOS 2030 Strategy, and the Roadmap towards Implementing the GOOS 2030 Strategy, GOOS assigned priority to developing an internal GOOS Implementation Plan (IP). The proposed GOOS IP, currently still in draft form, identifies priorities for GOOS structures to undertake individually, or across GOOS, on a 1-3 year time scale. Listed actions are accompanied with estimates of resource and other requirements, and describe the anticipated outcomes in relation to the strategic objectives of GOOS and goals of its elements. The document was presented for discussion during the recent GOOS Steering Committee (SC) meeting in April 2021, and is expected to be finalized by the end of 202.

Throughout the second part of 2020 and early 2021, IOCCP provided input and feedback on the content and format of the living document which is meant to guide the GOOS SC and GOOS Structures to efficient and timely realization of the strategic goals. In order to fulfil IOCCP's 2030 vision for a mature, sustained marine biogeochemistry observations being a part of a global, integrated

system delivering essential information to the society, IOCCP's input to the GOOS IP concentrated on specific actions aimed at implementing the following IOCCP Strategy recommendations submitted to the OceanObs'19:

- To reconcile the societal and scientific requirements for biogeochemistry observations by strengthening or establishing new partnerships between observing networks and relevant expert working groups (in particular IOC-UNESCO WGs such as GO₂NE and IOCR, SCOR WGs such as P-OBS and OASIS, and UNEP expert communities).
- To establish partnership between IOCCP and GEOTRACES to support the implementation and increase of readiness level of sustained observations of EOVs, such as Particulate Matter and Nutrients.
- To support centralized monitoring and performance evaluation of all observing networks carrying out biogeochemistry EOV observations (i.e. through OceanOPS).
- To increase the observing capacity by adding routine biogeochemistry (and biology) EOV measurements on existing observing networks, in particular GO-SHIP and OceanSITES.
- To support observing networks and communities in regularly assessing the potential of newly developed observing techniques to better elucidate changes in key ocean phenomena, (e.g. ventilation, biological carbon uptake, deoxygenation).

It is worth noting that all developed activities which require IOCCP's involvement are now aligned with the new 2020-2023 IOCCP Action Plan.

GOOS Task Team on EOVs

During the 10th Session of GOOS SC, IOCCP Project Officer together with Maria Hood (G7 FSOI, France) reported on the current status of the GOOS Task Team on EOVs. The decision to establish the EOV Task Team was taken during the 9th Session of GOOS SC with the intention of inviting not only SC members but also other members of the ocean community in order to establish guidance for GOOS on the current use and future evolution of the EOV process. As of June 2021, the Task Team has not yet formally been established but is expected to officially commence once a new GOOS consultant is hired in the second half of 2021. Nevertheless, a number of activities were taken up by Maria Hood, hired as a GOOS consultant in late 2020, supported by IOCCP and other GOOS Panels' Secretariat.

Building on the EOV Task Team Preparation report and the review of EOVs from the OceanObs'19 Community White Papers, a revised version of the draft Terms of Reference and a proposed list of Task Team members were developed for consideration by the GOOS Project Office. It is proposed that the Task Team address the following issues and questions:

1. Review the current set of GOOS EOVs with respect to issues raised in the OceanObs'19 Community White papers, identify gaps, and distinguish between global needs vs regional / national needs.
2. Consider whether GOOS should provide oversight / management for an expanded set of EOVs.
 - What structure(s) in GOOS will oversee and guide the development of new EOVs, what is the procedure for adoption of new EOVs, what is the procedure for recognition of regional / national EOVs as contributions to GOOS? What are the benefits of being recognized as a contribution to GOOS?
 - What structure(s) in GOOS can facilitate and enable coordination and compatibility / interoperability of data streams between the national / regions systems and the global system?
 - How can GOOS facilitate international collaborations and public-private partnerships for sensor development to focus on the EOVs?

3. Revise the draft EOVS paper, ‘The Global Ocean Observing System Essential Ocean Variables (EOVs)’ by expanding the list of authors, addressing the expanded set of EOVs, and explaining the global and regional / national guidance structure.
4. Provide guidance about how to harmonize the sets of EOVs across the 3 Expert Panels of GOOS, and how to streamline reporting on the GCOS ECVs. The Task Team should evaluate the work required for this harmonization process (including development of a common review schedule and template similar to the OCG Network Specification Sheets).

In early 2021, IOCCP Project Office developed a [new, uniform template to store information about GOOS EOVS requirements](#) across the three Expert Panels of GOOS: Physics & Climate, Biogeochemistry, and Biology & Ecosystems. Currently, the new template is being implemented by the Panels across the EOVs which they are responsible for curating. In parallel, necessary updates are introduced, and new information added in response to feedback from the community. In particular, the new template clarifies the relationship between EOVs and various policy indicator frameworks, and requests more detailed information on the observing requirements in line with the GCOS Requirements and the WMO Rolling Review of Requirements.

The new template will form the basis for updated EOVS Specification Sheets to be published with a professional layout by the end of 2021, with DOI numbers assigned and version control established. It is anticipated that the exercise will also significantly help streamline and eventually harmonize the requirement setting process for climate, operational services and ocean health applications. The latter proposal was discussed by IOCCP, OOPC and WMO staff at a dedicated session of the 24th Session of OOPC held online in April 2021 - see details on page 22 of this report.

Global Climate Observing System Status Report

IOCCP as GOOS Biogeochemistry Panel took an active role in drafting and expert review of the 2021 Status Report on the Global Climate Observing System. This report, which was [released for public review in February 2021](#), provides an overview of the adequacy of the observing system as a whole and considers the status of observations of each Essential Climate Variable (ECV). It covers atmospheric, oceanic, terrestrial, cryospheric and hydrological variables. The GCOS Status Report, aimed to be published in July 2021, will be considered by the UNFCCC, sponsors of GCOS and other international observing systems. Its publication will be followed by an updated GCOS Implementation Plan which will address gaps and new and developing needs.

Technical capacity development, standards and best practices

2021 ICOS OTC pCO₂ instrument inter-comparison

In recent years, new technologies have been evolving with a whole new generation of sensors and instruments measuring pCO₂ in both the ocean surface and subsurface entering the market. These include “classical” equilibrator based systems with new CO₂ detectors to membrane based sensors that can be submerged. In the period 28 June - 11 July 2021, after 1 year postponement due to COVID-19, the Integrated Carbon Observation System - Ocean Thematic Centre ([ICOS OTC](#)) organized the [2021 ICOS OTC pCO₂ instrument inter-comparison](#). IOCCP Director, Maciej Telszewski and IOCCP SSG member Dariia Atamanchuk (Dalhousie University, Canada) are members of the Organizing Committee.

The aim of this exercise is:

- to compare the performance of instruments and sensors that are (or will be) used within the ICOS community over a range of temperatures and pCO₂ levels.
- to engage instrument suppliers and manufacturers to work together with the observational community to reach a high level of standardization in operating pCO₂ sensors and instruments.
- to give answers to the community of choosing the appropriate sensor for their application.

The aim was not only to compare different instrumentation, but also to improve the handling of instrumentation and of data, in order to achieve the best possible measurement quality being delivered. While the inter-comparison took place at the Flanders Marine Institute (VLIZ) in Oostende, Belgium, it was designed as a hybrid event, with those unable to travel being briefed on the progress through daily meetings.

