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IOC-UNESCO Taxonomic Reference List of Harmful Microalgae: Cyanobacteria Updates

The IOC-UNESCO Taxonomic Reference List of Harmful Microalgae is a globally recognised catalogue and website (*https://marinespecies.org/hab/*) developed under the Intergovernmental Oceanographic Commission (IOC) that lists the names of microalgal species (including cyanobacteria) known to produce toxins or cause harmful effects in aquatic environments. The list aims to promote taxonomic stability in support of monitoring, management, and research activities.

The list currently (December 2025) includes 122 dinoflagellates, 99 cyanobacteria, 31 diatoms, 8 haptophytes, 5 raphidophytes, and 3 dictyochophytes (Fig. 1).

The cyanobacterial editors have actively updated the cyanobacterial section to incorporate toxic species from both marine and freshwater environments. This ongoing effort reflects the increasing ecological and socio-economic importance of cyanobacteria in freshwater, coastal and estuarine systems, where climate-driven bloom expansion is enhancing their impact [1–2].

Cyanobacteria are remarkable for their diversity and their ability to occupy a wide range of ecological niches. They play a crucial ecological role as producers of oxygen. Some taxa are also key biological nitrogen fixers, acting either as free-living diazotrophs or as symbionts in diatom–diazotroph associations that sustain primary production in oligotrophic marine environments. Cyanobacterial symbionts are also found in association with dinoflagellates, and recent research on the dinoflagellate *Ornithocercus* has revealed genetically diverse, yet host-specific, cyanobiont assemblages in temperate coastal waters [3].

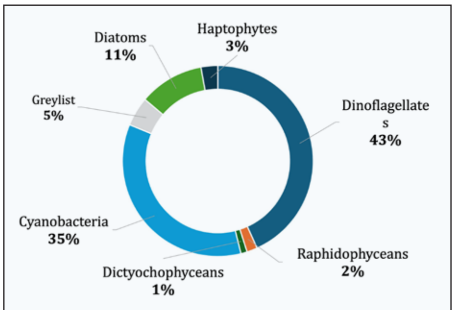

Fig. 1. Proportional representation of 268 taxa included in the IOC-UNESCO Taxonomic Reference List of Harmful Microalgae.

However, certain cyanobacteria are problematic as they form dense, harmful blooms and produce potent cyanotoxins, which pose serious risks to aquatic ecosystems and human health (e.g., [4]) (Fig. 2). The frequency and duration of cyanobacterial blooms have increased globally along with heightened anthropogenic nutrient loading associated with population growth and land-use change, as well as climate change (e.g., [5]). *Raphidiopsis raciborskii* (formerly *Cylindrospermopsis raciborskii*) is one of the most widely documented cyanobacterial species whose expansion has been linked to global environmental change (e.g., [6]).

Cyanobacteria produce toxins known as cyanotoxins, the most well-known of which are neurotoxins, hepatotoxins, dermatoxins and cytotoxins. These toxins can harm or even kill humans and animals (e.g., [7]). Depending on species and environmental context, cyanobacterial blooms may be associated with elevated cyanotoxin production. Exposure to cyanobacterial toxins during harmful algal blooms in marine or freshwater environments can result in diseases affecting the liver, nervous system or skin in humans and animals. This exposure can occur through the ingestion of contaminated water, dermal contact (e.g., during swimming), inhalation of aerosols, and consumption of seafood or crops irrigated with contaminated water [8]. The link between

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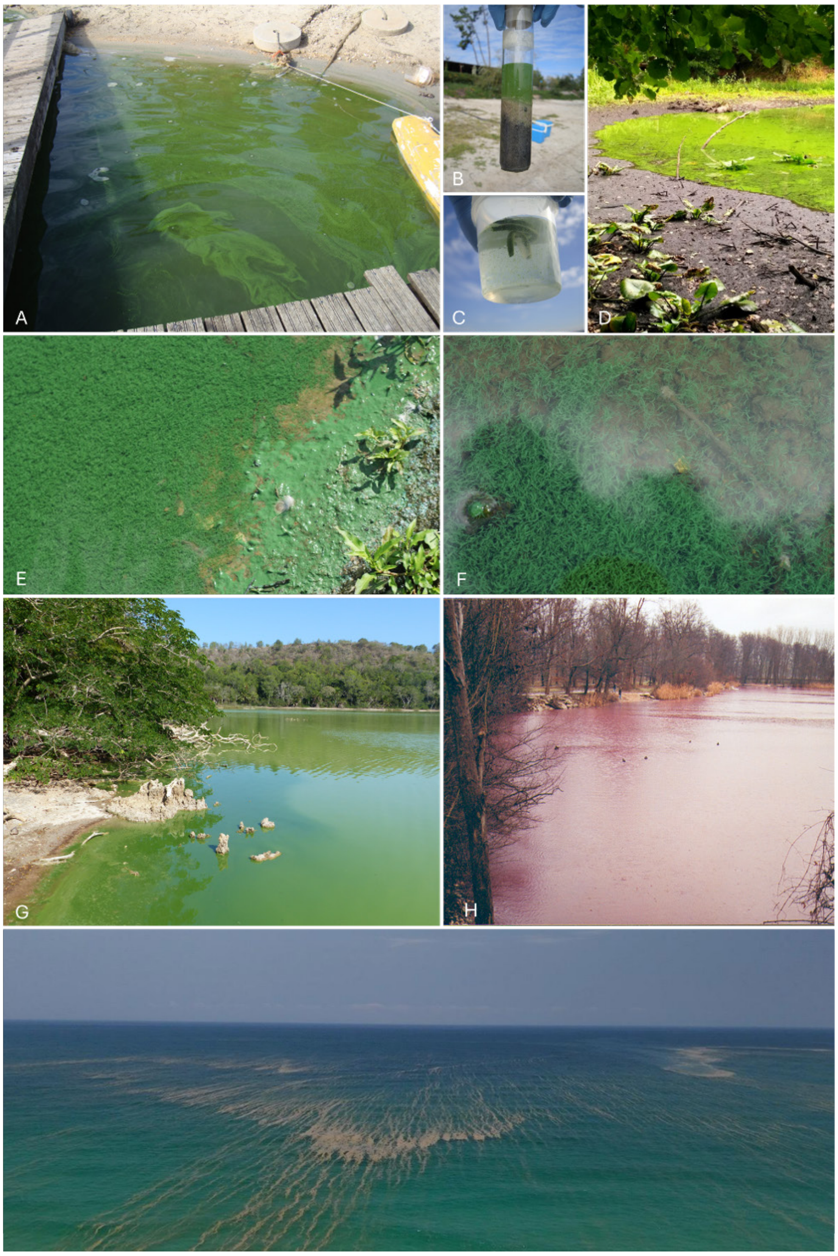

