The Global Ocean Observing System

unesco Intergovernmental Oceanographic Commission

WORLD METEOROLOGICAL ORGANIZATION

UN environment United Nations Environment Programme

International Science Council

14th GOOS Steering Committee meeting (SC-14) | 19-21 February 2025 (Paris)
Background paper

Session:

3. Strengthening data integration and delivery

Agenda item:

Provide **update on coordination and strengthening of GOOS data flow**, data integration and delivery of end-to-end data system including standards, best practice and metrics**.** Consideration of plans, process, needs and deliverables on data flow and integration and the evolving IOC data architecture.

Background paper: updates from OCG, OceanOPS, BGC/IOCCP, and OBIS/BioEco

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Introduction/Background

Including links to relevant documents, mandates etc.

The OCG cross-network Data Implementation Strategy, released in early 2024, catalysed a discussion at the Fifteenth **Observation Coordination Group** Meeting (OCG-15) in May 2024 on the individual networks and how to develop and leverage their data implementation pathways. The strategy provides a framework to enhance data discovery and access through federation of these distributed data nodes based around the ERDDAP server technology. This federated strategy, in combination with high quality metadata, will underpin the future growth of the digital ocean ecosystem by better supporting discovery and access, as well as harvesting of data and metadata for operational, climate and ocean health services, weather forecasts and future development of digital twins. In addition, the launch of WMO's WIS2.0 system (replacing the GTS in 2027) is underway and the OCG cross network data implementation strategy should help to advance these directives within the GOOS/OCG networks. A decision was taken to set up a cross-network OCG Data Task Team to work on the elements raised. OCG-15 Report here.

The OCG report on basic data metrics through the Ocean Observing System Report Card (2023 version here and see networks table -behind the simplified 'star' system of reporting there are specific definitions for data, metadata and best practices).

An IODE-GOOS Data Workshop: 30 Sep – 02 Oct 2024 focused on enhancing collaboration between the International Oceanographic Data and Information Exchange (IODE) and the Global Ocean Observing System (GOOS). The goal was to enhance coordination and discuss an integrated and scalable IOC digital architecture that would improve data sharing, management and accessibility, across ocean systems, and enhance the IOC's support to key United Nations mandates. Workshop Report here.

The Workshop participants agreed on a basic schema and a joint vision for an IOC Data

Architecture, linking key IOC components into a holistic ecosystem (see Figure 1 below), which is based on the following agreed concepts:

- Use proven concepts that have demonstrated great utility to GOOS and IODE: open and modular technology, distributed-yet-federated system designs, metadata-driven exchange, an interoperability-first approach to data management and system engineering
- Extending the IODE Ocean Data and Information System (ODIS) Architecture
- Providing consistent implementation of the FAIR and CARE Principles, and alignment with the Ocean Decade
- Enabling data provenance and lineage metadata - enabling derivative data products to be traced back to the point of truth (e.g. observations or models)
- Recognising that the GOOS EOVs are an essential element within this architecture

The architecture will serve as the foundation of global ocean data sharing across the IOC, powering global solutions and the IOC mission by:

- Supporting global services and data products - available to all - to detect, consolidate, and deliver GOOS-certified EOV data of documented quality
- Delivering data on EOVs, SDG indicators, and other artefacts into global assessment and multilateral processes
- Provide IOC with a clearly defined, unique niche in the ocean digital ecosystem for more efficient investment
- Interface - at scale - IOC's core digital capacities with other existing architectures and infrastructures (e.g. WMO's WIS 2.0, UNEP's WESR)

Many elements of the proposed IOC Data Architecture already exist. The workshop outlined an approach forward to optimise connections between existing elements, and clarified the some elements of support that will be needed to strengthen delivery of ocean data for operational services. As a first step, the Workshop participants agreed to set up a working group to develop a proposal for the IOC Data Architecture for the IOC Assembly in June 2025.

Current status

OCG Update

The OCG Data Task Team is working towards implementation of the OCG Data Implementation Strategy and elements to support IOC Data Architecture:

- A concept and a set of minimum metadata across networks as required at OceanOPS to gain a unique WIGOS identifier and track data to 'delivery' (metadata passport) has been identified for OceanOPS and at OBIS (hosting the BioEco Portal), we will discuss the cross-walk soon
- Outline of the metadata workflow for networks, their data managers and centres, and OceanOPS, to enable network, GOOS, and WMO services

- Survey to identify data endpoints (GDACs/ERDDAP server installations) across the observing networks that can be federated into the OCG hypernode

Metrics Update
The metrics for data, metadata, and other attributes will be developed as a network 'health' index (OCG-15). As with data work, this should be connected to discussions in the BioEco Panel and to any tracking that OBIS/BioEco Portal will do.