On June 25, IOCCP together with ICOS OTC held a public webinar to kick off the 2021 ICOS OTC pCO₂ instrument inter-comparison. The webinar was organized and moderated by IOCCP SSG member Dariia Atamanchuk and IOCCP Project Officer Artur Palacz, and featured talks by leads and participants of the current and past pCO₂ inter-comparison exercises. The webinar introduced the structure and goals of the exercise but also provided a historical overview and legacy of past pCO₂ inter-comparison exercises which took place between 1994 and 2010. The webinar was attended live by over 70 participants from many time zones. Stimulating questions were posed by the attendees, and sparked follow-up conversations, for example on linking the pCO₂ intercomparison results with the strategy for diversifying the supply of Certified Reference Materials globally.

The webinar was the first in a series of three webinars related to this inter-comparison. The second webinar will take place on Monday, 12 July to provide a quick summary of the inter-comparison exercise outcomes. The third and final webinar will take place in October 2021 (tentatively) and will deliver a synthesis of the results and give an opportunity for community discussions prior to the final report publication.

Recordings from all webinars will be available online, and results of the inter-comparison published in open access, in an effort to further promote the importance of comparability of pCO₂ measurements globally, and to ensure legacy and maximum impact of the 2021 inter-comparison.

Upgrade of the Instruments and Sensors Directory

In line with several of its Terms of Reference, IOCCP promotes the development and adoption of necessary measurements and measurement technology for the benefit of marine biogeochemistry sustained observations, and the global ocean observing system as a whole. Apart from developing and supporting training activities for users of observing technologies, IOCCP wants to keep the community up to date with the latest information on the instruments, sensors and platforms used around the globe. The IOCCP [online hardware directory](#) of instruments and sensors measuring biogeochemical parameters in the marine environment is a unique service among the projects and programmes contributing to the global ocean observing system. This online resource provides information about commercially available hardware (sensors and instruments) and associated contacts and reference documents. It remains one of the most popular sites among those visiting the IOCCP website.

Following the appointment of Dariia Atamanchuk as the new IOCCP SSG member responsible for the Instruments & Sensors Theme, IOCCP resumed the outstanding task to update and significantly expand the online hardware directory. A large number of new instrument and sensor models was added to the portfolio of well-established as well as recently emerged companies. Particular attention was paid to including information about sensors and instruments measuring all biogeochemical EOVs, as the directory was up to now strongly focused on inorganic carbon measurement technology. A new,

more user-friendly interface allows for easier and quicker navigation. By (re-)establishing contacts with instrument and sensor manufacturers, IOCCP confirmed their strong interest in jointly maintaining the online hardware directory, in particular among the young and emerging companies.

IOCCP hopes that the updated and significantly expanded online directory will satisfy the growing needs of the marine biogeochemistry community, and facilitate broad application of state-of-the-art measurement technology across the open ocean - coastal continuum.

Recognizing shortage of Certified Reference Materials

A major issue faced by the marine carbon community in general, including those making ocean acidification relevant measurements, is the vulnerability to the supply of Certified Reference Material (CRM), currently produced and supplied solely by Andrew Dickson's lab at Scripps Institution of Oceanography. This vulnerability has been exacerbated by the temporary halt in CRM distribution due to COVID-19. The need to diversify the supply has been recognized internationally.

Consistent with [IOCCP Term of Reference #4](#), IOCCP SSG has been discussing their role in the process with several partners. A common approach was discussed with ICOS OTC which in 2020 set up a temporary production of 'emergency' (i.e. in response to COVID-19 related supply shortages) standards similar to Dickson's Lab CRMs. The activity was however mostly limited to members of the ICOS network in Europe, and such production of secondary standards could not be considered a viable long-term solution to the problem. In the European context, it was suggested that the community should bid, via the next Horizon Europe Programme, for funding to build capacity/facility to produce CRMs as a comparable alternative to the CRMs from Dickson's Lab in the US. IOCCP is involved in initial discussions with leaders of this potential bid.

In the meantime, the IOCCP Office and several members of the SSG participated in a webinar hosted by the US Interagency Working Group on Ocean Acidification on March 16, entitled "CO₂-in-seawater reference materials: yesterday, today, and tomorrow." The webinar, presented by Prof. Andrew Dickson (Scripps Institution of Oceanography, UC San Diego, USA), was the first broad community engagement in the discussion on how to increase the resilience of the production and distribution of ocean carbonate chemistry reference materials. IOCCP obtained important insight into issues highlighted by the CRM producers as well as potential issues CRM users might face globally under various future scenarios. Ensuring stability and comparability of CRMs potentially produced in new and multiple locations around the world is on top of IOCCP's agenda in this regard. Following the webinar, IOCCP helped distribute the post-webinar "CO₂-in-seawater Reference Materials Community Survey" aiming to obtain a critical mass of responses from CRM users in order to provide a baseline understanding of how reference materials for the quality control of measurements of seawater CO₂ system parameters are used and how to build resilience in their future production and distribution globally.

Sensors training course: new dates, long-term sponsorship of ICOS

In June 2019, IOCCP and EU BONUS INTEGRAL Project (Integrated carboN and TracE Gas monitoRing for the bALtic sea) held the 2nd International Training Course on "Instrumenting our ocean for better observation: a training course on a suite of biogeochemical sensors". Building on the success of the 1st IOCCP International Sensors Training Course ([2015 summer school](#)), the course responded to the growing demand of the global ocean observing system and the marine biogeochemistry community for expanding the correct usage and generation of information from a suite of autonomous biogeochemical sensors.

Due to COVID-19 travel restrictions, the IOCCP SSG approved the recommendation of the IOCCP Executive to postpone the next edition of the [IOCCP Training Course on A Suite of Biogeochemical Sensors](#) until June 2022. The venue has already been confirmed for the new dates.

Despite the postponement, ICOS OTC extended its offer to co-sponsor the next edition of the sensors training course. More importantly, it was confirmed that IOCCP and ICOS OTC had reached an agreement on a long-term co-sponsorship of this unique technical capacity building initiative for the marine biogeochemistry community.

MEETINGS AND WORKSHOPS

5th GO₂NE Annual Meeting, 31 August - 1 September 2020, online

GO₂NE 5th Annual Meeting took place as a virtual meeting on 31 August - 1 September, 2020. Marilaure Grégoire and Véronique Garçon (IOCCP Co-Chair) presented a brief overview of the Sopot Scoping Workshop and the status of the White Paper on the Building of the Global Ocean Oxygen Atlas. The meeting discussions helped the white paper writing team enforce the link with biodiversity and climate feedback thematics among other identified issues. The white paper was ultimately submitted as a manuscript to the journal *Frontiers in Marine Science* in June 2021.

As for the implementation road map and business plan of the oxygen data platform, it was suggested to come up with a short brief for stakeholders, end-users and policy makers, and to approach national agencies and private organizations as funding search actions, keeping in line with guidelines agreed upon internationally. Several avenues to ensure sustained funding are being pursued (e.g. UN Decade Programme “Digital Twin Ocean” with Copernicus and EMODnet). All actions towards the roadmap implementation for this community effort have been transformed into a dedicated project to be included in the approved UN Decade Programme Global Ocean Oxygen Decade (GOOD). The team will commence its efforts in September 2021.

