Towards a global marine plankton observing network: development of a strategy and implementation plan

WORKSHOP REPORT

25 to 27 September 2023 | Online

FUTURE OF THE SEAS & OCEANS INITIATIVE

The Global Ocean Observing System

The workshop: "Towards a global marine plankton observing network: development of a strategy and implementation plan" organized by the G7 Future of the Seas and Oceans Initiative (FSOI) and the GOOS Biology and Ecosystem Panel, was held online on from 25 to 27 September 2023.

The aim of this 3-day workshop was to deliver tangible advice on how to overcome current gaps and limitations on the two goals related to the three pillars of plankton research: data infrastructures, observing, and forecasting. This is an intersessional activity supported by Germany, the EU, Japan, Italy, the UK, and the USA as part of the G7 FSOI 2023 workplan.

48 participants with expertise on observational and modelling approaches, data management and policy, discussed actions needed to bridge the gap between different observing (in-situ, satellite) and modelling approaches for advancing research knowledge and its use in policy needs (frameworks, assessments, operational oceanography, Digital Twins of the Ocean).

Workshop goals

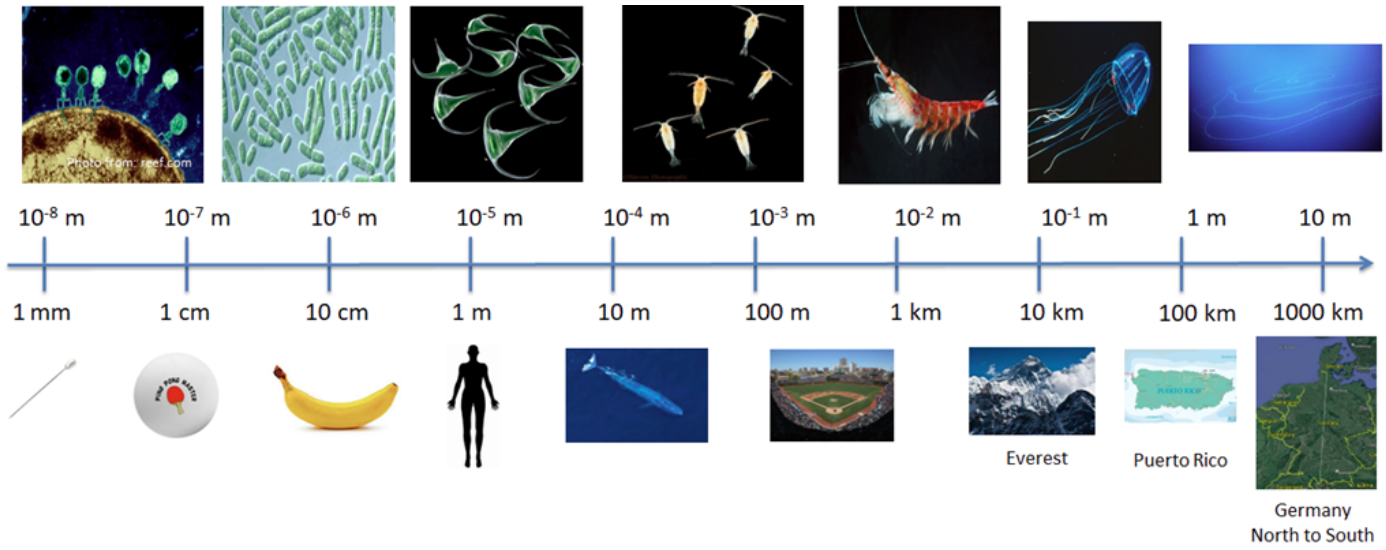
The workshop had two specific goals:

- **Goal 1:** Enhancing integration: bridging ocean surface and underwater observations for ecological projections and policy guidance
- **Goal 2:** Unlocking plankton data: enhancing interoperability and fairness for comprehensive plankton data analysis, ecological understanding, and forecasting

Specific focus on plankton

Plankton was the targeted marine life group. Plankton makes Earth livable, is an essential climate and ocean variable, regulates marine life as the base of the food web, and controls ecosystem services with high socio-economic interest like fisheries. It has global and local interest, from our coasts to the open ocean and deep sea, and from pole to pole. Plankton also represents the bio-carbon concentration in Earth System models that the Intergovernmental Panel on Climate Change (IPCC) uses for future scenarios and policy advice.

