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**Seventeenth Session of the IOC-FAO Intergovernmental Panel**

**on Harmful Algal Blooms**

Paris, 18-20 March 2025

Item 4.4.1 of the Provisional Agenda

**REPORT OF THE IPHAB TASK TEAM ON THE EARLY DETECTION, WARNING AND FORECASTING OF HAB EVENTS**

*Task Team on the Early Detection, Warning and Forecasting of HAB Events*

Report – March 2025

Task Team members and advisors: B. Karlson (Sweden) Chair, A. Duarte Silva (Portugal) , D. Clarke (WGHABD/Ireland), P. Mozetic (Slovenia), M. Broadwater (USA), C. McKenzie (Canada), D. Anderson (USA); L. Guzmán (Chile); J.L. Peña (Mexico); L.J. Naustvoll (WGHABD, Norway).; Greg Doucette (USA), A. T. Yñiguez (Philippines), M. J. Botelho (Portugal) and M.Y. Dechraoui Bottein (Morocco)

Alexandra Silva, Portugal, was chair of the task team until autumn 2024 and Bengt Karlson, Sweden, was an un-official co-chair. Bengt and Alexandra have switched roles.

*Terms of Reference (*[*https://oceanexpert.org/doclist/230*](https://oceanexpert.org/doclist/230)*)*

(i) Serve as a strategic and advisory group for the establishment of guidelines, recommendations, and advancement of Early Warning Systems, ensuring the alignment with UN Ocean Decade challenges, objectives and actions, Workshops on EWS for HABs and Biotoxins

(ii) Interact with HAB working groups and committees (e.g. ICES-IOC/WGHABD, PICES, IOC/FANSA, IOC/HANA, IOCARIBE/ANCA, IOC/WESTPAC-HAB) in the development of regional EWS and in the standardization of alerts, harmonization of key messages and initiating sessions on near real time HAB Observing and Early Warning Systems at forthcoming international and national science meetings (e.g. ISSHA, U.S HAB Symposium),

(iii) Invite the scientific community and stakeholders, e.g. from the desalination industry, to contribute by identifying early warning research topics, assessment of capabilities, seeking for transformative solutions, promoting strategies for engagement, and communicating scientific information to policy makers, managers and other end-users,

(iv) Promote the presence of HAB observations in the IOC Global Ocean Observing System and its regional components such as USA-IOOS and EuroGOOS, and the consolidation of integrated multi-hazard Early Warning Systems that employ scalable and affordable HAB technologies and methodologies for the continuous monitoring of coastal and ocean ecosystems.

The TT has addressed the present terms of references and several activities are currently in progress mostly focused on promoting new solutions for monitoring HABs and Biotoxins and providing early warning. Several approaches are either being developed or in implementation while others present opportunities to seek funding to advance these EWS on multiple fronts.

## Workshops on EWS for HABs and Biotoxins

In 2022 and 2024, Intergovernmental Oceanographic Commission’s HABs programme conducted follow up expert missions on Early Warning System development and capacity enhancement for predictive HAB forecasting in Morocco and Namibia..

The workshop on “Monitoring Methods and Data Management for Establishing an Early Warning System (EWS) for Harmful Algal Blooms (HABs) in Morocco” was held in Casablanca during December 2nd - 6th 2024, sponsored by UNESCO/IOC and hosted by L'Institut National de Recherche Halieutique, INRH, Casablanca, Morocco. The objectives of the workshop were to assess the validation of the test method for biotoxins, and to analyse monitoring phytoplankton and biotoxin long-term data to support science-based monitoring strategy revision. Twenty-eight participants attended the workshop, composed mainly of representatives (scientists and professionals engaged in marine biotoxin and phytoplankton monitoring programmes) from the six INRH biomonitoring centres (Nador, Tangier, Casablanca, Agadir, Laayoun, and Dakhla), as well as international scientists and IOC representation.