Fig. 2. Cyanobacterial blooms illustrating environmental pressure in aquatic systems. (A) Microcystis aeruginosa *bloom in Magos reservoir, Portugal; (B) sample from the* M. aeruginosa *bloom; (C)* M. aeruginosa *macroscopic colonies in the Magos reservoir, (D)* M. aeruginosa *bloom in a lake near Hillerød, Denmark; (E, F)* Aphanizomenon sp. *in a lake in the Paris area, France; (G)* Limnospira sp. *in the lake Dziani Dzaha of Mayotte, France, (H)* Planktothrix sp. *in a lake of the Paris area, France; (I)* Trichodesmium erythraeum *in the channel linking Bazaruto to Pomene, Inhambane, Mozambique. Photos are courtesy of C. Bernard, MNHN and C. Churro, IPMA.*

climate change, environmental contamination, population growth, cyanotoxin production, and disease are now well established (e.g., [9, 5]).

Due to the increasing number of genomic sequences of cyanobacteria, the availability of well-described reference strains, and the establishment of standardised workflows for describing new taxa, cyanobacterial taxonomy is currently undergoing a period of rapid change [10]. The most recent major update to cyanobacterial classification at the order and family levels was introduced by Komárek et al. [11, 12], based on a polyphasic approach. In 2023, Strunecky et al. proposed a robust phylogenomic framework for taxonomic purposes, integrating genome-based phylogenies with traditional polyphasic descriptions of type species and corresponding genera across the Cyanobacteria phylum. According to this classification, cyanobacterial genera are currently assigned to 19 orders [10].

Like other bacteria, cyanobacteria exhibit high plasticity and substantial genotypic diversity, not only between species but also within a given genus, and particularly at the strain level. From an ecological perspective, this microdiversity is essential for marine or freshwater cyanobacterial populations, enabling them to cope with spatio-temporal environmental variability and to adapt to specific micro-niches within ecosystems.

However, this aspect of intraspecific diversity is often overlooked in studies of bloom development or the relationship between cyanobacterial species and toxicity (e.g., [13, 14]). Further-

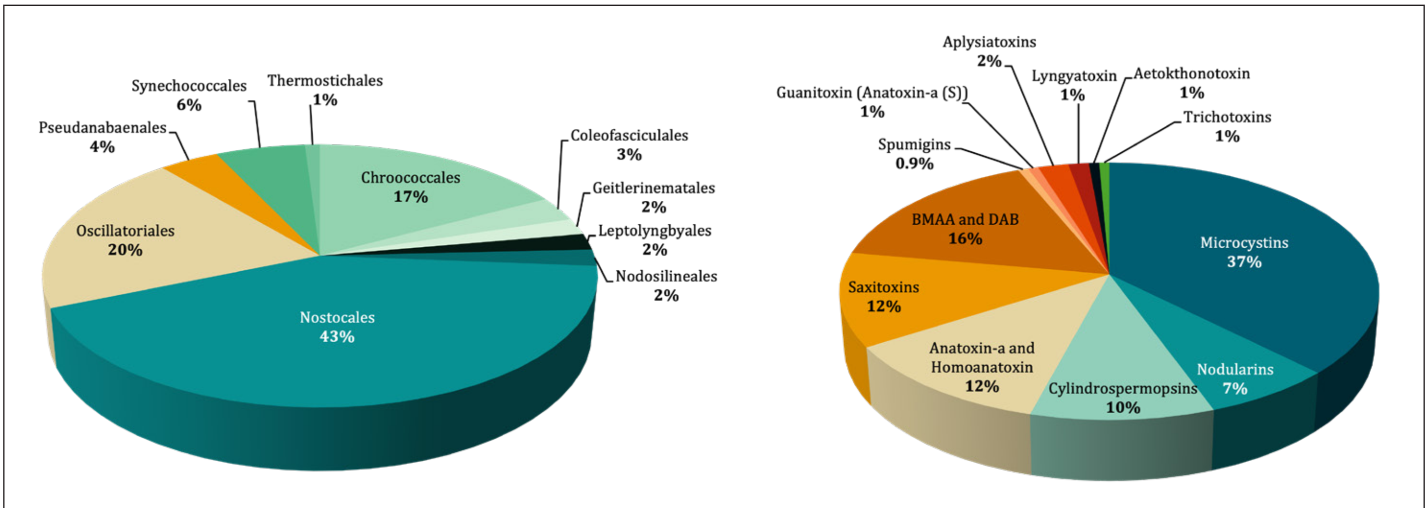

Fig. 3. Proportional representation of (A) cyanobacterial orders that include toxic taxa (10 of the 19 currently recognised orders) and (B) cyanobacterial toxins produced by the 99 cyanobacterial taxa included in the IOC-UNESCO Taxonomic Reference List of Harmful Microalgae (December 2025).

more, genome comparisons among individuals within monospecific blooms have revealed considerable heterogeneity in gene content, despite similar genome sizes and high similarity indices. These differences are mainly associated with mobile genetic elements and biosynthetic gene clusters. Metabolomic analyses have confirmed corresponding heterogeneity in the production of secondary metabolites, including cyanotoxins, and the harmful consequences of this heterogeneity (e.g., [15]). Consequently, within a single cyanobacterial species, toxic and non-toxic strains may coexist, as well as multitoxic strains carrying multiple functional toxin biosynthetic gene clusters.