Ocean Best Practices System IV Annual Workshop, September 2020, online

The 4th Evolving and Sustaining Ocean Best Practices Workshop was held online at various times between 17-30 September, addressing community needs for advanced method development and implementation in ocean observations, data management and applications. The workshop consisted of three plenary sessions and eleven Working Group meetings. These Working Groups, who met multiple times during 21-24 September, included topics in: Convergence of methods and endorsement of best practices, Data and information management: towards globally scalable interoperability Developing community capacities for the creation and use of best practices Ethics and best practices for ocean observing and applications, Fisheries, Marine Litter/Plastics, Omics/eDNA, Partnership building, Sargassum, Surface radiation, Uncertainty quantification.

With over 600 registrations and a number of thematic sessions, the community obtained a unique opportunity to broadly and actively participate in discussions which will not only guide the OBPS WG in its future developments but also provide important recommendations for several communities loosely formed around several themes where the need for common best practices was identified as a critical issue.

IOCCP Project Officer, Artur Palacz, convened the Marine Litter/Plastics Working Group during the OBPS workshop, assisted by René Garello (IEEE Oceanic Engineering Society, France) and two Early Career Ocean Professional (ECOP) Co-leads: Ngozi Oguguah (Nigerian Institute for Oceanography and Marine Research, Nigeria) and Florence Jovinary Peter (Institute of Marine Sciences, Tanzania).

The WG gathered over a dozen world-leading experts who led 7 thematic sessions focused on best practices in a number of aspects related to marine litter monitoring, from environmental monitoring and remote sensing to modeling, citizen science, data management and knowledge co-creation. The experts co-leading the individual sessions included: Sanae Chiba (JAMSTEC, Japan), Jillian Campbell (CBD, Canada), Heidi Savelli-Soderberg (UNEP, Kenya), Francois Galgani (Ifremer, France), Alexander Turra (Univ São Paulo, Brazil), Yannick Lerat (SeaCleaners, France), Anne Bowser (Wilson Center, USA), Shungudzemwoyo Garaba (Univ Oldenburg, Germany), Paolo Corradi (ESA, the Netherlands), Christophe Maes (LOP-IRD, France), Audrey Hasson (LOCEAN-IPSL, France), Thierry Huck (LOP-IUEM), Hans-Peter Plag (Old Dominion Univ, USA), Dan Martin (Old Dominion Univ, USA).

The goal of the OBPS Marine Litter Working Group was to foster community discussions on aspects of developing guidelines and best practices for coordinated collection, quality control, streaming and management of marine litter data. The need for standardized monitoring and research on marine litter underpins the development of globally coordinated observing and information systems, the visions for which were recently described in community white papers on an [Integrated Marine Debris Observing System \(IMDOS\)](#) and [A Global Platform for Monitoring Marine Litter and Informing Action](#). In line with some of the white paper recommendations and the overall goals of the OBPS workshop, we have set the following objectives for the Marine Litter WG:

- Identify criteria for selecting variables and methods for which we require guidelines, best practices and standard protocols as a priority
- Establish a process towards developing first standard protocols for high impact and feasibility elements of marine debris monitoring
- Decide on the scope of best practice documentations/resources needed beyond standard monitoring, i.e. for (i) remote sensing observations, (ii) modelling, and (iii) citizen science components of marine debris monitoring
- Identify short-term actions to implement a Global Platform for Monitoring Marine Litter and Informing Action and IMDOS as its backbone

Attendance at WG sessions varied from ca. 15 to over 75, with a broad geographical distribution. Priority during most sessions was given to open discussions, with a limited number of presentations introducing the session topics and providing perspectives on lessons learned and future needs of best practices. Participants were interacting through chat but were encouraged to make direct interventions.

Video recordings from most sessions are available from the OBPS YouTube playlist here: <https://www.youtube.com/playlist?list=PLkuDz7rC6Mb9p-xIXqmJ8iKfVoazIa5Tr>

The outcome of the workshop was a series of recommendations which IOCCP through EuroSea has been helping to implement. These recommendations along with working group session summaries were published as part of Annex 2 to the workshop proceedings available from the OBPS repository here: <https://doi.org/10.25607/OBP-1036>

9th Session of the GOOS Steering Committee - Part 2, 28 September - 1 October 2020, online

IOCCP Co-Chairs and Office represent GOOS Biogeochemistry Panel at the GOOS Executive and Steering Committee level. During the global pandemic, the 9th Session of the GOOS SC was divided into two parts: the first one completed as a 4-day block of 2.5 hour online sessions in April 2020, and the second part taking place on 28 September - 1 October 2020 in the same format. Each daily session was repeated to accommodate participants from all time zones. The four IOCCP representatives were split across the two instances, effectively contributing to all discussions.

The agenda of the September meeting focused strongly around the development of a draft GOOS Implementation Plan and the planned submission of three bids for GOOS-led programmes under the UN Decade. Other agenda items fostered discussions around two strategic objectives of GOOS: (i) Open Data, and (ii) Communications and Advocacy, both of which are closely aligned with several of IOCCP Terms of Reference.

The main outcome of the meeting for IOCCP was the setting of high priority for GOOS Central Office to produce an implementation plan which would provide a much needed, interdisciplinary context for the strategic plans of IOCCP as the Biogeochemistry Panel of GOOS. IOCCP is committed to strengthening the interactions and pursuing common activities among the three disciplinary panels of GOOS towards a truly, integrated global ocean observing system.

EuroSea ECV indicators meeting, 8 October 2020, online

IOCCP continues to fulfill its mandate for setting requirements for marine biogeochemistry observations, and actively engages in efforts leading to evolving EOV and ECV frameworks for a more efficient and targeted delivery of data in response to stakeholder needs.

In October 2020, IOCCP participated in an online meeting dedicated to developing new ocean and climate indicators derived from corresponding EOV and ECV observations. The online session was organized by Sabrina Speich and Hugo Dayan (LMD-IPSL, France), as part of the EU H2020 EuroSea project. The goal was to obtain feedback about priority needs for new ocean indicators as expressed by various stakeholder groups invited to the meeting, represented in the EuroSea's three so-called demonstrators on: (i) ocean health, (ii) coastal resilience and operational services, and (iii) ocean climate indicators.

The role of IOCCP as GOOS Biogeochemistry Panel was to contribute to the discussion on how to relate new indicator development with the ongoing EOV requirement setting framework in the context of marine biogeochemistry parameters, in particular Nutrients, Oxygen, Particulate Matter and Ocean Colour. Reconciling regional and global needs for sustainable ocean measurements is a challenge for GOOS and regional observing systems as highlighted by several OceanObs'19 Community White Papers. The EuroSea task on ocean indicator development is likely to help address this challenge. As it has been also considered a long-term action in the draft GOOS Implementation Plan, IOCCP will continue to provide input into the process over the next 3-5 year time span.

15th Session of the IOCCP SSG & GOOS Biogeochemistry Panel of Experts, 17-19 November 2020, online

The 15th Session of the IOCCP SSG & Global Ocean Observing System Biogeochemistry Panel of Experts (IOCCP-SSG-15) was held as an online event distributed over 3 days on 17-19 November 2020. The meeting was attended by all IOCCP SSG members, in spite of the many time zones which separate them. Taking advantage of the online format, the IOCCP Executive invited many guest participants who contributed to very fruitful strategic discussions about ongoing and future activities to be pursued by IOCCP and partner organizations. Guest speakers and attendees included the Past President of SCOR, Executive Director of SCOR, the Co-Chair and Director of GOOS, Co-Chair of GOOS Physics & and Climate Panels of Experts, Co-Chairs and Project Officer of the Biology & Ecosystems Panels of Experts, Director of ICOS Ocean Thematic Centre, Executive Director of US OCB, and a member of the SOLAS Scientific Committee.