A “Scientific meeting on data needs and code of practice for establishing an Early Warning system (EWs) for Harmful Algal Blooms (HABs) in Namibia” was held in Swakopmund, Namibia during 28th October to 1st November 2024 sponsored by UNESCO/IOC and hosted by Ministry of Fisheries and Marine Resources (MFMR). The meeting was attended by a number of stakeholders (including oyster and desalination industries, scientists and Ministry representatives), involved in the detection and management of Harmful Algal Blooms. The 2024 meeting was to progress the recommendations as identified and documented in the previous meeting in October 2022, specifically focusing on areas such as the implementation of a stakeholder and scientific committee group, a Code of Practice for shellfish sanitation, R programming and tutorials for the co-development of a revised stakeholder adapted and focused phytoplankton bulletin. These specific areas were focused on to enable further progression and capacity enhancement of an Early Warning System in Namibia.

The above expert missions are supported and funded through a cooperation agreement between UNESCO and the Norwegian Agency for Development Cooperation (NORAD), the project led by UNESCO's Intergovernmental Oceanographic Commission (IOC) in partnership with FAO and IAEA. Funding these workshops, in more countries that are highly vulnerable to these phenomena, is vital as they provide the foundational knowledge and tools needed for establishing EWS. By involving stakeholders from the outset, these workshops ensure that the EWS developed are tailored to meet specific regional needs, thus enhancing their effectiveness and sustainability.

## Other ongoing activities

### Listing operational or pre-operational HAB early detection and warning systems for ICES countries.

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) met in Nantes, France in spring 2024. One activity was to start compiling a list of operational or pre-operational HAB early detection and warning systems for ICES countries. This work is ongoing and will continue during the WGHABD meeting in Gothenburg, Sweden 8-10 April 2025.

### Promoting automated plankton observations for early detection of HAB

Automated observations of HAB organisms at the species or genus level are important to provide near real time data for HAB early warning systems. There are ongoing activities with imaging flow cytometry worldwide. Some activities that the TT can benefit from:

* USA: National HAB Observing Network NHABON - https://ioosassociation.org/nhabon/
* Europe: The European IFCB user network (Karlson 2021)

The US NHABON initiative has established a Community of Practice (CoP) for HAB observing that, among other activities, organizes quarterly [webinars](https://ioosassociation.org/nhabon/) on topics of interest to the HAB observing community across both marine and freshwater systems. Recordings of all webinars are identified and available to access on the NHABON website. The CoP “includes a broad spectrum of HAB observing experts, system operators, manufacturers, data managers, stakeholders, and others from around the country involved in or considering being involved in developing, operating, maintaining, or using data from US HAB observing systems. The Committee is guided by a [Terms of Reference](https://docs.google.com/document/d/1HJHKRGPtYohTjCzjWkKsvrnWrFfG0XZYQy2rblARyo8/edit?pli=1).”

The European IFCB user network now includes more than 15 Imaging Flow CytoBots (IFCBs) that are used for observing harmful algae and other plankton. Also the Cytosense and the FlowCam are used. The network arranges regular on-line workshops about every two months and plans an in-person workshop in Oslo, Norway, 24-26 September, 2025, see below. Standardisation of methods and code for working with instruments and images acquired has been in focus. Code is available on GitHub <https://github.com/EuropeanIFCBGroup>. One example is iRfcb, a software library for R, developed by Anders Torstensson et al. A recommended format for data flow from data provider to data repositories such as GBIF, EMODnet, and OBIS was developed in a European Digital Twin Ocean project. The data format is based on the Darwin Core format. Another important aspect is sharing of annotated images, i.e. training data for AI-models. Links to training data are available at https://nordicmicroalgae.org/annotated-images/.