Considering this microdiversity at the species and strain levels, the cyanobacterial editorial committee considers the following attributes for the updated list of toxic cyanobacteria:

- The list is based on publications documenting harmful effects associated with cyanobacterial isolates/strains or natural blooms dominated by a cyanobacterial species.
- Environmental conditions may selectively favour toxic or non-toxic genotypes within a species due to underlying microdiversity.
- Attribution of toxicity in environmental samples to the dominant species should be interpreted with caution until confirmation using isolated and characterised strains is available.

As of 2025, the list includes 99 cyanobacterial taxa, of which 62 are freshwater and 32 marine, representing 33% and 12%, respectively, of the total toxic taxa included in the list. Among the newly described species is *Okeanomitos corallinicola*, a marine heterocyte-forming cyanobacterium isolated from coral reefs [16]. Remarkably, this species produces 13 classes of microcystins and exhibits cytotoxic activity against cancer cell lines. Another notable microcystin producer is *Aliinostoc bakau* [17], highlighting that microcystin production in marine environments may be more widespread than previously thought.

Recent updates also include newly described toxins and novel effects on other organisms. For example, *Aetokthonos hydrillicola* produces aetokthonotoxin (AETX), colloquially known as the “eagle toxin”, identified in 2021 as the causative agent of Avian Vacuolar Myelinopathy (AVM) in North American eagles [18]. Another notable class of toxic compounds are spumigins, protease inhibitors with pharmaceutical relevance, reported in 2015 from *Sphaerospermopsis torques-reginae*. Spumigin congeners are inhibitors of serine and cysteine proteases and may have applications in drug development.

Of the 19 cyanobacterial orders currently recognised, 10 include toxic species. The order with the highest proportion of toxic taxa is Nostocales (43%), followed by Oscillatoriales (20%), and Chroococcales (17%) (Fig. 3A). In terms of toxin prevalence, microcystins remain the most widely produced compounds, associated with 55 taxa. Saxitoxins and anatoxins follow, with 17 and 15 producers, respectively, occurring in both benthic and planktonic taxa. Other toxins include cylindrospermopsins (12 taxa), nodularins (10 taxa), β-N-methylamino-L-alanine (BMAA) (23 taxa), and its co-occurring isomers DAB and AEG. Less frequently reported toxins include spumigins (one taxon), guanitoxin (anatoxin-a(S)) (five taxa), homoanatoxin-a (four taxa), aplysiatoxins (three taxa), lyngbyatoxin (two taxa) and aetokthonotoxin (one taxon) (Fig. 3B).

Nevertheless, caution is warranted when interpreting toxin production in widespread species such as *Prochlorococcus marinus* (linked to BMAA) and *Pseudanabaena limnetica* (linked to anatoxin-a). These taxa are globally distributed in marine and freshwater environments, respectively, and their ecological roles—particularly that of *Prochlorococcus* as a globally dominant picocyanobacterium–strongly suggests that toxin production is strain-specific and/or context-dependent.

In conclusion, the description of new toxic cyanobacterial species and advances in cyanobacterial taxonomy demonstrate that the diversity of these microorganisms remains substantially under-described, and that their functional roles within ecosystems are still only partially understood.

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Harmful phytoplankton species recorded during a survey near the submarine outfall discharges of the Seaflower Biosphere Reserve

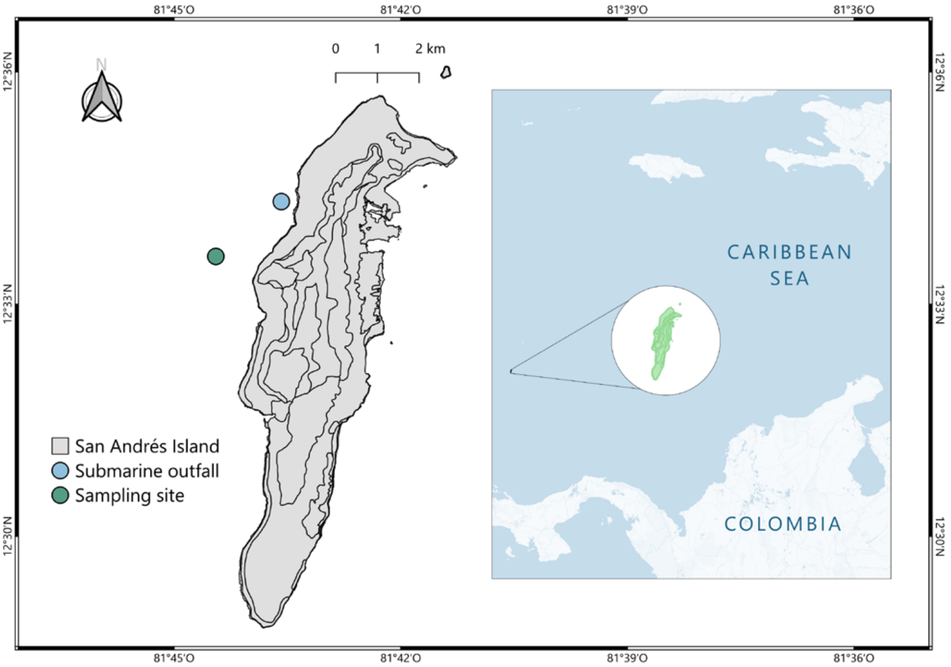

Fig. 1. San Andrés Island showing submarine outfall discharges and sampling site.