In order to maximize the online meeting time for discussions, a number of pre-recorded presentations were made available to all attendees at least a few days before the meeting. The presentations were recorded in a webinar format, effectively engaging several IOCCP SSG members in lively discussions already prior to the meeting.

During the 3-day online meeting, the IOCCP SSG discussed with sponsors and partner organizations the strategic directions for the next years, feeding into the new 3-5 year IOCCP Action Plan. Moreover, we reviewed the status of action items identified for each IOCCP Theme during the previous meeting, and agreed on a set of new activities for the next 12 month cycle. The last session was devoted to internal IOCCP matters concerning project office activities, budgets and panel rotations.

It should be noted that IOCCP-SSG-15 was the final IOCCP meeting attended by 5 outgoing SSG members: Rik Wanninkhof, Cristian Vargas, Bjorn Fiedler, Benjamin Pfeil and Masao Ishii who also served as IOCCP Co-Chair for the past years. IOCCP SSG expressed their gratitude for being able to channel their enthusiastic and visionary leadership to develop and implement activities of strategic importance to the marine biogeochemistry community over the past many years.

As a result of such an unprecedented large rotation, there was a limited number of concrete actions proposed under several of IOCCP Themes. Instead, discussions focused on identifying general priorities for new members to consider in order to ensure legacy of past to current actions while leaving space to move in potential new directions, as guided by incoming members who will not have been approved by sponsors until later in 2021.

The report of IOCCP-SSG-15 was published in early 2021 and can be accessed from the IOCCP website [here](#).

Ship-based Biogeochemistry Time Series Data Product Workshop, 23 & 25 November 2020, online

A workshop on “A Ship-based Biogeochemistry (BGC) Time-Series Data Product”, endorsed by EU H2020 project EuroSea and IOCCP, was held remotely on 23rd and 25th of November 2020. The overarching goal was to obtain consensus between different time-series sites about an envisioned global and consistent ship-based BGC time-series data product - a longer-term initiative which was identified in 2019 as a pillar of IOCCP’s coordination work under the Time-Series Efforts Theme, and which is described on page 8 of this report.

Specific objectives of the workshop were to:

- Review analytical and QA/QC routines of each contributing time-series (TS) site for the core parameters (S, T, O₂, nutrients, inorganic carbon) using the outcomes of the [2012 joint IOCCP-US OCB workshop on TS methods](#) as the basis
- Review data flow and management of each contributing TS site
- Agree on scope and format of the pilot data product, defining scientific objectives the pilot can address
- Discuss QC routines for the pilot
- Facilitate international time-series collaboration
- Form a group of experts that give advice to the development of the pilot and its later transformation into a product

The global scale of this effort resulted in 24 participants joining in from all over the globe; including principal investigators from Hawaii (HOT), Bermuda (BATS), New Zealand (Munida), Venezuela (CARIACO), Canada (Line-P), Cabo Verde (CVOO), Canary Islands (ESTOC), Iberian Peninsula (Radiales) and Iceland (Iceland Sea). Also, leaders from IGMETS, GOA-ON, US OCB, SOCAT, GLODAP, ICOS and the recently funded METS RCN were present to complete the expert group on ocean BGC time series. Colleagues from Japan (K2, KNOT), as well as from France (DYFAMED) did also supply material but could not join in person due to time zone and/or meeting conflicts.

The participants raised a number of issues and challenges which need to be resolved in order for this initiative to become successful, such as ensuring visibility, recognition and impact of individual time-series sites, or avoiding multiple different versions of the same dataset at different data centers. Within this context it was agreed that the product can only be successful and beneficial for the entire community if the needs and concerns of all sites are addressed, and all sites provide data to the product.

Constructive discussions were focused on the purpose and reasons, as well as on the envisioned boundaries and framework of such a BGC time-series data product. The discussions were supported by pre-recorded presentations and further background documents on the participating time-series sites, envisioned QC routines, the role of existing BGC data products (e.g. GLODAP and SOCAT) and links to other time-series efforts (EarthCube, Bermuda, METS RCN).

The central outcome of the workshop is the agreed way forward and commitment to the first pilot product. The first steps in the process included the formation of four working groups: (i) concept/head, (ii) commonality of methods, (iii) data handling, and (iv) data policy.

Marine Plastic Litter Monitoring Data Sharing Project Workshops, 18 December 2020 & 24 February 2021, online

Establishing global coordination of sustained marine litter observations requires obtaining a thorough overview of the different challenges and opportunities related to aspects of standardizing methodologies and developing interoperable data management streams for a broad range of parameters identified as indicators of marine pollution. Surface ocean floating microplastics are currently classified by UNEP as a Level-2 (regional) indicator informing SDG Target 14.1.1b on marine litter pollution. However, considering the recent technological developments and the growing recognition that monitoring surface and ocean interior microplastics is likely to be critical in constraining the overall marine litter budget, the indicator was recommended by GESAMP WG 40 as a global level-1 indicator.

The importance and global scalability of surface ocean floating microplastics have also been recognized by the Ministry of Environment, Government of Japan (MOEJ) which, acting on behalf of G20 countries, has commissioned a development of a global data hub for microplastics, and in the long-term, other fractions of marine litter. Upon invitation from MOEJ, IOCCP on behalf of GOOS, engaged in expert consultations on the MOEJ Plastics Data Hub to maximize the potential of this initiative in the context of IMDOS, and to guide the MOEJ effort towards sustainability and future integration in the global data management systems of GOOS.

A series of two workshops on “Marine Plastic Litter Monitoring Data Sharing Project” were organized by MOEJ as online events on 18 December 2020, and on 24 February 2021. The workshops built upon and presented the results of past months of efforts to harmonize methods used to collect information on surface ocean floating microplastics abundance and concentration. The workshops also presented the current status of the Data Hub and associated synthesis products, ranging from level-0 raw data to level-3 interpolated global maps of microplastics. IOCCP was invited to provide expert advice on a number of topics included in the workshop agendas, including those related to optimizing the structure and functionality of the database, data quality control and curation, data policy, coordination of future sampling surveys, and synergies with other international initiatives.

The MOEJ Plastics Data Hub should be recognized as a tremendous undertaking, akin to the bottom-up community initiative of SOCAT which later motivated the formation of a coordinated reference observing network for surface ocean CO₂ observations, SOCONET. As such, there is strong potential in the MOEJ initiative to be used as a launchpad for establishing a coordinated observing network focused on surface ocean floating microplastics, operating across several observing platforms. IOCCP recommended that a global Reference Group be created to steer the development of the data product, and at the same time, take steps towards better coordination of national surveys of microplastics in line with the requirements set up by GOOS Observations Coordination Group. In addition, a number of other recommendations were passed on regarding the MOEJ Plastics Data Hub, including: (i) the need to develop a standardized vocabulary/ontology for microplastics and a common internationally adopted metadata sheet, (ii) preferred federated and distributed data management system based on interoperability between several data centres rather than a single, central repository for microplastics data; (iii) consideration of quality control procedures and required resources for automation to replace a community volunteer model, (iv) plan to establish a global sampling design in order to fill gaps identified by scientific assessments.

