Title

FISHGLOB: a collaborative infrastructure for marine science and management

Authors

Aurore A. Maureaud[1,*], Zoë Kitchel[1,2], Alexa Fredston[3], Robert Guralnick[4], Juliano Palacios-Abrantes[5], M.L. Deng Palomares[6], Malin L. Pinsky[1,7], Nancy L. Shackell[8], James T. Thorson[9], Bastien Mérigot[10], and the FISHGLOB Consortium

Affiliations

[1]Department of Ecology, Evolution, and Natural Resources, Rutgers University, New Brunswick, NJ, 08904, USA

[2]Vantuna Research Group, Occidental College, Los Angeles, CA, USA

[3]Department of Ocean Sciences, University of California, Santa Cruz, Santa Cruz, CA, USA

[4] Department of Natural History, Florida Museum of Natural History, University of Florida, Gainesville, FL, USA

[5]Changing Ocean Research Unit, Institute for the Oceans & Fisheries, The University of British Columbia, Vancouver, BC, Canada

[6]Sea Around Us, Institute for the Oceans and Fisheries, The University of British Columbia, Vancouver, BC, Canada

[7]Department of Ecology & Evolutionary Biology, University of California Santa Cruz, Santa Cruz, CA, USA

[8]Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth NS, Canada

[9]Habitat and Ecological Processes Research Program, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, Seattle WA, USA

[10]MARBEC, Univ of Montpellier, CNRS, IFREMER, IRD, Sète, France

*Corresponding author: aurore.aqua@gmail.com

List of FISHGLOB consortium contributors

Daniela Alemany, Kofi Amador, Jonathan Belmaker, Esther D. Beukhof, Steven J. Bograd, Mohamed Lamine Camara, Pierluigi Carbonara, Shahar Chaikin, Martin A. Collins, Tyler D. Eddy, Dor Edelist, Heino O. Fock, Romain Frelat, Kevin Friedland, Arnaud Grüss, Manuel Hidalgo, Didier Jouffre, Saïkou Oumar Kidé, Mariano Koen-Alonso, Ian Knuckey, Stan Kotwicki, Edward Lavender, Martin Lindegren, Marcos Llope, Laura Mannocci, Julia G. Mason, Hicham Masski, Matthew McLean, Laurène Merillet, Vesselina Mihneva, Francis K. E. Nunoo, Richard L. O'Driscoll, Cecilia O'Leary, Laurene Pecuchet, Elitsa Petrova, Jorge E.

Ramos, Ignacio Sobrino, Jón Sólmundsson, Vaishav Soni, Ingrid Spies, Maria Teresa Spedicato, Fabrice Stephenson, Ndiaga Thiam, Feriha Tserkova, George Tserpes, Evangelos Tzanatos, Daniël van Denderen, Paraskevas Vasilakopoulos, Tom Webb, Daniela V. Yepsen, Philippe Ziegler, Walter Zupa

Author Contributions

-Conceptualization: AAM
-Funding Acquisition: BM, MLDP, MLP
-Methodology: AAM, RG
-Project Administration: BM, MLDP
-Software: AF
-Supervision: AAM, BM
-Visualization: AAM, ZK, MLP
-Writing - Original Draft Preparation: AAM, ZK, RG, JPA, MLDP, MLP, NLS, JTT, BM
-Writing - Review & Editing: AAM, ZK, AF, RG, JPA, MLDP, MLP, NLS, JTT, BM, FISHGLOB consortium

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marine scientific survey, community-building, global change, biodiversity monitoring, dataset integration, knowledge transfer

Abbreviations

ICES: International Council for the Exploration of the Sea
WoRMS: World Register of Marine Species
OBIS: Ocean Biodiversity Information System
GBIF: Global Biodiversity Information Facility
FishMIP: Fisheries and Marine Ecosystem Modelling Intercomparison Project
NOAA: National Oceanographic and Atmospheric Administration
FAIR: Findable, Accessible, Interoperable, Reusable
UN: United Nations
UNESCO: United Nations Educational, Scientific and Cultural Organization

Standfirst Abstract

Producers and users contributing to diverse scientific enterprises are often siloed. FISHGLOB is a sociotechnical infrastructure supporting collaboration and data sharing between experts in, and users of, fish bottom trawl surveys, a form of ocean monitoring.