The island of San Andrés, located in the Colombian Caribbean, is part of the Seaflower Biosphere Reserve, which was designated by UNESCO in 2000. Due to its scenic beauty and high biodiversity, San Andrés is a major tourist attraction, receiving annually an estimated one million visitors of various nationalities, representing 60% of the island's GDP. However, the island is also characterized by its high vulnerability, being small (27 km^2), oceanic (110 km offshore), and densely populated (2,000 inhabitants/km^2) [1]. The island also faces extreme weather events such as Hurricane Iota, a Category 4 storm that struck the archipelago in November 2020 [2]. In addition, precarious management of natural resources is compromising the environmental quality of its ecosystems.

One measure adopted to improve domestic wastewater management — identified as one of the island's main sanitation problems — was the construction of a submarine outfall to collect domestic and hotel wastewater from the northern sector, the most densely populated part of the island, in 2007 (Fig. 1). The outfall discharges untreated wastewater at a depth of only 18 m [3]. After nearly two decades of operation, changes in water transparency and odor near the discharge point are evident.

To assess the potential effects of the submarine outfall on coastal waters of San Andrés Island, plankton sampling was conducted at three depths. Samples were collected in duplicate during the rainy season approximately 1 km offshore within the discharge zone. Surface samples were obtained using subsurface circular tows with a 20 µm mesh net. Samples from depths of 0, 10 and 20 m were collected using a 5 L Niskin bottle and subsequently concentrated by passing them through a 20 µm mesh net. All samples were fixed with 10% formalin and analyzed using an Olympus CK2 inverted phase contrast microscope, using the 40x objective. Results were compared with historical records from previous years and from different sampling locations around San Andrés.

Among the 62 morphotypes identified, five species and three genera are listed as toxic, and seven species and one genus as harmful, according to the IOC-UNESCO HAB Taxonomic Reference List of Harmful Microalgae [4]. Fifteen of these are new records for San Andrés (Table 1). Although plankton sampling does not allow a causal link to be established between outfall discharges and the presence of toxic and harmful non-toxic taxa, the detection of previously unreported species in a single survey is noteworthy.

Point-source discharge of wastewater from the outfall — serving roughly one-third of households in the island's northwest sector — has been associated with increased concentrations of total inorganic nitrogen in coastal waters. Adverse impacts on western reef systems, including coral diseases, proliferation of microalgae and sponges, and detection of the fecal indicator *Escherichia coli* in coral mucus, have been linked to exposure to wastewater from the outfall and other diffuse sources [5]. These findings highlight the need to re-establish a plankton monitoring program to improve early detection of HAB events. San Andrés is also notable for recurrent ciguatera cases [6], which are uncommon along the continental Caribbean coast of Colombia.

HAB events associated with coastal pollution not only pose risks to public health but also reduce the ecosystem and cultural services provided by the island. Because these impacts are not always apparent to decision-makers, dissemination of information should form part of an early warning strategy [7].

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Table 1. Potentially Toxic and Harmful Non-Toxic Species Reported from the Waters Surrounding San Andrés Island.

Type	Taxon name	Associated Toxins
Potentially Toxic	*Coolia malayensis* Leaw, P.-T.Lim & Usup, 2001	Yessotoxin analogues
	Gambierdiscus caribaeus Vandersea, Litaker, M.A.Faust, Kibler, W.C.Holland & P.A.Tester, 2009	44-methylgambierone, C-CTX5
	Lyngbya majuscula Harvey ex Gomont, 1892	Lyngbyatoxins, Debromoaplysiatoxin, Aplysiatoxin
	Prorocentrum concavum Y.Fukuyo, 1981	OA, OA diol ester, DTX-1, fast acting toxins (FAT)
	Prorocentrum hoffmannianum M.A.Faust, 1990	Okadaic acid, fast acting toxins (FAT)
	Coolia sp. Meunier, 1919	Yessotoxin analogues
	Phormidium sp. Kützing ex Gomont, 1892	Cyanotoxins
	Trichodesmium sp. Ehrenberg ex Gomont, 1892	Microcystins, Palytoxin (PLTX) and 42-OH-PLTX, Saxitoxins, CTX-like
Potentially Harmful non-toxic	*Coscinodiscus concinnus* W.Smith, 1856	
	Cylindrotheca closterium (Ehrenberg) Reimann & J.C.Lewin, 1964	
	Chaetoceros wighamii Brightwell, 1856	
	Protoperidinium depressum (Bailey, 1854) Balech, 1974	
	Tripos furca (Ehrenberg) F.Gómez, 2013	
	Tripos lineatus (Ehrenberg) F.Gómez, 2013	
	Tripos muelleri Bory de Saint-Vincent, 1826	
	Rhizosolenia sp. T. Brightwell, 1858	

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New Machine Learning-Based Tool, CyFi, Uses Sentinel-2 Imagery to Enable HAB Monitoring in Small Inland Water Bodies

Fig. 1. A series of satellite images contrasting sensor resolution — medium-resolution (Sentinel-2, 10 m, Right) imagery that can resolve small lakes vs coarse (Sentinel-3, 300 m, Left) imagery that cannot.

Current efforts to monitor harmful algal blooms (HABs) face a challenge: an entire class of water bodies we need to watch — small lakes, reservoirs, and rivers — are precisely where our tools are constrained. Chlorophyll estimates from Sentinel-3 satellite data have been used extensively in large lakes, coastal, and marine environments, but the spatial resolution (300 m) cannot resolve smaller inland waters of a few hundred acres (100 hectares) or less (Fig. 1). Conversely, traditional in-situ buoys, Imaging FlowCytobots, and manual field sample collection provide point-based precision, yet are limited in coverage and frequency by costs, logistics, staff and volunteer availability, and lab capacity. This gap in observational capability has left resource managers with incomplete situational awareness, especially in regions with thousands of small water bodies that have significant recreational, drinking water, and ecological value.