EU H2020 EuroSea 2nd General Assembly, 18-22 January 2021, online

“Improving and Integrating European Ocean Observing and Forecasting Systems for Sustainable Use of the Oceans (EuroSea)” is a European Union Horizon 2020 Innovation Action running from November 2019 to December 2023. Through its ambitious vision and objectives EuroSea will, among other things, strengthen European and global coordination of marine biogeochemistry observations.

EuroSea generously supports the IOCCP Project Officer position for the time frame 2020-2022, and enables a number of key activities which help fulfil IOCCP Terms of Reference as well as implement relevant recommendations from OceanObs’19 Conference and Community White Papers. The activities are related to: (i) increasing the readiness level of delayed mode biogeochemical data products, (ii) enhancing ocean carbon flux observations (and estimates of their economical value), and (iii) supporting global coordination of marine debris observations. These activities, and the role of IOCCP in executing them, were described in an [article published in 2020](#).

The EuroSea 2nd General Assembly, held online on 18-22 January 2021, was an opportunity to review the status of the work which is led by IOCCP, or to which IOCCP contributes via the SSG members and the Project Office. More importantly, feedback received from the consortium members and

invited stakeholders provided guidance on the future evolution of the relevant tasks. In particular, much attention was paid to the development of data synthesis products, both GLODAP as an established resource for the ocean and climate observing community, and for the ship-based biogeochemical time-series product as an emerging new resource with potential applications for climate as well as ocean health applications. In addition, the IOCCP Office presented an extensive update and outlook for the future of a proposed Integrated Marine Debris Observing System (IMDOS). An ensuing lively discussion provided new and important insights into recent developments in the marine litter space, in particular around the development of a dedicated ontology and vocabulary for all SDG indicators related to marine litter pollution. It was agreed that the consistent ontology would be applied when developing the first drafts of the new Marine (Plastics) Debris EOVS Specification Sheet. The existing strong link between IOCCP and the Ocean Best Practices System (OBPS) will guarantee the successful implementation for the benefit of harmonization and standardization of sampling methods and data streams used for reporting on the status and trends in marine plastics pollution.

GOOS Biology & Ecosystems Panel Meeting, 23 March 2021, online

In the past months IOCCP has committed strongly to strengthening the interface between the three Expert Panels of GOOS for the benefit of more efficient coordination of global ocean observations, but also delivery against the three themes of GOOS which require cross-disciplinary activities. In mid 2020, Emmanuel Boss and Fei Chai joined the IOCCP SSG, and among other things, they were tasked with identifying priorities for cross-panel synergies under their respective Particulate Matter Theme, which includes measurements of living and non-living particles, and the Observations-Modelling Interface Theme which mostly considers increasing the capacity to better constrain and model coastal phenomena driven by biogeochemical and biological processes alike. In addition, Emmanuel Boss became the official liaison between IOCCP and GOOS Biology & Ecosystems Panel, invited to join meetings of both panels whenever possible. At the start of 2021, after the appointment of a new OOPC Officer, the Secretariat of all three Panels committed to increased frequency and efficiency of dedicated cross-panel communication beyond the general GOOS Staff meetings. A dedicated workspace in Slack was set up, and a first couple of virtual meetings took place in the first half of 2021, focused on the new EOVS requirements and Specification Sheet template, revision of GOOS EOVS Specification Sheets, and streamlining expert review of the GCOS Status Report.

IOCCP SSG member Emmanuel Boss and IOCCP Project Officer Artur Palacz took part in the quarterly meeting of the GOOS Biology & Ecosystems Panel Meeting which was held online on 23 March 2021. The meeting agenda covered a number of issues related to the development of data portals and other data management actions, updates on EOVS implementation plans, or harmonization of EOVS and potential new CBD indicators. A separate thread was dedicated to the role of the Panel and GOOS in the programme bids submitted under the UN Decade of Ocean Science.

Two main outcomes from this meeting for IOCCP were as follows:

- (1) The Biology & Ecosystems Panel of GOOS progressed with the rollout of the new EOVS template which had been developed by the IOCCP Office. First feedback from Panel Co-Chairs and members was very positive, and no issues or requests for amendment were reported. Moreover, it was confirmed that GOOS can continue to aim for a general cross-panel update of all EOVS Specification Sheets by the end of 2021. This means that IOCCP can continue to rely on the other Panels to join in the effort on making the EOVS update process more transparent, consistent, efficient and thus useful for the ocean observing community.

- (2) Following up on a discussion regarding the upcoming EuroSea BioEco workshop on coordinated seagrass and macroalgae monitoring in Europe schedule for November 2021, IOCCP and BioEco Officers agreed to include a dedicated session on the co-design of seagrass and macroalgae monitoring with shallow seabed macrolitter surveys. See more details on page 28 of this report.

10th Session of the GOOS Steering Committee - Part 1, 26-29 April 2021, online

As members of the GOOS Executive and GOOS Steering Committee, IOCCP Co-Chairs and Office represented GOOS Biogeochemistry Panel at the 10th Session of GOOS Steering Committee (GOOS-SC-10) Part 1 which was held as an online event on 26-29 April 2021. The meeting was run twice each of the first three days to accommodate participation from all time zones, with a single session organized on the final day. In advance of the meeting, IOCCP provided a pre-recorded presentation on the past year's achievements as GOOS Biogeochemistry Panel. In addition, we highlighted several issues which we recommended should be discussed at the plenary during the actual meeting, in particular related to a common GOOS strategy on data management and information products.

On behalf of all GOOS Panels, IOCCP also reported on the Panels' Secretariat contribution to the actions intended for the future GOOS Task Team on EOVs, such as the harmonization of the EOVS Specification Sheets, and streamlining the process of requirement setting for EOVs and ECVs among other frameworks.

24th Session of the Ocean Observations Panel for Climate (OOPC), 21 April 2021, online

IOCCP Project Officer was invited to attend the 24th Session of the Ocean Observations Panel for Climate (OOPC-24), held virtually on the 21 April 2021, to give a presentation on the current status of harmonization of ECV and EOVS requirements setting frameworks, and how both framework would in the long-term contribute to the WMO Rolling Review of Requirements. IOCCP has been co-leading this effort with OOPC since July 2019. However, due to structural changes in WMO and the relative uncertainty about GCOS work plan, as well as due to changes in GOOS Panel leadership and Secretariat support experienced between end of 2019 and early 2021, the harmonization process was largely stalled. The OOPC meeting, attended also by WMO representatives, was therefore an opportunity to reinvigorate this important effort and summarize the outstanding challenges, especially as GOOS is about to engage with GCOS in drafting the 2022 GCOS Implementation Plan.

The meeting discussions were very fruitful and helped establish a common vision and set of objectives for GOOS Panels to work on in collaboration with GCOS and WMO. Detailed outcomes will be described in the report of the OOPC-24 meeting.