**Promoting the use of AI as a tool for an integrated multi-hazard EWS**

Artificial Intelligence can significantly enhance the capabilities of EWS by improving the accuracy, efficiency, and timeliness of predictions and responses. AI can handle and integrate large volumes of data from multiple sources, such as in-situ sensors, satellite images, weather data, and historical records, providing a comprehensive view of potential HAB risks. These systems can learn from new data and continuously update and improve prediction models, ensuring that the EWS adapts to changing environmental conditions and new information. By automating data analysis and monitoring processes, AI can reduce the costs associated with manual data collection and analysis. Large amounts of high-quality data are needed for training AI models and robust computational infrastructure is needed to process and store large volumes of data. Developing and maintaining AI models requires specialized expertise in data science, machine learning, and domain knowledge of marine ecology.

There are several ways AI can be integrated and it is open for discussion the possibility of exploring funding opportunities related to e.g., the use of historical data for training machine learning models that predict HAB events based on environmental factors such as temperature, salinity, nutrient levels, and water currents; processing data from water sensors using AI for real-time monitoring of water quality; the development of AI algorithms that analyse satellite images for identifying and tracking the development and spread of algal blooms, as well as assessing their diversity (e.g. the ongoing PETRI-MED project in the Mediterranean region; https://petri-med.icm.csic.es/); detecting unusual patterns or anomalies in environmental data, which may indicate the onset of a HAB event, and the use of AI to assess the potential impact of HABs on public health, fisheries, and tourism by predicting the severity and duration of blooms. This funding would also support the development of systems that generate and disseminate automated alerts to relevant stakeholders, enabling timely actions to mitigate the impacts of HABs.

One example of an AI-based EWS for the HAB toxins causing paralytic shellfish poisoning that can serve as a guide for establishing such system is the PSP forecast developed by Bigelow Laboratories in partnership with the state of Maine Department of Marine Resources (DMR) as well as the aquaculture sector ([Grasso et al., 2019](https://doi.org/10.1002/ecs2.2960); [Record et al., 2022](https://doi.org/10.3389/fmars.2022.923738)). These forecasts are posted weekly on Maine DMR’s Maine [Phytoplankton Data and Biotoxin Forecast](https://mainedmr.shinyapps.io/bph_phyto/) website.

In 2024 at the annual ICES-IOC Working Group, Blue Lion Labs, Canada, presented to the group on ‘AI for HABs, an early warning system for Harmful Algal Blooms’ which highlighted the current AI approaches and technologies being developed and implemented for HAB event detection focusing on the developed Plankton AI software used on the OTAQ Live Plankton Analysis System (LPAS).

**Engaging with industry on HAB observing, data tools & services, and control technologies.**

The [Marine Technology Society](https://www.mtsociety.org/)’s [Ocean Enterprise Initiative](https://oceanenterprise.com/) (OEI) recently sponsored the second in a series of Dialogues with Industry focused on HAB-related topics. The *Dialogues* series have been co-designed for compact, meaningful discussions with new and established companies, academia, and governments worldwide to identify challenges and ways these sectors might overcome impediments to progress and to highlight opportunities for increasing industry involvement, capitalizing on existing and new technologies, and fostering public-private partnerships to achieve a mature and vibrant Ocean Observing Enterprise.

The [*Dialogues* series focused on HABs](https://oceanenterprise.com/previous-engagements/), consisted of three curated dialogues held in January and February 2025. The HABs *Dialogues* explored and defined the market dynamics, including barriers and opportunities, for maturing the public/private/academic partnership, capability, and capacity to support the growing societal need for delivery of actionable, fit-for-purpose ocean data, information, and knowledge based on regional requirements and use cases. The HABs *Dialogues* were less focused on technical and scientific discussions, except as they influenced the market dynamics.

Recordings of the three individual discussions are available on the [Marine Technology Society’s YouTube channel](https://www.youtube.com/@MarineTechSociety). and cover the topics of: HAB observing sensors and platforms; user-driven data products and services; and, advancing HAB control technologies. Summary reports for each of the discussions, as well as an overall synthesis report identifying common themes and action items for the future, will be posted to the OEI website.