Best Practices Update

For GOOS best practices: there are now 10 GOOS Endorsed Best Practices, all of which have elevated levels of downloads - e.g. 5-6000, Argo's best practices have had over 2000 downloads within a few months, and have between 30-50 downloads a month. There are more best practices under development, which is positive, but development is slow and there are less best practices focused on data. Each practice in general needs a champion and 12+ months work.

BGC/IOCCP Update

1. Establish a unified approach for equipment infrastructure and protocols for collecting 'climate' and 'weather' quality Ocean Acidification (OA) data.

Evaluate the current observing capacity to deliver the necessary data products to track OA progress and trends globally:

- efforts to update and harmonize the equipment directory and its SOPs.
- Encourage hub members to offer help or identify and address needs through surveys.
- Updated list of marine tech companies and engage in dialogue for new/cheaper OA sensors, involving scientists in testing new technologies, updating hardware directory

2. Submission and archiving of quality-controlled data within national and regional data centres. 1st Step: Publish 1st QC Data Catalogue, Wepal Quasimeme workshop on quality assurance for inorganic carbon system measurements in the context of ocean acidification monitoring, NOC, UK, 18-20 March 2025

3. Finalizing our Best practices paper on oxygen EOV: A best practices, documented metadata format and consistent quality control procedure and quality flagging (QF) system for open and coastal ocean oxygen data, GO2DAT Steering Committee meeting on line this spring and in person hopefully in Nice, June 2025

4. Finalizing the update of the N_2O/CH_4 EOV Spec Sheet: identification of common

harmonized measurement techniques versus mission-specific measurements, which potentially cannot be included, finalize and make available the SOPs developed, development of a strategy for marine N_2O/CH_4 measurements as part of the WHO GGGW initiative

5/ Ocean and coastal Nutrient Workshop Brest September 2024 - Working groups on Online platform, Metadata reporting, Open source scripts, and Coastal manual

BioEco Panel Update

A paper has been published highlighting existing capability to deliver information on benthic invertebrates, and another paper on measuring and reporting seagrass as an EOV has been submitted for publication raising the profile of GOOS BioEco EOVs. Additionally, data workshops on fish EOV supported by SCOR were undertaken in 2024.

The recent (Feb 2025) BioEco Panel meeting discussed data issues extensively, the following are preliminary outcomes:

- OBIS proposal for minimum metadata for BioEco EOV observations will be discussed with OCG to decide a common GOOS framework
- Data Flow will be looked at for each EOV and network specification sheets adjusted accordingly

IOC Data Architecture Update

The IOC Data Architecture Working Group held an initial meeting in Feb 2025. The ToRs and initial Membership of this Task Team can be found in the Workshop Report (page 67). The IOC is in the process of hiring a jointly funded (IODE-GOOS) consultancy to support the work of the WG, additional members from with industry links and from across IOC will be invited to join the WG.

Work/Project plan

Including Deliverables (e.g. Activities/Actions/ KPIs) and Budget / Resource needs

➔ 2025

➔ 2026-2027

OCG Data actions 2025:

- A survey will gain cross-network feedback on the minimum metadata (passport) and identify the Global Data Assembly Centres for RT and DM data
- Crosswalk minimum metadata specifications and flow with BioEco Panel/OBIS
- Define/agree minimum metadata specifications and flow between network data systems, ODIS, OceanOPS, and external stakeholders (WMO, IODE, etc) to meet requirements (e.g. WMO/OSCAR, GOOS reporting, IOC Data Architecture)
- Identify global data nodes for federation, expand ERDDAP servers implemented

across OCG networks - and under the IOC Architecture work IODE OBIS node IPT servers
- Host discussions on provenance, licensing and GOOS semantic identifier metadata, with input from external experts and members of OBIS/BioEco Panel, towards looking at needs of providers/networks and GOOS towards the IOC Data Architecture

2026-2027
- Track and visualise the GDAC/ERDDAP and OBIS/IPT network that needs to be supported by Member States for service delivery
- Pilot transition from WMO GTS to WIS 2.0
- Document and develop best practices

BGC/IOCCP

CHO_IP "Clean and Healthy Ocean" GEF-FAO-IOC proposal will be starting officially after summer 2025 with 1FTE working on data gathering, QC, QF, uncertainty attribution for EOV Oxygen towards GO2DAT (Global Ocean Oxygen Database and ATlas). Insertion of this FTE within the GOOS Data Strategy for all EOVs, with tight collaboration with IODE/ODIS

BioGeoSea proposal entitled "Enhancing Biogeochemical Essential Ocean Variables for European and Global Assessments" from EU Horizon call HORIZON-CL6-2024-CLIMATE-02 has been approved end of December 2024 and will start probably as of September 1st 2025. **BioGeoSea WP4** will ensure global and regional integration of BGC data by enhancing the accessibility and quality of EOV data across multiple scales through data products. This will include GLODAP, GO2DAT, CARIMED, MEMENTO and IMDOS, there will be some FTEs to help fulfilling WP4 objectives.