A new model for satellite-based wide area monitoring closes this gap. Cyanobacteria Finder (CyFi) is an open-source Python tool that combines medium-resolution (10–30m) Sentinel-2 satellite data with a computationally efficient tree-based machine learning model to infer cyanobacteria density and assign severity categories that align with WHO guidelines[1]. There is also support for optional imagery overlays via the CyFi Explorer, which visually contextualizes bloom extent around the point estimates in small water bodies (Fig. 2). CyFi's methodology has been published in the Proceedings of the Python in Science Conference[2], and the

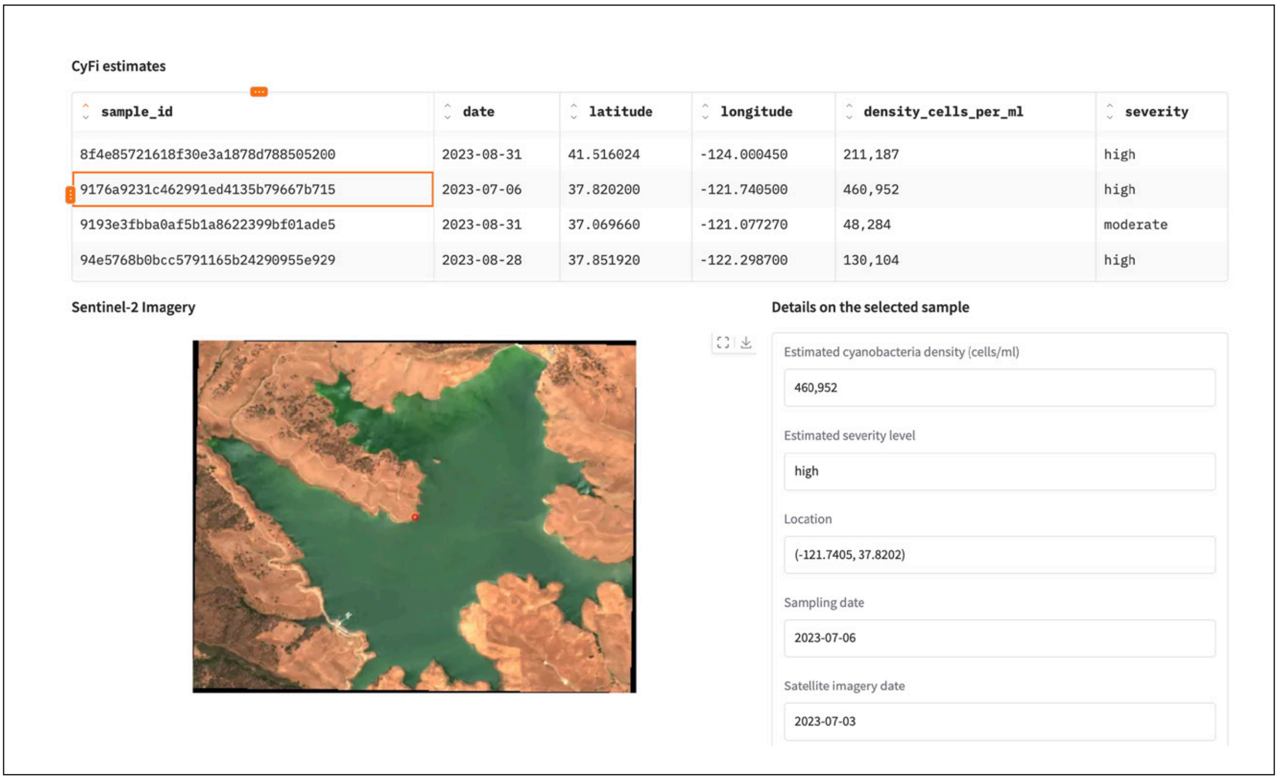

Fig. 2. Detection of HAB in a small lake in California, shown in the CyFi Explorer, which is a feature in the open-source CyFi package[3–4].

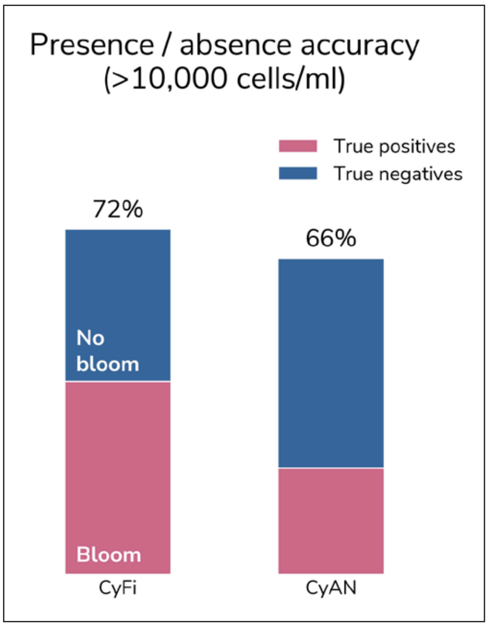

Fig. 3. A comparison chart showing CyFi vs. CyAN bloom detection accuracy in terms of true positives and true negatives for a test dataset covering 756 ground-sampled data points across the U.S. A true positive (bloom presence) is where cyanobacteria density > 10000 cells·mL^{-1}.

open-source software package is publicly available[3].