While the role of plankton in ecosystem processes is still not fully characterized, observing programs are declining and most of the plankton data are not accessible or in a format useful for decision-making and forecasting. For example, on a global scale, 19% of the zooplankton data collected from long-term monitoring programmes are freely available/open access (Ratnarajah et al., 2023 section: Sustained observations to quantify impacts of climate change).



Plankton is a very diverse community, including thousands of species. Plankton has a size range of 9 orders of magnitude, most of them invisible by the human eye. If we compare the plankton size range with macroscopic items, then the smallest one can be as big as a pinhead and the biggest zooplankton could be more than 1000 km.

Workshop proceedings and highlights

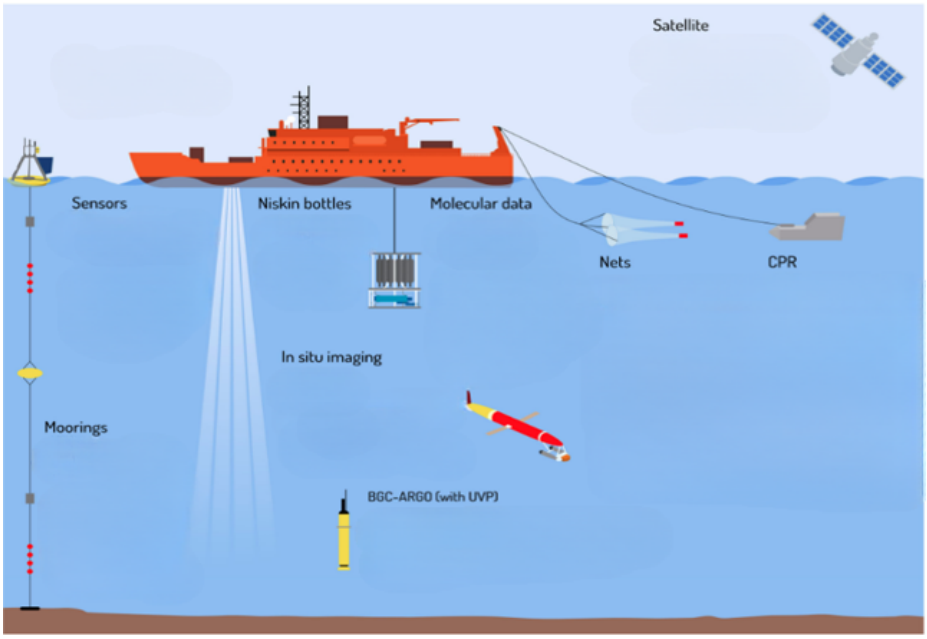
The first day included two state-of-the-science presentations, developed by collaborative groups of experts from international research projects, programs and networks. The second and third days featured breakout sessions on topics related to the workshop goals. The discussions emphasized the importance of sustained observing systems with the capacity to collect observations over the long-term, make data accessible and freely available and meet user needs.

Workshop participants highlighted the need for close collaboration among data providers, data managers, data users and modelers to identify observing needs and agree on priorities. Plankton communities are complex and dynamic with high patchiness across a vast, 3-dimensional ocean. A single observing or modelling method that captures all this complexity is not feasible. However, ensuring the integration and interoperability of data from different observing and collection methods and applying standards to ensure the data are FAIR is a powerful means of guaranteeing the delivery of data for decision-making.

Plankton observing systems for research, forecasting and policy

Connecting research and observing with management and policy needs is important for making progress towards the UN Sustainable Development Goals (SDGs) but not always easy. Policy frameworks for sustainable ocean and ecosystem services need to move from simple species indicators to connecting organismal functionality to ecosystem dynamics and ecosystem services. Participants suggested that we need to advance our efforts on identifying **indicators that can represent ecosystem status, resilience, and change** (e.g., ratios between functional groups linked with ecosystems services). These indicators are not static and will evolve with our knowledge of oceanic ecosystems. Bridging the communication gap between the science communities and policy makers will advance observing efforts, data sharing and accessibility, and modelling development useful for policy.