Main Text

Scientific surveys to monitor ocean biodiversity

The UN Decade of Ocean Science for Sustainable Development seeks to mobilize existing data to understand global change impacts on marine ecosystems and biodiversity [1]. Scientific surveys are vital to this effort and to inform resource managers because they use consistent and well-documented sampling methods through time [2]. However, few initiatives exist to compile and harmonize the metadata and data collected by multiple marine scientific surveys. This is mostly because of disparities in visibility, availability, and capacity across regions of the world, making such coordinated efforts particularly challenging.

To try to fill this gap, we initiated a project called FISHGLOB (originally the FRB-CESAB biodiversity working group "fish biodiversity under global change") to identify and integrate monitoring datasets from scientific bottom trawl surveys (SBTS) supporting research on ocean biodiversity. FISHGLOB's overarching goal is to support the translation of knowledge to action and to enhance decision-making in an era of profound change. This goal is supported by a social infrastructure enhancing cross-regional collaborations (FISHGLOB consortium), and a technical infrastructure developing analytical tools for integrating datasets (FISHGLOB technical infrastructure). Here, we present progress, lessons learned, and opportunities with FISHGLOB to increase awareness of needs and challenges in creating collaborative infrastructures around biodiversity monitoring datasets.

Mobilizing surveys

In 2019, three early career scientists organized a meeting at the ICES Annual Scientific Conference to discuss collaborations around SBTS performed along continental shelves (Fig 1), some of the most diverse and productive marine ecosystems. SBTS started in the 1900s to collect demersal marine species (living over and on the sea bottom) and provide data for fisheries management and ecosystem monitoring independently from the fishing industry.

This initiative led to the first global inventory of SBTS, revealing 95 ongoing surveys across all continents and covering more than 283,000 sampling events across 2.5 million km^2 of

seafloor since 2000 [3]. Over 40% of the survey data were publicly available, while the rest were not publicly available under different levels of accessibility (Fig 1F). Focusing initially on an inventory of metadata allowed us to build a comprehensive catalog of existing surveys and an international consortium encompassing all continents. Sharing our experience in consortium-building and inventorying is thus broadly valuable, as cross-regional data accessibility is a challenge for many other types of marine monitoring surveys (Fig 1F).

Survey data accessed via public repositories or collaborations have been integrated for the first time into a technical infrastructure by the FISHGLOB biodiversity synthesis working group. Procedures were developed for data quality control and standardization that allow for cross-continental integration of SBTS [4]. The public data products are version-controlled with openly available code to facilitate re-use of 29 surveys [5]. FISHGLOB's technical infrastructure includes several levels of information, ranging from survey metadata and event-based metadata to species occurrence and abundance data, thereby optimizing transparency under different levels of accessibility (Fig 2).

Linking the data infrastructure

The development of the data infrastructure led to questions about data standards for scientific surveys and links to other biodiversity databases. FISHGLOB currently reconciles taxonomic names and can import species' traits from WoRMS, FishBase, and FishLife (Fig 2). This enables connecting SBTS to other initiatives such as biogeography data repositories (e.g., OBIS, GBIF, Aquamaps), ecosystem modeling platforms (e.g., FishMIP), fisheries data platforms (e.g., RAM legacy database, Sea Around Us), and institutional data servers (e.g., ICES and NOAA data portals). However, further development of metadata standards is needed to better connect these initiatives. For example, Darwin Core [6] is a well-used data and metadata format for species occurrences that cannot fully capture central information from monitoring scientific surveys. Linking to nascent inventory metadata standards, such as the Humboldt Extension to the Darwin Core [7], may provide an elegant solution for FISHGLOB's technical infrastructure and alike initiatives.

Values to bring people together

While SBTS are similar in their sampling design, most surveys are conducted locally or regionally. This is true for most scientific monitoring programs, often leading to fragmented scientific communities with regional disparities in survey visibility, capacity, and availability

[3,8]. As such, larger scale integration is dependent on the success of cross-regional partnerships to allow for scientific knowledge exchange from data integration up to usage.