12th Meeting of the Observations Coordination Group, 18-20 May 2021, online

The 12th Meeting of the Observations Coordination Group (OCG-12) was held through a series of virtual online sessions from 18 - 20 May 2021. Updates from the intersessional work were discussed and new objectives set, plus new actions discussed for inclusion in the OCG Work Plan. Representatives of most observing networks forming GOOS as well as those serving operational

needs of marine meteorology report on the status, issues and challenges of their particular network. This meeting provides a platform for cross-fertilization as well as drawing interdisciplinary, multiplatform strategies. IOCCP was represented by Maciej Telszewski. Issues discussed during the 12th Session included but were not limited to:

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

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

PUBLICATIONS

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PROJECT OFFICE

SSG rotations

In January 2021 Véronique Garçon (LEGOS, France) joined Kim Currie (NIWA, New Zealand) at the helm of IOCCP as Co-Chair. Véronique joined IOCCP SSG in 2018 and has been engaged in several IOCCP activities related to the Oxygen theme, for which she is responsible, and beyond. We are convinced that under the combined leadership of Kim and Véronique, IOCCP will continue its gradual expansion of coordination and communication activities beyond carbon and onto all marine biogeochemistry Essential Ocean Variables, according to its mandate as GOOS Biogeochemistry

Panel. Véronique replaced Masao Ishii who has served on IOCCP SSG for a decade, including four years as Co-Chair, first alongside Toste Tanhua and then Kim Currie.

On top of the change in leadership, the 2020-2021 period has been marked with significant changes for the IOCCP SSG. In the second part of 2020 two new SSG members joined: Emmanuel Boss (University of Maine, USA) took responsibility for the [new Particulate Matter theme](#); and Fei Chai (Second Institute of Oceanography, China) took responsibility for the [new Observations-Modelling Interface theme](#). In January 2021 IOCCP also welcomed Dariia Atamanchuk (Dalhousie University, Canada) as a new SSG member to take over the responsibility for the [Instruments and Sensors theme](#).

On 1 May 2021, the IOCCP welcomed six more new members of the Scientific Steering Group (SSG), completing the biggest rotation on our Panel since its inception. Adrienne Sutton (NOAA PMEL, USA) and Keyhong Park (KOPRI, Republic of Korea) took over the responsibility for the Time Series Efforts theme; Richard Sanders (NORCE, Norway) now leads the Surface Ocean Biogeochemistry Observations theme; Maribel García-Ibáñez (UEA, UK) coordinates the ship-based component of the Interior Ocean Observations theme; Steve Jones (UiB, Norway) takes responsibility for Data & Information Access Services theme; while Sana Ben Ismail (INSTM, Tunisia) will strengthen the regional implementation of IOCCP coordination and communication services across several of the themes. The following SSG members have rotated off: Masao Ishii (MRI-JMA, Japan), Rik Wanninkhof (NOAA AOML, USA), Björn Fiedler (GEOMAR, Germany), Benjamin Pfeil (UiB, Norway) and Cristian Vargas (Uni. Concepción, Chile).

By welcoming a total of 9 new SSG members and initiating two new themes in the 2020-2021 period, IOCCP continues to evolve in order to fulfil its extended mandate as the Global Ocean Observing System (GOOS) Biogeochemistry Panel of Experts while addressing clear community needs for integrated multidisciplinary, multiplatform observing system. The current IOCCP SSG is made up of 12 members (incl. 2 early career researchers) working across 5 continents, supported by a 2-staff Project Office, who jointly provide coordination and communication services around a dozen themes identified to best fulfil the IOCCP Terms of Reference.

IOCCP Action Plan

One of the recommendations from the Review of IOCCP by its sponsors was to develop an IOCCP Strategy which would provide a written account of the mid- to long-term plans of IOCCP. The recommendation was supported by the SSG, and as a result of internal discussions, it was decided that the IOCCP Executive will prepare a 3-5 year Action Plan - a document which would combine strategic directions with a list of proposed actions aimed at implementing the strategic objectives. The proposal was presented and approved by the SSG during IOCCP-SSG-15 in November 2020.

The Action Plan in the proposed form and structure will improve our long-term planning and better align with long-term strategies and implementation plans currently being developed by GOOS or the UN Decade. The IOCCP Action Plan is also intended to facilitate project management. It has been available as an online spreadsheet since January 2021, which allows the Office and the SSG to provide input and monitor progress. Regular, transparent reporting on action items, with links to documents demonstrating progress and delivery of outcomes, will also provide a much needed legacy, e.g. passed on to new SSG members rotating onto the Panel.

The IOCCP Action Plan consists of a three-layer structure. Action Items, decided at annual and quarterly meetings, provide the bottom layer which serves as the foundation of IOCCP's delivery to longer-term (3-5 years) Actions (middle layer) developed periodically in response to one or more

specific IOCCP Terms of Reference (top layer). The ToRs constitute the overarching framework of IOCCP's mission, and are unlikely to be revised more often than once a decade.

Actions might be developed by the IOCCP SSG in response to community needs expressed directly or indirectly (for example via high-level agendas such as SDG Target 14.3, expert working group recommendations such as IOC WG on Integrated Ocean Carbon Research). Actions might also be proposed by sponsors and partners for approval of the IOCCP SSG. In either case they are delivered via implementation of related Action Items in a longer (2-5 years) period and might require contribution from several IOCCP Themes as well as close collaboration with several partners in the community.

Communications

IOCCP continues to serve as an international communication centre on ocean carbon and biogeochemistry observing activities, according to Term of Reference #10. Currently, we rely on three main communication channels: (i) website, (ii) email newsletter, and (iii) Twitter.

IOCCP website

Every IOCCP theme has its own dedicated page hosted at ioccp.org. The Office along with responsible SSG members maintained and periodically updated the theme pages. In principle, each theme page contains information about current and past IOCCP activities related to the theme, and stores information about relevant references and various resources, which include peer-reviewed publications, technical reports, manuals, guides and best practices, videos, lectures and presentations among others. During early 2021, two new theme pages were added to the IOCCP communications portfolio: Particulate Matter, and Observations-Modelling Interface. More information will be available on these pages as we develop the first major activities under these themes.

Email newsletter

The IOCCP Office has maintained a steady flow of information to the ca. 600 subscribers who have signed up to receive the IOCCP email newsletter. The frequency of newsletters ranges from twice-weekly to bi-weekly, and has been optimized based on the past +5 years of experience in communicating with our community through this channel. During the pandemic, an increasing number of announcements informed about webinars, virtual meetings and workshops.

Considering that a significant percentage of our subscribers come from developing countries around the globe, we are keen on promoting such virtual events among the groups of scientists who would typically not be able to participate in meetings and workshops held in an in-person mode. To this end, our new SSG members Sana Ben Ismail (INSTM, Tunisia) and Keyhong Park (KOPRI, Republic of Korea) have begun to encourage colleagues in North Africa and South East Asia to subscribe to the IOCCP newsletter, and this way help IOCCP gradually expand the global network of marine biogeochemical observationalists.

Twitter

To accommodate members of the community who prefer to receive concise but frequent news, and to continually improve our communication efficiency, the IOCCP office maintains the [@ioccp_org](https://twitter.com/ioccp_org) Twitter channel. During the past year, we have gained another 150 followers, corresponding to at least

1 new follower for every tweet posted (140 over the past 12 months). Expanding our pool of followers at such a rate into the future would be considered a success.

In addition, it should be mentioned that Twitter has often become a unique source of relevant information announced with a tight deadline. Therefore, by monitoring Twitter channels of our partner organizations and selected members of the community, we are able to re-distribute news in a timely manner through our Twitter account as well as the more traditional communication channels such as the website and especially the email newsletter. With many newsletters being circulated on a monthly to quarterly time frame, a large group of members of the community not active on social media might be missing out on potentially relevant events, especially during the global pandemic where practically all events take place in the virtual space and are often not announced far in advance.