IOC Data Architecture:

2025
- Proposal on the IOC Data Architecture for the 33rd IOC Assembly in Paris in June 2025, including vision, structure, governance and resource needs - [GOOS/IODE are co-funding a consultancy for 4 months to produce the proposal]
- Map the data flows - what to govern and what to implement - look at optimisation/eliminating redundancy
- Create 'rules' of coordination, responsibilities - ODIS broker, services, data flows
- Select showcase pilots that demonstrate data flows and the broker services, and test that assumptions regarding the architecture are robust
- Set minimum metadata requirements, including provenance, licensing, EOV data precision, and a semantic identifier for 'GOOS' EOV data
- Develop a joint resource strategy and solicit feedback from key stakeholders to shape the IOC Data Architecture
- Create a phased implementation plan that identifies goals and roles of different IOC

groups, with clear regional support, including for SIDS.

2026-2027 (work on phase 1 - estimate as plan will be developed in next months in WG)

- Establish a pathway to mature the IOC Data Architecture and its associated digital ecosystem into an IOC Data Space to support advanced data handling.
- Establish regular consultation and need/opportunity assessments with stakeholders
- Create Minimal Viable Product(s) to support value demonstration and to test robustness and utility of the architecture
- Implement a quality assessment framework to support certification of data quality and reporting of GOOS EOVs and SDG Indicators or related data
- Support the maturation of digital culture for all those using or contributing to the IOC Data Architecture
- Provide a plan that includes resource requirements for phase 2, and related success markers

Resourcing:
For the IOC Data Architecture work this will at a minimum need a consultancy/consultant to convene the discussions of the Working Group and at other levels, to enable integrative work, the tracking of plans and communication, etc. This should be a cross IOC funded support, and so GOOS commitment would be of order 30-40K$/year.

In addition, GOOS should consider support to GOOS OCG and the BioEco Panel specifically for data, currently the work of the OCG has been bootstrapped using interns and the BioEco Panel has had some initial support from EU Project funding and OBIS. It should also consider supporting the BGC Panel to deliver data products associated with the GOOS Carbon and GHG Plan work that is targeting supporting WMO G3W Implementation Plan, 2022 GCOS Implementation Plan and IOC-R. Dedicated support for data at GOOS level would deliver consistency, speed and efficiency in cross GOOS progress.

Finally, there will likely be some additional elements in the IOC Data Architecture Plan that may need further targeted funding from Member States. GOOS will be a beneficiary if this is forthcoming, but this does not negate the need for the above in the short term.

Expected outcomes for GOOS

- A federated network of ERDAAP servers across all OCG networks connected to a focal GOOS OCG ERDAAP node (a hyper node for the IOC Data Architecture)
- Recognition of GOOS EOV data (i.e. from quality controlled, sustained ocean observing) in data lakes and provenance/providers recognized, e.g. in products
- A step change in the quantity and quality of data products available, especially based EOV, indicators and model ready data products, likely starting with Oxygen
- More data available across physics, biogeochemistry and biology and ecosystems
- Clear links and co-planning/on data/metadata established with operational ocean

services, as with weather – supporting more co-design
- Integration of GOOS OCG observing network metadata into ODIS to provide a global discovery layer for GOOS network produced data
- Stronger partnerships for products
- Increased support for critical observations
- Enhanced delivery of BGC and other data products, through expanding and improving internally consistent and quality-controlled data and improving international and European coordination. Including improving access to high-quality data of BGC and other EOVs on regional scales, e.g. in the Mediterranean Sea, including relationship between BGC, physical and BioEco EOV
- For BGC the initial targeted data products will be:
    - dissolved oxygen maps for the global ocean and selected coastal areas
    - data products for Nitrous Oxide and Methane and concentration and flux fields
    - Mapping the surface carbonate system (DIC, pH, TA, pCO2) in the ocean
- Supported technical coordination of the marine debris observing system

Considerations for the GOOS Steering Committee

Questions for the SC to consider

1. Identify the key outcomes of this work for GOOS and its stakeholders, and any missing elements/aspects in the planning
2. Identify support for the work of OCG, BioEco and BGC Panels in this area as a priority towards the IOC Data Architecture
3. Consider what additional resource BGC Panel/IOCCPwill require to implement the GOOS Carbon and GHG plan associated with data products (ensure considered in the Carbon Plan outline)
4. Facilitate and support a deeper engagement between OCG, BioEco Panel and OBIS to align data workflows and enable interoperability of the systems, and any metrics
5. Facilitate and support the BioGeoSea funded resource (1 FTE - 4 years) in developing connections to IODE/ODIS, perhaps within the framework of the IOC Data Architecture work, if not directly
6. The development of key GOOS network and community best practices is slow. If GOOS wants best practices across its networks and communities more fully, we will need to discuss and provide more incentives
7. The Best Practices endorsement process is being opened up to other institutions, which is reasonable and necessary, GOOS, through its work with the OBPS, should remain vigilant that the identity of what an endorsed best practice represents is not diluted in the OBPS