This is why in the FISHGLOB consortium we identified people, relationships, and trust among partners to be fundamental to understanding changing demersal biodiversity and ecosystems across regions. In 2022, a series of webinars resulted in recognition of shared interests in data and knowledge exchange among consortium members, while also revealing substantial diversity in goals (e.g., providing, using, or coordinating technical and social infrastructures) and capacity. Maintaining long-term participation requires shared values, ethos and frameworks for data sharing that offer tangible benefits to participants. In this context, we identified key values for the project (Fig 2) aligned with the UNESCO's recommendations on open science, including:

- Open data and open science as guiding principles to enable wide societal benefits.
- Data sovereignty and a recognition that data originators may place limits on visibility, access, and on how data are used, such as through licensing, data use agreements, and prior and informed consent approaches, all of which follow the FAIR principles [9].
- Capacity building to grow an international community that addresses historical, linguistic [10], cultural, financial, political, technical, and structural barriers to participation. Growing capacity is essential because sharing data can perpetuate rather than overcome inequities by benefiting users from countries that already have the most capacity [11,12].
- Credit and visibility for consortium members, including documented methods for citing data products and inclusive models for authorship.

At the core of the infrastructure, these values facilitate participation while respecting sovereignty and credit for contributions by experts. The values are transferable to other cross-regional monitoring schemes and can serve as a foundation for more equitable infrastructures that sustain long-term partnerships.

Opportunities for engagement and ways forward

Infrastructure building relies on a social process of identifying needs and solutions that maximize community participation and thus requires consultation for development [8]. A survey distributed to data providers, regional experts, and users involved in the FISHGLOB

consortium identified that standardized sets of visual summaries, including biodiversity change indicators and maps of species distributions, would be a useful, value-added product. As such, a future initiative may share these deliverables on an online platform to lower the barrier to using SBTS data, much as similar maps from OceanAdapt enabled widespread use by journalists, students and teachers, textbook authors [13], fisheries management councils, environmental agencies, and conservation non-profits. Partnerships with regional and global initiatives strengthen efforts to co-develop products responding to the needs of the consortium and larger audiences.

The FISHGLOB project has already enabled multiple applications and publications, includes more than 100 contributors from 36 countries, and was recently endorsed by the UN Decade of Ocean Science SUPREME Programme, already demonstrating broad participation and recognition. As part of the UN Decade of Ocean Science, a longer-term priority is the development of opportunities for collaborations with regions from the Global South and regions that do not operate under open infrastructures. Such opportunities need support from international organizations and funding agencies.

Conclusion

In four years of work, we established fundamental components towards a globally coordinated sociotechnical infrastructure. The FISHGLOB infrastructure facilitates innovation by integrating SBTS across regions in a time when scientific evidence is needed to tackle unprecedented ocean change. FISHGLOB creates an opportunity for all those who wish to be involved to collectively provide evidence for how humans changed the ocean, and to act for the ocean we want (to join the consortium, readers can sign up at https://fishglob.sites.ucsc.edu). We encourage similar collaborative projects to embrace the representation of diverse perspectives by connecting communities who generate and use marine datasets.