FUTURE DIRECTIONS

Oxygen Data Synthesis Product

In the next 12 months and beyond, the IOCCP will work with several partners (including IOC-UNESCO, GO₂NE, US NOAA and German SFB754) in an internationally coordinated effort to build a consistent open-access Global Ocean Oxygen Database and Atlas (GO₂DAT).

Following the call for international programs contributing to the success of the UN Ocean Science Decade, the group submitted the “Global Ocean Oxygen Decade” (GOOD) proposal which has been endorsed. GOOD will be implemented through several projects carried out by different consortia in different regions of the world ocean. The development of GO₂DAT is proposed as one of the outcomes of the GOOD proposal. GO₂DAT will be a key element, a tool to support assessments and decision-making leading to mitigation strategies for climate change and its impacts, maintaining ocean health and biodiversity preservation, and sustainable fisheries management. Declining O₂ is a stressor that covaries with warming and ocean acidification and making relevant data available in consistent form and with known quality will enable the scientific and management communities to develop a more comprehensive portfolio of analyses and applications. When combined with socioeconomic data GO₂DAT will support the decision making processes associated with the emerging blue economy.

To implement a flexible and efficient GO₂DAT we will need to strictly follow the criteria of interoperability, acknowledgement of data providers, a data center targeted to needs of the community, and inclusivity for ongoing activities. In order to enable a sustainable data submission system that will integrate and make use of existing infrastructure, it is crucial to align it with overarching data flow and the structural elements of the International Oceanographic Data and Information Exchange program (IODE). The proposed data submission should be two-fold, where all information is being exchanged with the various repositories: a centralised data submission platform at Global Data Assembly Centres (GDACs) or national hub level to address the needs for incoming data from individual scientists and research projects and a bottom-up data flow via National Oceanographic Data Centres (NODCs), Associated Data Units (ADUs) and regional hubs. These different databases and DACs have their specific metadata structure, rules of data dissemination, QC, QF and correction procedures and, inside a given platform, it may differ across regional DACs. An alignment of metadata definition, QC and QF procedures will facilitate the integration and use of O₂ data from different platforms and sensors in science analysis and applications. An interactive web-platform where GO₂DAT data and products can be visualized will enhance communication with the users and

general public. This GO₂DAT web interface will be optimized in order to obtain feedback on the datasets and products.

3rd International IOCCP Sensors Training Course

Based on the very successful two editions of the sensors training course in 2015 and 2019, and in response to a great demand for such technical capacity building, the IOCCP SSG strongly supported organizing the sensors training course as a recurrent event. The SSG approved of the proposal to hold the course on a bi-annual basis, provided that we avoid overlap with other major international summer schools (IMBeR, SOLAS) to avoid competing for funding and lecturers. Arrangements have already been made to organize the 3rd IOCCP Sensors Training Course in June 2022, also in Kristineberg, Sweden. The third edition of this activity will provide trainees with lectures and hands-on experience across the whole spectrum of operations—from deployment and interfacing, through troubleshooting and calibration, to data reduction, quality control, and data management. Insights into complementary use of remote sensing, modelling, and smart data extrapolation techniques will not only broaden participants' perspectives, but also effectively open new avenues for research ideas and collaborations that will expand their career portfolios.

The IOCCP Office will continue the fundraising efforts in order to secure the remainder of the budget before the end of 2021. Because of the resource-intensive nature of this undertaking, early course planning will begin around August 2021 with the focus on developing the agenda, assembling the Organizing Committee and the Scientific Advisory Committee, and inviting lecturers.

Ocean Acidification Data QC Online Package

During the past year, the IOCCP and GOA-ON developed a scope of work for years 2021-2023 to build a library of best practice documents and corresponding online training resources in data quality control for the ocean acidification observing community.

Under the leadership of Kim Currie and Adrienne Sutton (both providing their expertise to IOCCP SSG and GOA-ON Executive Council), and with input from several partners interested in creating a widely accessible ocean acidification data quality control toolbox, we will now start implementing the developed work plan.

We plan to create an online package inspired by the Meddle tool for designing experiments (<https://meddle-scor149.org/>), bringing together a combination of different types of resources from video to written materials to decision trees. Global access is a priority for this work, so resources will be available for download to enable offline use for researchers in areas with unreliable access to the internet. Documentation is planned to be translated into several languages. The Ocean Acidification Data QC Online Package will cover QC techniques for ocean acidification chemical data, data QC best practices such as flagging conventions, and how to estimate data uncertainty. Data QC techniques include using reference data sets and climatologies (e.g., SOCAT and GLODAP), identifying outliers, and identifying sensor drift and biofouling. The package will cover general data QC principles and approaches with examples, but due to the variety of data formats and software used by the community for data QC, it will not provide new scripts or programs which implement these tests. The goal of the online package will be to provide a new resource on data QC best practices and to act as a portal for connecting all four main steps in the data workflow by compiling resources in one place. Some elements of the QC package could be mirrored within other resources such as the ocean acidification courses planned by IOC-UNESCO in collaboration with the Ocean Teacher Global Academy.

Development of the material will require a team of experts in data QC methods who are comfortable communicating scientific aspects to the public, have time and interest to follow-through with the tasks, and provide linkages to related efforts to create synergies and avoid overlaps. Some materials developed by the team may require review by the broader community prior to implementation, which will be organized through IOCCP and GOA-ON. Translating the scientific materials into a web application will require contracting a communications and programming group. Promotion of the online package will be done through the networks of affiliated partners as well as through a series of virtual and in person training events, town hall meetings, and conference sessions.

Integrated Marine Debris Observing System (IMDOS)

In collaboration with multiple partners including EU H2020 EuroSea project, we will continue efforts leading to establishing sustained observations of marine plastic contaminants in the global ocean by bringing together technical experts leading individual global observing networks with leading authorities focused on marine litter monitoring including UNEP, GESAMP, GEO Blue Planet, IOCCG among others.

As reported on page 9 of this report, IOCCP will focus on refining the draft proposal for a joint GOOS-UNEP project on IMDOS. The first follow-up strategic meeting is planned for 5 July 2021. It will aim to clarify strategic objectives, scope out funding opportunities and determine a timeline of initial joint activities. It is anticipated that a joint GOOS-UNEP project on IMDOS could be submitted by UNEP for acceptance during UNEA-5b in February 2022, and for acceptance as a GOOS project by the GOOS Steering Committee in April 2022.

One of the priorities, as described in the original Action Plan on IMDOS, is to produce the first version of a Marine (Plastics) Debris Essential Ocean Variable Specification Sheet. UNEP and GOOS recognize the importance of reconciling the EOVS and SDG indicator frameworks for the benefit of building a backbone observing system complementary to the GPML Digital Platform which will feed information to the large number of stakeholders. It is likely that the new EOVS will be based on a list of globally-scalable indicators of marine pollution initially put forward by GESAMP WG 40 and discussed with the broad community as part of the Marine Litter Working Group co-convened by IOCCP during the OBPS IV Annual Meeting which took place in September 2020 (see page 15 of this report).