Proposed decisions/recommendations

Session 2: The GOOS Steering Committee welcomed the results of the IODE-GOOS Data Workshop that represented a first step towards a holistic approach to data sharing across the entire IOC value chain. The Committee also confirmed the important role of GOOS Observations Coordination Group, BioEco Panel and its connections to IODE's OBIS, and the IODE ODIS architecture for the emerging IOC data architecture.

The GOOS Steering Committee:

1. Recommends that GOOS components focus on work towards achieving the proposed IOC Data Architecture, bearing in mind the following key priorities for GOOS:
   - that OCG and OBIS work together to align workflows and interoperability
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2. Requests that OCG, BioEco Panel (with OBIS) and the GOOS BGC Panel identify what is the common resource needed to support work across GOOS and within each area's planning. Such that this resource could be core and undertake work to support data flow across physics, biogeochemistry and biological and ecological observations, and towards the IOC Data Architecture.

Figure 1:

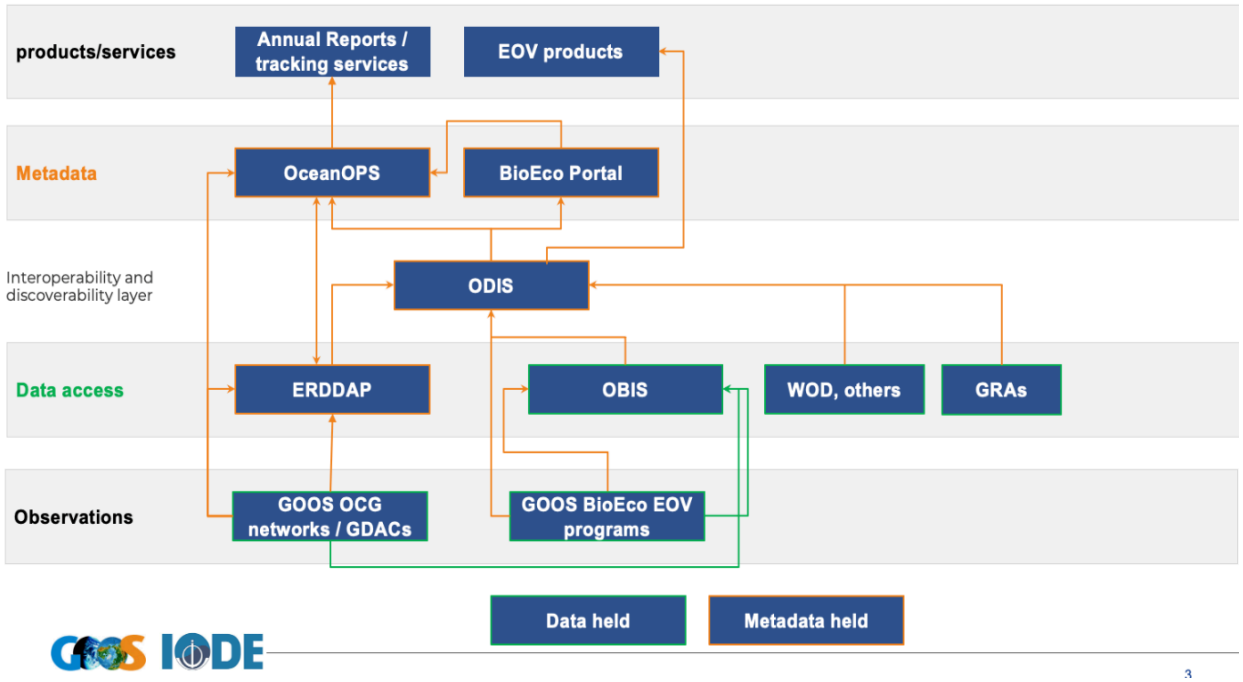

Figure 1: Schematic of the proposed IOC Data Architecture that will be developed further through the proposal. This schematic was adjusted from the Workshop Report to show the key IOC components. Key to acronyms: IODE Ocean Data Information System (ODIS), IODE Ocean Biodiversity Information System (OBIS), GOOS OceanOPS (WMO-IOC Joint Operational Centre Ocean Observing), ERDDAP™, World Ocean Database (WOD), GOOS Regional Alliances (GRAs), GOOS Observation Coordination Group (OCG), GOOS Ocean Observing Networks/Global Data Assembly Centres (networks/GDACs), GOOS Biological and Ecological EOV Observing Communities (BioEco EOV programmes).