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Figures

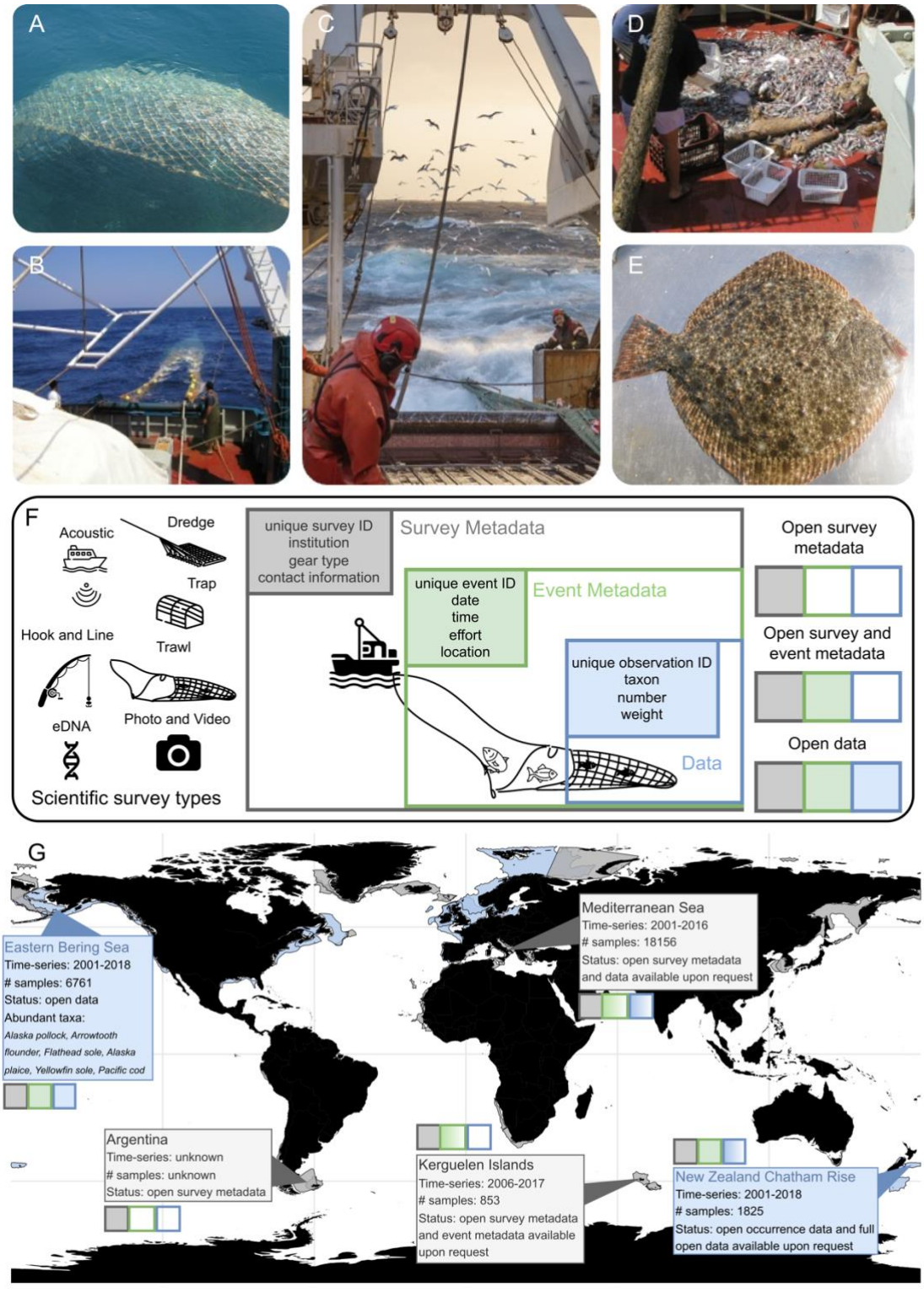

Fig 1. Sampling demersal communities with scientific bottom-trawl surveys (SBTS). Sampling steps with SBTS: trawling operation (A) and (B), bringing the trawl back onboard (B) and (C), catches from the haul (D), individual specimen identification and measurements (E). Scientific survey datasets in the oceans can be performed with a wide range of designs

and sampling methods ((F) on the left). Within scientific surveys, SBTS in FISHGLOB ((F) on the right) are structured around the integration of the survey metadata (gray) with individual sampling event metadata (green) and biological observations (blue). The FISHGLOB technical infrastructure supports a range of data privacy, from fully open survey data to surveys with only survey-level metadata that are public. SBTS regions sampled since 2001 and their range of data accessibility are shown in (G), adapted from Maureaud et al., 2021 [3]. When the metadata or data are available upon request, the corresponding legend box was colored with a gradient. Survey photo credits: Svanhildur Egilsdóttir from the Marine and Freshwater Research Institute in Iceland (Icelandic survey in (C)), Elitsa Petrova from the Institute of Fish Resources in Bulgaria (Western Black Sea survey in (A) and (E)), George Tserpes from the Hellenic Center for Marine Research in Greece (Mediterranean Survey via the MEDITS program in (B) and (D)). Icon credits in F: https://www.flaticon.com.