CyFi's development followed a replicable pattern of crowdsourced innovation, then experimentation, validation, and tool development. It began with an open machine learning competition — the *Tick Tick Bloom: Harmful Algal Bloom Detection* Challenge run by DrivenData and funded by NASA, with collaboration from NOAA, EPA, USGS, DOD's Defense Innovation Unit, Berkeley AI Research, and Microsoft AI for Earth. The community-driven phase (900 submissions from 115 teams) yielded practical methodologies that generalized across a wide range of inland environments. A subsequent model experimentation phase iterated on approaches from winning models and restructured the code into a robust, configurable, and runnable pipeline. In parallel, DrivenData conducted user interviews with water quality managers in several U.S. states. Insights from these interviews were used to align CyFi's design with decision-making workflows, ensuring its outputs were not only scientifically robust but also operationally useful. This development arc — from competition to practitioner feedback to a deployment-ready open-source package — helped to balance technical rigor with real-world utility.

The core innovation in CyFi is the way machine learning infers signals that the satellite itself cannot explicitly measure. Sentinel-2 lacks the narrow spectral bands that directly isolate cyanobacteria pigments such as phycocyanin, yet it provides imagery at spatial resolutions that can resolve smaller water bodies. For the competition, a novel dataset of over 23,000 in situ cyanobacteria measurements was compiled from the 48 contiguous U.S. states and is now publicly available through the NASA SeaBASS archive[5]. Through training, the CyFi model learned to translate combinations of broadband *reflectances into estimates of bloom severity*. When benchmarked against established tools like the Cyanobacteria Index (CyAN), developed for Sentinel-3 data (300 m resolution), CyFi achieves comparable presence/absence accuracy while covering an order of magnitude more water bodies by leveraging higher spatial-resolution imagery (Fig. 3).

The potential benefits of CyFi for a regional monitoring program include: adding spatio-temporal depth to HAB detections from field samples and monitoring buoys; extending the reach of monitoring systems by identifying blooms that are otherwise undetected because they fall outside the resolution, geographic area, or frequency of current sampling regimes; providing context that can be used to prioritize/optimize field sampling and the placement of in situ systems; and providing an extra level of regional HAB awareness that can be fed into dashboards and advisory systems.

Operationalizing tools like CyFi highlights challenges common to machine-learning systems. Model outputs may need adjustment for environments they have not been trained on; while training datasets are extensive, they may not be fully representative of local conditions. Accordingly, practitioners are advised to pair CyFi predictions with targeted ground-truthing to calibrate models for their region as part of the CyFi adoption process.

Advances in machine learning and remote sensing are steadily improving both spatial and temporal resolution of our observational systems, and each advance creates opportunities to improve environmental monitoring and decision-making. CyFi exemplifies this progression; its data-driven approach to HAB monitoring extends the observational reach to small inland water bodies while preserving rigor and relevance to water-quality management.

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Report from workshop on automated imaging of plankton in Oslo, Norway, 24–26 September 2025

Automated plankton analyses using imaging in-flow methods make it possible to acquire near real-time data on harmful algae that possess morphological features distinguishing them from other phytoplankton. Organisms smaller than 5–10 µm are currently not well detected using this approach. The high sampling frequency and quantitative near real-time output make the results particularly valuable for early detection of harmful algal blooms (HABs), thereby supporting timely mitigation of their impacts.

The *ICES-IOC Workshop on automated plankton analysis using imaging-in-flow methods* was held in Oslo, Norway, 24–26 September 2025. The workshop was a follow-up to a workshop held in Sweden in 2022 [1] which had a hands-on approach with demonstrations and instrument use. The main aims of the workshop in 2025 were to share experiences in using automated plankton imaging methods for observing harmful algae in near real time and to share best practices regarding the technology and data processing. In this note some of the activities during the workshop are reported.

A total of 37 participants representing 16 different nationalities took part in the workshop (Fig. 1). The workshop included oral presentations, posters and on-site demonstrations. One presentation was made online by Clarissa Anderson (USA) on the Harmful Algal Bloom Data Assembly Center: A national cyberinfrastructure framework for plankton imagery. Youngju Lee travelled from South Korea to participate in the workshop and to present a poster titled *Monitoring Phytoplankton Blooms in Polar Oceans Using Imaging FlowCytobot*.

There are currently at least three commercially available instruments widely used for automated imaging of harmful algae: 1) the Imaging FlowCytobot (IFCB, McLane Research Laboratories Inc.) [2, 3], 2) the CytoSense (CytoBuoy b.v) [4, 5] and 3) the FlowCam (Yokogawa Electric Corporation) [6, 7]. Advantages and disadvantages of the different instruments were discussed during the workshop but are outside the scope of this note.

Automated identification of organisms captured by cameras relies on supervised machine learning. Phytoplankton identifications experts, often referred to as taxonomists, examine large numbers of images to identify plankton, usually to species or genus level. The annotated images are used as training data. The sharing of training datasets was discussed and examples of available datasets were presented [8–13]. Methods for sharing and aggregating image data for global applications were presented by Raphael Kudela. A poster on the California IFCB Network: data sharing and scientific applications was presented by Kasia Kenitz. There is a trend towards using Convolutional Neural Networks (CNN) to automatically identify plankton at present [14], but the Random Forest method [3] is still used by many. CNNs were discussed in detail during the workshop.

Gary Groves demonstrated a data pipeline used in Scotland and the Shetland Islands including a method to identify and count individual cells in chain-forming organisms [15]. Ongoing work in the Western English Channel was presented by Claire Widdicombe and from the Eastern part by Felipe Artigas and Valentine Szrama. A demonstration of a data pipeline developed in Finland was presented by Kaisa Kraft [16]. A presentation on the use of pre-trained convolutional neural networks to recognize phytoplankton species at the Italian Acqua Alta Oceanographic Tower station in the Adriatic Sea was also given. Presentations and posters on research conducted in the Gulf of Naples were also shared. Anders Torstensson demonstrated how IFCB-data can be formatted in a standardised way, including the Darwin Core format, and submitted to data repositories such as GBIF, EMODnet and OBIS. A library for handling IFCB data in the software R is available [16]. Michael Brosnahan demonstrated shipboard deployments using PhytO-ARM and IFCB Data Sharer.