It is crucial to forecast plankton and marine ecosystems as effectively as we forecast weather, and that comprises a suite of observations (e.g., density, rates, diversity, predator-prey interactions), modelling that can estimate uncertainty, and an emulation framework. Participants further emphasized the need to quantify the uncertainty of our projections and indicators used in policy as we do with weather and use reference points of ecological status (e.g., diversity) for measuring the success of policy actions/frameworks. Actions can be taken that will help to quantify and report uncertainties with data reporting, and to find solutions where uncertainties remain difficult to measure.



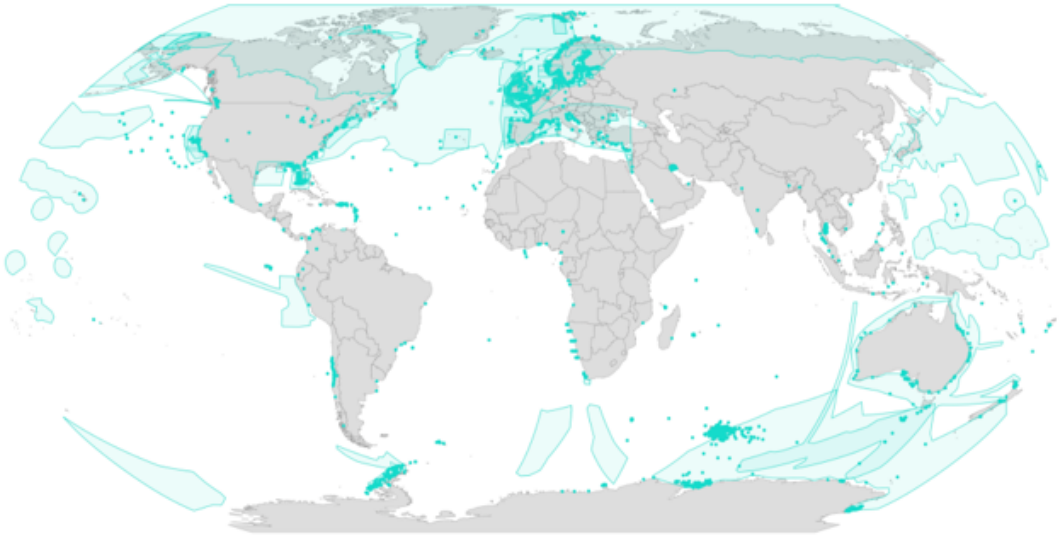
Left: Figure adapted and modified from Ratnarajah et al., 2023 section). Traditional techniques such as Continuous Plankton Recorder (CPR), nets and Niskin bottles have been used to monitor zooplankton for decades with great success. However, coupling traditional techniques with newer methods such as molecular data (for example, DNA, RNA and proteins), advanced sensors, in situ imaging approaches and satellites can improve geographic coverage, particularly in under sampled regions and improve our understanding of the impact of climate change on plankton communities.

Participants proposed two key essential actions for quantifying observational and prediction uncertainty:

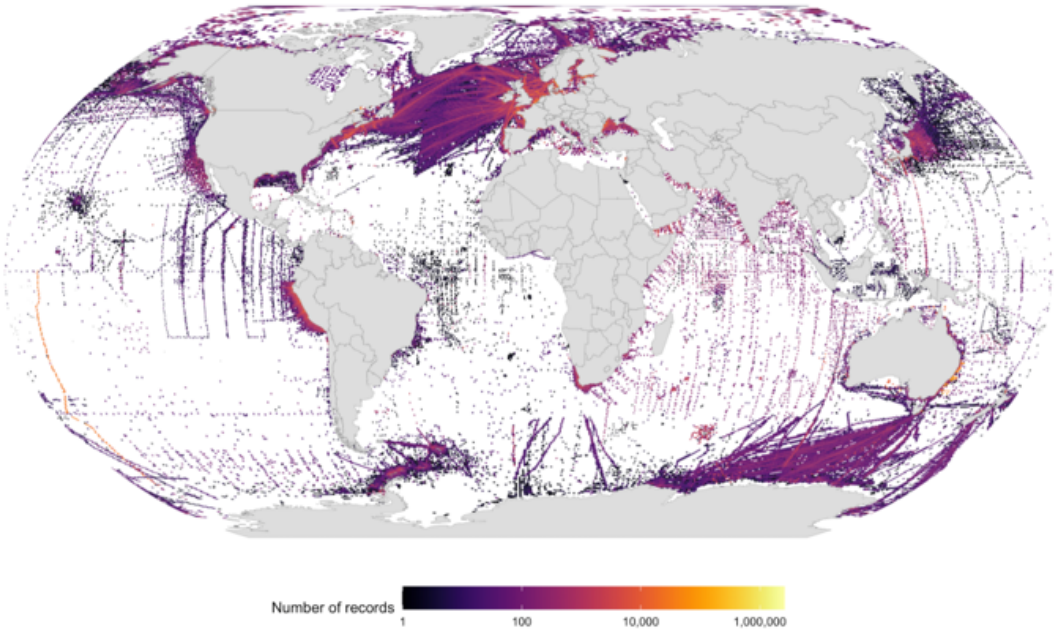
1. **The establishment of a feedback loop between data providers and users (e.g., models, policy needs) for co-design and agreement on observational priorities and**
2. **Long-funded programs for the intercalibration and integration of various instruments at the same time and space including sharing research infrastructure. Long-term time-series are fundamental for model validation and predicting biodiversity status, monitoring, and tracking signals of change.**

Participants identified access to data as the backbone of every step forward**. Historically, biological oceanography** as a field has been slow to share data funded by individual projects. For zooplankton for example, **on a global scale only 19% of the plankton data collected from long-term monitoring programs are freely available** (Ratnarajah et al., 2023). This undermines our existing understanding of plankton communities and creates obstacles in producing knowledge that can be relied upon for trustworthy projections and guiding policy decisions. Large, international programs such as Biogeochemical (BGC) Argo and the Continuous Plankton Recorder (CPR) Survey have recognized data sharing as key to their success, and this culture is shared with the field of genomics, where data sharing is required for publication. Opportunities exist to convey these success stories, to provide database recommendations, to facilitate and provide training on data provision, and to incentivize scientists to make a more universally open culture around data sharing with plankton observing.

Plankton monitoring programs from around the globe (270) included in the GOOS BioEco Portal: https://bioeco.goosocean.org



Plankton data in OBIS (Ocean Biodiversity Information System):
485 datasets
8,662 species
13,767,740 records