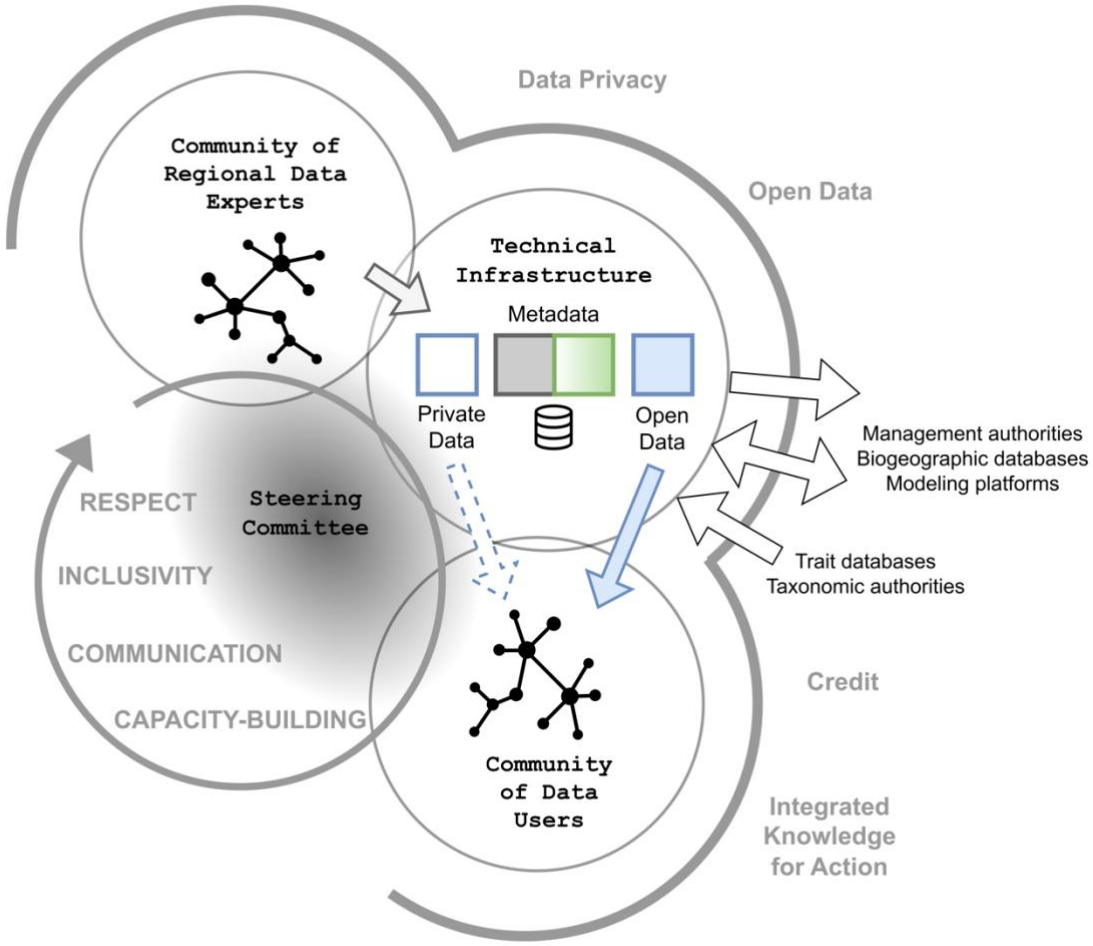

Fig 2. The FISHGLOB socio-technical infrastructure.

The FISHGLOB infrastructure is centered around shared values, two primary communities, and a technical data integration process and datastore, coordinated by a steering committee. The FISHGLOB infrastructure specifically recognizes and includes of a range of data privacy for the metadata and survey data [3], following both open science and FAIR principles [9]. FISHGLOB needs to further develop its connections within the landscape of other data platforms to ensure interoperability of SBTS. The philosophy behind the infrastructure supports both credit to experts and contributors, as well as the use of integrated knowledge for action in an era of global change.