Workshop participants shared ideas, results and computer code. Computer code for working with data from the IFCB is available at GitHub, for example in the repository of the European IFCB network (Fig. 2) [18] (*https://github.com/EuropeanIFCBGroup*, and repositories for Woods Hole Oceanographic Institution by Heidi Sosik, Michael Brosnahan and others, e.g. *https://github.com/hsosik/ifcb-analysis* and *https://github.com/WHOIGit/whoi-hab-hub*).

Sophie Clayton presented a draft of an *Operational Phytoplankton Observations Best Practices Guide* [19]. The workshop ended with demonstrations of the AquSens plankton imager [20] by Holly Bowers and of the PlanktoScope [21], by Thibaut Pollina (Fig. 3). The PlanktoScope is a low-cost instrument

Fig. 1. Group photo of workshop participants. A few people are missing from the photo.

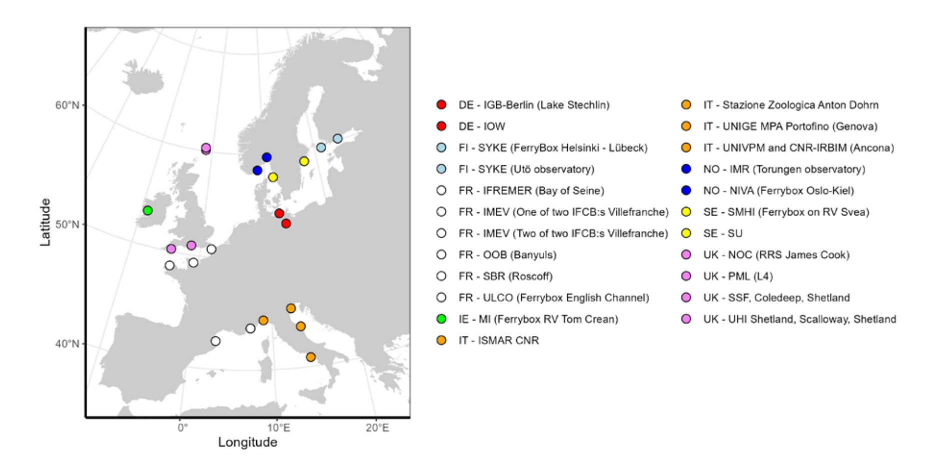

Fig. 2. Map showing institutes or universities in Europe using the Imaging FlowCytobot (updated in December 2025). Some of the systems are operated in situ while others are operated on piers or in ships with pumps supplying sample water. At least one system is used with an automated winch to facilitate sampling at different depths. Sampling frequency is usually approximately every 25 minutes.

that can be built by users. It is suitable for semi-quantitative analyses or detection of zooplankton and large phytoplankton including some harmful algae.

Acknowledgements

The workshop was hosted by the University of Oslo and the Norwegian Institute for Water Research (NIVA) at the Natural History Museum in Oslo. Co-convenors were Bengt Karlson (Sweden) and Wenche Eikrem (Norway). The Scientific Steering Committee consisted of Bengt Karlson (Sweden), Michael Brosnahan, USA, Dave Clarke (Ireland), Raphael Kudela (USA), and Wenche Eikrem (Norway). Co-organisers were the IOC-FAO IPHAB Task Team on the early detection, warning and forecasting of harmful algal events, the ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD), the European IFCB user network and the Nordic Marine Phytoplankton group. The IOC provided support for workshop lunches and travel grants for approximately ten early-career ocean professionals.

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Fig. 3. The PlanktoScope was demonstrated by Thibault Pollina (seated) during the workshop.

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Formation of ANZ HABNET in response to an unprecedented HAB in South Australia, 2025–2026

The catastrophic South Australian *Karenia cristata* marine mass mortality and biotoxin event, first detected in March 2025 and ongoing, highlighted the importance of strengthening national coordination of harmful algal research and risk management, and demonstrated the need for a unified, knowledgeable voice to inform response planning and public communication (full details on the South Australian HAB taxonomy and toxicology will appear in the next HAN issue. See also Murray et al. (in revision) [3]).

In response, the Australian and New Zealand Marine Harmful Algal Bloom Network (ANZ HABNET) was established in July 2025. Our aim is to strengthen capability and connectivity across the field and to support the dissemination of information on marine Harmful Algal Blooms (HABs), ensuring that relevant, expert knowledge informs both current and future HAB events. The network will also promote training opportunities, conferences, workshops, and the exchange of relevant local and international research advances.

Current membership (239) spans all Australian states and territories and New Zealand, and includes representatives from government agencies, academic institutions, industry bodies, and citizen scientists. Collectively, members bring expertise across the full spectrum of marine HAB science and management, from monitoring, regulation, and seafood safety to chemistry, ecology, modelling, genetics, and species identification. The collaboration between Australian and New Zealand representatives in bringing together this collective knowledge is especially powerful and will allow us to address common issues across both countries. This network is powered by the voluntary contributions of its members and will actively pursue funding opportunities to support long-term sustainability and growth as an organisation.

The interim ANZ HABNET committee of Christopher Bolch, Steve Brett, Ruth Eriksen, Hazel Farrell, Gustaaf Hallegraeff, Tamsyne Smith-Harding, Tim Harwood, Michaela Larsson, Shauna Murray, Kirsty Smith, and Alison Turnbull has been highly active. Since inception, we have contributed to a Commonwealth Senate Inquiry [1] on the South Australian bloom, produced a public website [2] for information, and conducted a HAB identification, molecular detection, and quantification training course over four days, followed by a Marine Harmful Algal Symposium.

Fig. 1. Attendees at the Australia New Zealand Harmful Algal Bloom Network Workshop.