Towards Plankton FAIR data

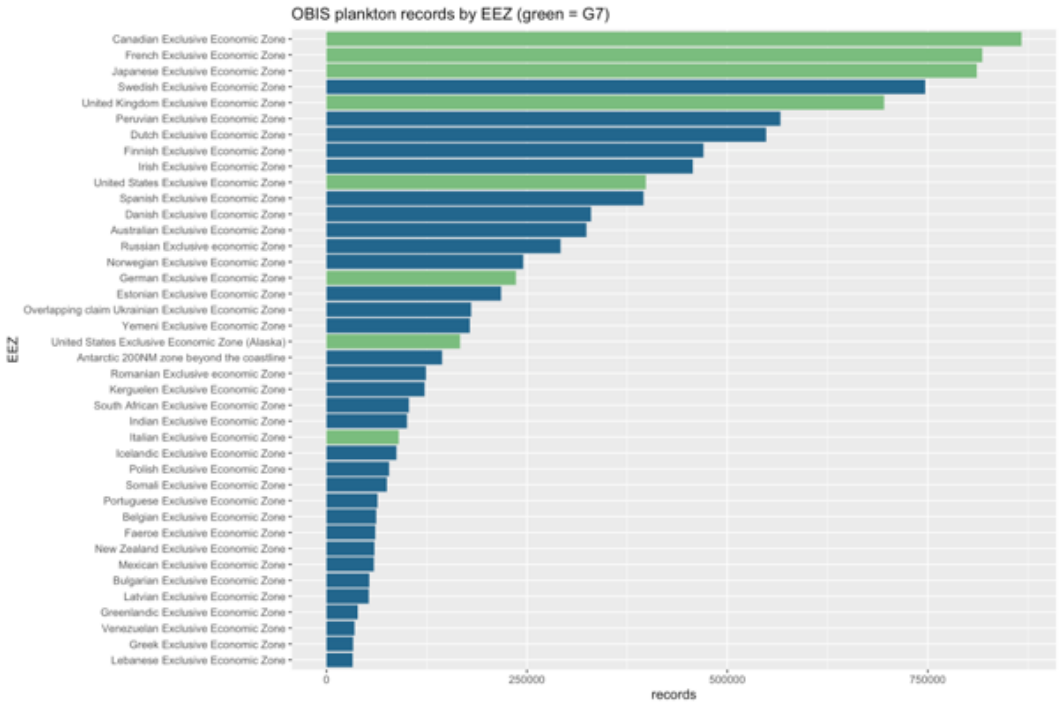
The participants discussed three main barriers toward Findable, Accessible, Interoperable, Reusable (FAIR) data in biological oceanography:

1. **lack of funding for sustainable long-term projects, including dedicated fund for data management**
2. **different policies between institutions, countries or/and funders and**
3. **cultural attitudes about data sharing.**

Participants mentioned that publications instead of sharing data are the metric of success at an institutional and funding level. Hence, data sharing is not a priority for many scientists, especially when there is no data management capacity on an institutional or national level to support the process of converting raw observations to FAIR data.

In many countries (including the G7), the financial sustainability of observing/monitoring programs relies on the number of publications rather than the amount of FAIR data and fast access to data after collection that the program delivers. Policies and requirements for sharing data have been introduced in funding calls by many G7 countries and the EU in the last decade. Still, many of them do not include specific guidance on where and how to submit which data (publish once, harvest many times).

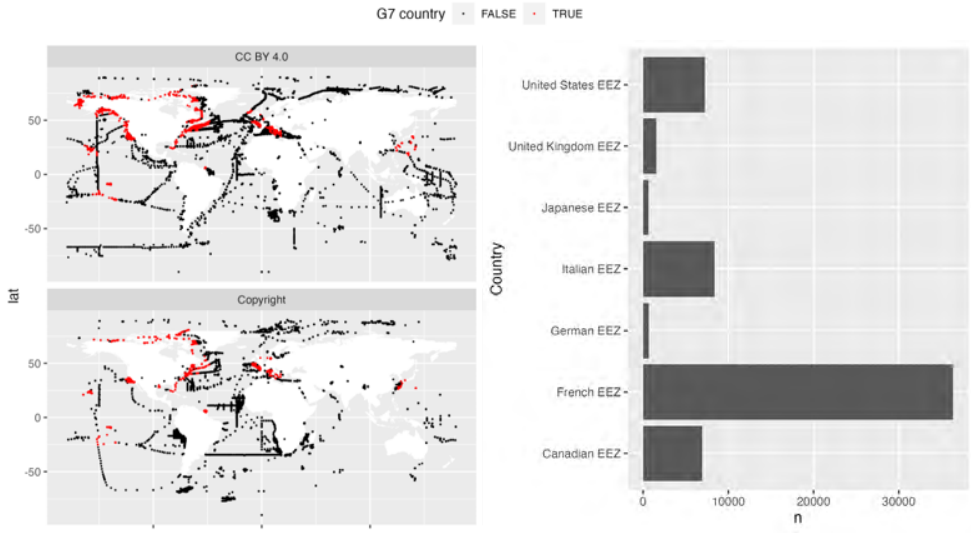
Additionally, the lack of documentation on data flows from national repositories to regional/ global federated systems creates challenges for both data providers and users in understanding the interoperability across dataspaces. Consequently, there is often uncertainty regarding whether the same data is utilized multiple times within a given data sample.