## Planned activities

### Workshop on automated plankton analysis using imaging in flow methods

The workshop is planned to be arranged in Oslo, Norway, 24-26 September 2025, and hosted by the Oslo University. The venue is the Natural history museum in Oslo and the max number of participants is 50. Local host is Wenche Eikrem. Co-organisers are the ICES-IOC WGHABD, the European IFCB user network and the Nordic Marine Phytoplankton group. A scientific steering committee will be established for planning the detailed agenda. The main aims of the workshop are to share experiences of using automated plankton imaging methods for observing harmful algae in near real time and to train new users on the technology. This includes discussing practical aspects of operating automated imaging systems such as the Imaging FlowCytoBot and applying novel AI-based methods for automated recognition of plankton in images acquired. Another aspect is sharing annotated images in a systematic way to improve the availability of training data for Convoluted Neural Networks such as RESNET18. Also standardising data flows is an important aspect of the workshop.

### Workshop on HAB Early Warning Systems

A workshop on HAB Early Warning Systems is planned to be arranged during the International Conference on Harmful Algae, ICHA, in Punta Arenas, Chile 2025. The HAB EWS workshop is planned for Friday 24 October. The aims are to present recent activities in the field with selected scientific presentations and to discuss the current state of the art. Presentations of HAB events observed/predicted and the use of novel observing and modelling methods will be encouraged. A small scientific steering committee with representatives from the task team will be established to define the agenda.

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### Promoting the use of novel satellites and sensors for observing HAB

Satellite remote sensing of ocean colour has been used for a long time to observe chlorophyll *a* as a proxy for phytoplankton biomass. Certain types of high biomass HAB can be differentiated from phytoplankton in general based on pigments or other bio-optical properties. The launch of the NASA Plankton Aerosol Cloud Ocean Ecosystem mission (PACE) early 2024, with the hyperspectral sensor OCI, opens up new possibilities to differentiate types of phytoplankton, e.g. HAB. The TT will collaborate with ocean colour experts to develop HAB related products. NASA also anticipates launch of their Geosynchronous Littoral Imaging and Monitoring Radiometer (GLIMR) hyperspectral ocean colour radiometer in the 2026-2027 time frame, for improved monitoring of ocean biology, chemistry, and ecology throughout the Gulf of Mexico, the southeastern U.S. coastline and Amazon River plume that stretches to the Atlantic Ocean. In 2028 the European Space Agency, ESA, plans to launch the CHIME mission, with two satellites with hyperspectral sensors. Beyond this time horizon, there are also other initiatives such as the NOAA/NESDIS Geostationary Extended Observations (GeoXO) mission planned for the early 2030s, which will (among other capabilities) include a hyperspectral, ultraviolet through near-infrared passive imaging radiometer with ~390-meter resolution with new ocean colour images at least every three hours throughout the US Exclusive Economic Zone and Great Lakes. A possible activity would be a special session on the Ocean Optics meeting in 2026. These meetings are arranged every other year. There may also be opportunities to collaborate with GOOS, NASA and/or ESA and to take part in workshops, conferences and seminars.

### Planned on-line workshop on citizen engagement and low-cost observations- promoting citizen science as an EWS tool

Integrating citizen science into EWS can enhance monitoring capabilities, improve data collection, and engage the public in environmental stewardship. Citizens can report sightings of algal blooms, unusual water discoloration, or fish kills using mobile apps or online platforms (e.g. [FitoAvista](https://www.instagram.com/fitoavista/), Portugal; NOAA [Phytoplankton Monitoring Network](https://coastalscience.noaa.gov/monitoring-and-assessments/pmn/), US) and contribute with data and observations that can supplement official monitoring efforts, providing more comprehensive coverage, especially in areas with limited resources. Volunteers can collect water samples from local beaches, lakes, and rivers, which can be analysed for algal concentration and toxin levels. Involving citizens fosters a sense of ownership and responsibility for local water bodies, promoting environmental awareness and advocacy. Maintaining long-term citizen engagement and data collection efforts can be challenging (providing feedback and demonstrating the impact of citizen contributions can help sustain participation).