As part of the joint project, IOCCP plans to enhance the co-design between marine litter monitoring and other elements of the coordinated ocean observations, in particular with the emerging Seagrass and Macroalgae observing networks. Developing a common sampling protocol for shallow seabed macrolitter and seagrass and macroalgae marine habitat monitoring is a possibility, with likely implementation on the European scale at first. Recognizing the common source of sampling methodologies and observing platforms (scuba dives, ROVs), as well as the synergies in developing remote sensing algorithms for detection of marine habitats and litter accumulated therein, IOCCP and GOOS BioEco intend to work jointly with relevant expert working groups to initiate discussions through a dedicated session during the upcoming EuroSea workshop "Toward a Coordinated Observing System for Seagrasses and Marine Macroalgae" planned for November 2021. A draft proposal for joint sessions developed by IOCCP was shared with the workshop Co-Chairs, to be discussed in the coming weeks in consultation with marine litter experts from the MSFD Technical Group on Marine Litter and the IOCCG Task Force on Remote Sensing of Marine Litter and Debris.

IOCCP and the UN Decade of Ocean Science for Sustainable Development

During the 2021-2024 period, the IOCCP will become actively involved in transformative actions for the Decade across the hierarchy of structures, from Decade Programmes, through Decade Projects and Activities, to Decade Contributions, with levels of involvement identified as needs for actions will become clear.

In order to fulfil our 2030 vision for a mature, sustained marine biogeochemistry observations being a part of a global, integrated system delivering essential information to the society, we will be actively involved in the development of 8 Decade programmes indicated on page 5 of this report, ensuring that our responsibilities within these Programmes are fully in line with the IOCCP Terms of Reference and the following IOCCP Strategy recommendations submitted to the OceanObs'19:

- To actively guide the co-design of the observing system by engaging expert working groups and observing networks to determine phenomena-based observing targets and jointly agree on implementation plans for all EOVs for the period 2025-2030.
- To increase the comparability of measurements and thus increase the quality of information products and generated knowledge by:
 - establishing globally agreed-upon standards and protocols;
 - whenever possible, support producing Certified Reference Materials for EOVs, e.g. through establishment of central calibration facilities and regular inter-laboratory comparison studies;
 - enforcing strict requirements for use of globally-accepted standards, protocols and CRMs in all observing networks recognized by the GOOS Observations Coordination Group.
- To strengthen existing and promote creation of new EOV-based observing networks that would facilitate implementation of EOV requirements across platforms
- To create new data synthesis products based on multi-EOV and multi-platform observations needed to fulfil the end user product requirements for various applications globally (e.g. SDG14 indicators, Global Carbon Budget, IPCC and World Ocean Assessment) and regionally (e.g. harmful algal bloom forecasts, regional carbon budgets, integrated ecosystem assessments).
- To increase the availability, discoverability and interoperability of marine biogeochemistry data and to enable product development by end users. This assumes creating and maintaining a Global Data Assembly Centre for Biogeochemistry EOVs, and where relevant (e.g. Particulate Matter EOV) designing new data repositories capable of integrating EOV data from many heterogeneous sources.

Apart from promoting the need for further advancing biogeochemical observations and data management, IOCCP would use its expertise and mandate to strengthen the capacity at the observations-modelling interface and guide the development of new remote sensing products for the ocean user community.

Ship-based measurements of atmospheric CO₂

The IOCCP will continue to coordinate the operation of the Surface Ocean CO₂ NETWORK (SOCNET) with the atmospheric Marine Boundary Layer (MBL) CO₂ measurements to focus specifically on the operational aspects of measurements of CO₂ in both the ocean surface and atmospheric MBL. The goal is to provide accurate pCO₂ data to within 2 µatm for surface ocean and 0.2 ppm for MBL measurements following rigorous best practices, calibration and intercomparison procedures. Final, quality-controlled data will be provided to the community within a year to aid the

operational production of SOCAT as well as maps of monthly resolved surface ocean CO₂ and air-sea CO₂ flux. These products and other derivatives using surface ocean and MBL CO₂ data, such as surface ocean pH maps and MBL CO₂ maps, will be of high value for policy assessments and socio-economic decisions regarding the role of the ocean in sequestering anthropogenic CO₂. IOCCP will continue to liaise with intergovernmental science organizations such as Global Atmosphere Watch (WMO) and Greenhouse Gases and Measurement Techniques Group (WMO/IAEA) to gain support for the surface ocean carbon observational community to assure the availability of required resources and technical expertise.

Strengthening regional implementation of IOCCP Activities

Under the leadership of newly appointed IOCCP SSG members, Sana Ben Ismail and Keyhong Park, we will develop dedicated relevant activities to strengthen regional implementation of our objectives.

We will work with Dr Ben Ismail to strengthen the local and regional network of biogeochemical observations in an environment where the observing and data management needs are not prioritized by most of the local stakeholders. Our activities will be initiated around the southern Mediterranean community, but tools and practices developed will be applicable in other regions facing similar challenges. Perhaps the initial activity will be to organize a regional workshop to assess the baseline status of the observing system and most urgent needs as well as data management challenges. Southern Mediterranean and North Africa are rather underrepresented in most constructs relevant to the global ocean observing system and our aim is to develop stronger ties with this regional community, and utilize them to raise the regional capacity into the future.

Our work with Dr Park will be focused on strengthening the ties with colleagues involved in observations in Polar regions, with most focus on the Southern Ocean. There are strong groups coordinating regional activities (e.g. SOOS) and we would like to utilize Dr Park's regional expertise to develop working connections between their needs and requirements and our potential for contribution to meeting those. We will also utilize Dr Park's regional links to strengthen multilateral partnerships with the Asian biogeochemistry observational community, particularly with regards to ship-based and moored time-series stations.

Addressing shortage of Certified Reference Materials

As indicated on page 14 of this report, the vulnerability to the supply of Certified Reference Material (CRM) is a major issue faced by the marine carbon community recently. In response, the IOCCP SSG recommended addressing the issue of CRM shortages in partnership with EU ICOS-OTC, IAEA, US NOAA, Dickson's Lab and other interested parties. After a number of new IOCCP SSG members with relevant expertise and interests joined the group in May 2021, IOCCP would like to convene an adequate forum of experts, representing all involved and interested parties to develop a feasible way forward towards a functional and resilient global ocean carbon CRM production and distribution system.

We hope to facilitate the development of a globally relevant roadmap reflecting the needs and opportunities for production and distribution on one hand, and addressing current vulnerabilities and inconveniences on the other hand. Three key complex aspects that need to be part of developing any such roadmap were identified in recent discussions among interested parties:

First, it is important that an effort be made to characterize the desired properties of such reference materials: e.g. type of materials; uncertainties of any values assigned to the materials; stability of the materials; number of units of each type of material needed each year. Ideally these will be driven by

clear scientific goals rather than being compromised by a more pragmatic “access for all” driven sentiments.

Second, it is critical to plan for sustainability. This primarily means assuring a suitable long-term funding model and planning for inevitable staff turnover (at technical and management level). One also needs to develop protocols describing mitigation strategies regarding the latter, allowing constant availability of CRMs at required quality.

Third, it is necessary to plan for resilience. This ultimately entails the possibility of parallel suppliers, ideally subject to different local stresses so that an adverse circumstance (of whatever kind) in one location need not mean a world-wide end to the availability of CRMs. Inevitably, parallel suppliers also bring the difficulty of planning to ensure equivalence between the CRMs they produce, an essential and not trivial aspect.