Plankton data in OBIS by exclusive economic zone (EEZ) with G7 in green, which shows that most of the OBIS plankton data come from the G7 members.

Left: Plankton monitoring programs publishing to Ocean Biodiversity Inforamation System (OBIS) by G7 member. Note this is based on Exclusive Economic Zones (EEZs) and not on program affiliations as the latter are not reliably available.

Left: Plankton monitoring programs publishing to Ocean Biodiversity Inforamation System (OBIS) by G7 member. Note this is based on Exclusive Economic Zones (EEZs) and not on program affiliations as the latter are not reliably available.



On the right: Data in ECOTAXA Hosts 350M images, 145M human validated >250k samples 2000+ users in 600+ organisations worldwide. In red data from the G7 countries.

On the left: Plankton imaging data in ECOTAXA from the G7 EEZ. Note that France has imaging time-series that explain the high number of data

Key actions for advancing FAIR data

As key actions for advancing FAIR data the participants agreed on the following recommendations:

1. Capacity development for data management at national and institutional level (develop network of data managers to support scientists - without data managers at hand the job often doesn't get done)
2. Capacity development to enhance interoperability between national and international dataspaces.
3. Coordination between countries on data policies and data formats for harmonization of data products.
4. Countries should prioritize and incentivize data sharing and FAIR data as a metric of success instead of publications. Robust and realistic data management plans (allowing the necessary time/moratoria) with adequate funding allocated within projects could be a condition for funding with a follow-up mechanism on tracking where the data are stored.
5. Advanced communication and education about the ultimate goals of FAIR data and data sharing could be included in educational programs and research institutes to change the existing culture from data holding to data sharing.

Recommendations for consideration at the G7 FSOI 2023 annual meeting

The group identified four key recommendations for consideration at the **G7 FSOI 2023 annual meeting in Tokyo, November 14-16, 2023**. The recommendations can be applicable to other marine life groups and are strongly linked to other G7 FSOI Priorities (identified in brackets).

1. Include optical remote sensing (ocean color) as a source for operational information (direct links with the Digital Twins of the Ocean (DTO), Ocean Carbon, Indicators G7 FSOI Priority topics).
2. Prioritize investments to ensure the continuation of existing long-term time series, the development of new ones and the incorporation of new high-resolution technologies into both (each having links with the DTO, Ocean Carbon, Indicators G7 FSOI Priority topics).
3. Capacity development for data sharing and interoperability of national and international databases. Support of the OBIS nodes.
4. Integration of plankton measurements into existing national and global observing systems that also collect abiotic environmental measurements like Ocean Sites, Argo, BIO-GO-SHIP (links with the DTO, Ocean Carbon, One Argo, indicators G7 FSOI Priority topics) for identifying environmental drivers and provide a set of both biotic and environmental observations useful for models' validation.

The workshop organizers:

- Grigoratou Maria (EU Coordinator of G7 FSOI Coordination Centre/ Mercator Ocean International)
- Conesa Alcolea Ivan (nominated expert from the European Commission)
- Canonico Gabrielle (nominated expert from the USA and co-chair of the GOOS EioEco panel)
- Casotti Raffaella (nominated expert from Italy)
- Creach Veronique (nominated expert from the UK)
- Kraberg Alexandra (nominated expert from Germany)
- Yamakita Takehisa (nominated expert from Japan)

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Acknowledgements:

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Useful links:

- **G7 Future of the Seas and Oceans Initiative:** www.g7fsoi.org
- **GOOS Biology and Ecosystems Panel:** http://www.goosocean.org/index.php?option=com_content&view=article&id=289&Itemid=438
- **Ocean Biodiversity Information System:** https://obis.org/
- **Ratnarajah et al., 2023. Sustained observations to quantify impacts of climate**: https://www.nature.com/articles/s41467-023-36241-5 change

Participants List

* Nominated expert from the G7 FSOI members and organizer of the workshop

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Stemman	Lars	LOV	France	Goal 1 - presenter
Vandepitte	Leen	VLIZ	Belgium	Goal 2 - presenter
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