An on-line workshop is planned to share user experiences, present case studies, and promote the use of portable microscopes in citizen science. Participants will learn about the diverse applications of portable microscopes, how to use them effectively in different environments and for different types of samples, and the impact they can have on scientific research and community engagement. Real-world case studies and user experiences to highlight successful applications and outcomes will be shared. Target Audience: Citizen scientists, Educators and students, Environmentalists and nature enthusiasts, Researchers, Community leaders and organizers. A meeting coordinator and supporting material are needed.

Establishing relationships with companies that provide essential monitoring equipment, partnerships with suppliers of portable microscopes, small nets, and other necessary tools can significantly improve the accuracy and reliability of the data collected by volunteers, the effectiveness and reach of citizen science initiatives. Several low-cost microscopes are available and others may be in development. They include e.g. the PlanktoScope, the OpenFlexure microscope, the HABscope and the Foldscope.

Funding proposals are planned for public awareness and participation. Resources are needed to produce educational materials, such as infographics, videos, and articles, to increase public understanding of HABs and their impacts; and, to announce and coordinate volunteer opportunities for water sampling, visual monitoring, and other citizen science activities.

### Open Science meeting on HAB early detection and warning systems

Pending available funding this open science meeting could be arranged in 2026 or 2027, e.g. at the IOC headquarters in Paris or at FAO in Rome. The content of the meeting would be developed in cooperation with GlobalHAB and HAB-S. The general idea is to gather specialists from different disciplines that can contribute to HAB early warning systems. These include:

* Automated observations based on plankton imaging
* Novel, near real time, molecular methods
* Satellite remote sensing of ocean colour
* Modelling of bloom advection
* Modelling of bloom development and triggering conditions including AI-approaches
* HAB effects
* End user involvement.

The outcome of the open science meeting will be articles in a special issue of a scientific journal. Funding is needed for invited presenters and for the venue. A meeting coordinator is needed. The person could be funded e.g. by the IOC or FAO.

## Harmful Algae Bloom Solutions (HAB-S) Programme.

*“This UN Decade program aims to collaborate with stakeholders to enhance data resources, develop innovative observing instruments, and promote informed decision-making. It aims to manage and mitigate HAB impacts on human health, aquaculture, fisheries, desalination, and tourism, while also protecting the environment. Through public awareness campaigns, education initiatives, and interdisciplinary solutions, HAB-S seeks to reduce the frequency and severity of HAB events, lessening their negative effects on society and ecosystems. L*ead institution: Intergovernmental Oceanographic Commission (IOC) and Food and Agriculture Organization (FAO) Intergovernmental Panel on Harmful Algae Blooms (IPHAB) <https://oceandecade.org/actions/harmful-algae-bloom-solutions/>

The majority of the TT initiatives and activities are planned to be conducted in collaboration with HAB-S.

## Need for resources

1. Workshop Automated plankton analysis using imaging in flow methods 24-26 September, Oslo, Norway
   1. Travel and accommodation for invited specialists
2. Workshop EWS during ICHA2025 in Chile
   1. Workshop coordinator – provided by the IOC HAB program
   2. Travel and accommodation for invited specialists
   3. Venue – International Conference on Harmful Algae, Punta arenas, Chile.
   4. The EWS workshop is planned for Friday 24 October.
3. Citizen science on-line workshop
   1. Workshop coordinator – provided by the IOC HAB program
   2. Acquisition/Building costs for low-cost microscopes
   3. Cost for sampling and equipment
4. Promoting the use of novel satellites and sensors for observing HAB
   1. Special session during the Ocean Optics meeting in 2026
   2. Collaboration with GOOS, NASA and ESA funded workshops, seminars or conferences
   3. Travel costs for selected specialists
5. Open science meeting in cooperation with HAB-S.
   1. Meeting coordinator – provided by the IOC HAB program
   2. Travel and accommodation for invited speakers
   3. Venue – provided by the IOC or FAO