The four-day course brought together experts from across Australia and New Zealand to share knowledge and best practices for detecting, identifying, and quantifying HABs. The event was hosted by the University of Technology Sydney in their state-of-the-art teaching laboratories in December 2025. The first two days focused on microscopic identification of harmful algae, covering toxic and non-toxic species known to have caused food safety, environmental, or human health issues. Students were encouraged to bring their own samples, which were supplemented by personal research collections and material from the CSIRO Australian National Algae Culture Collection. The following two days focused on molecular identification, with a mix of hands-on practicals and bioinformatics training. Thirteen scientific experts (Shauna Murray, Gustaaf Hallegraeff, Steve Brett, Chris Bolch, Kirsty Smith, Greta Gaiani, Mark van Asten, Ruth Eriksen, Tamsyne Smith-Harding, Kiralee Baker, Michaela Larsson, Cheong Xin Chan, Nansheng Chen) volunteered their time to teach the course, which was attended by 35 participants representing government agencies, researchers, students, citizen scientists, and the seafood industry from around Australia.

The training concluded with a one-day symposium, which brought together 180 leading researchers, managers, and citizen scientists either in person or online to share insights into the science and management of the recent South Australian HAB event. The day opened with an overview of the extensive scientific effort undertaken to identify and track the causative algae and associated toxins, along with updates on the ongoing investigative work. The pivotal role of citizen science in the devastating and highly publicised event was highlighted, as were the outstanding questions, particularly around toxic mechanisms. Virtual appearances by U.S. scientists Professors Cynthia Heil and Barbara Kirkpatrick detailing the experience in Florida were key highlights of the day.

Fig. 2. Prof Gustaaf Hallegraeff (A) and Dr Ruth Eriksen (B) teaching into the workshop at the University of Technology, Sydney.

The symposium also marked the announcement of the inaugural winner of the ANZHABNET prize for HAB research and management, awarded to Clinton Wilkinson of Primary Industry and Regions South Australia in recognition of his leadership in initiating investigation of brevetoxins and managing bivalve shellfish safety during the HAB event. Overall, the symposium provided a valuable platform for collaboration and knowledge exchange, reinforcing the importance of integrated, cross-sector approaches to HAB monitoring and response.

"I found the HAB workshop was an excellent opportunity for networking. It brought together professionals and academics from diverse backgrounds related to Harmful Algal Blooms, which provided a rich learning experience."(Aisling Brenan, Natural Resources and Environment Tasmania).

The ANZHABNET is now progressing toward incorporation status, establishing a formal governance framework that will ensure the longevity and impact of this important new initiative. Through this structure, we aim to build capability across Australia and New Zealand, fostering emerging expertise and encouraging both nations to develop policies, guidelines, and research programs that enable more proactive responses to future HAB events.

Acknowledgements

We are grateful to the Commonwealth Government of Australia and the Australian seafood industry for sponsorship of the workshop and symposium through SafeFish, FRDC Project 2024-046.

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Fig. 3. Presenting the inaugural ANZHABNET prize for HAB research and management, awarded to Clinton Wilkinson.

MedHab members meet at the Technical Workshop on One Health in the Mediterranean

The Mediterranean region faces multiple serious and interconnected challenges–including climate change, pollution, and biodiversity loss– that reflect the global "triple crisis" and have major implications for human health and well-being. The One Health approach—promoted globally through the Quadripartite One Health Joint Plan of Action (2022–2026) led by the World Health Organization (WHO), Food and Agriculture Organization (FAO), World Organisation for Animal Health (WOAH), and United Nations Environment Programme (UNEP), and reflected in the UNEP/MAP Medium-Term Strategy 2022–2027—provides a framework to address these challenges in an integrated manner, linking human, animal, and ecosystem health.

In the Mediterranean, many initiatives already exist at national and regional levels, but they often remain fragmented, with limited coordination across sectors and countries. Strengthening synergies between existing frameworks, improving regional cooperation on data sharing and indicators, and enhancing early-warning systems are key priorities, together with better alignment between science, policy, and practice to increase resilience. In response, a two-day technical workshop titled "*Understanding and Measuring the One Health Nexus in the Mediterranean*" was held on October 2–3, 2025, at IMREDD, Université Côte d'Azur (Nice, France). The event was co-organized and funded by Plan Bleu – Regional Activity Center of UNEP/MAP and Université Côte d'Azur (project UCAJEDI). The workshop brought together around forty scientists, experts, and students from across the Mediterranean basin—representing Egypt, Tunisia, Croatia, Greece, Italy, Monaco, France, and Spain—to share insights and exchange ideas through presentations and interactive group sessions aimed at understanding current progress and define future pathways for a more effective One Health approach in the region.

This event marked the first ever in-person meeting of the Mediterranean Network of Harmful Algal Bloom Experts (MedHAB), which had convened only online since its creation in June 2024. Bringing together fifteen MedHAB members (Fig. 1), the meeting placed harmful algal blooms and biotoxins within a broader multi-hazard and One Health perspective, emphasizing their links with human, animal, and ecosystem health.

During the workshop, participants explored four categories of hazards—chemical, biological, environmental, and geohazards—through interactive working groups (Fig. 2) examining their cascading risks across marine and coastal systems With the participation of MedHAB members, particular attention was given to harmful algal blooms, which represent a complex interaction of hazard types through toxin production, algal proliferation, and ecosystem impacts such as hypoxia—while also being influenced by hydrological, pollution and climate-related stressors.

The workshop also fostered exchanges between professionals and early-career researchers, including students from the MSc Environmental Hazards and Risks Management (*MSc RISKS*) at Université Côte d'Azur.

By bringing together participants from both northern and southern Mediterranean countries, the event underscored the importance of regional cooperation in addressing shared environmental and health challenges. Through a live Slido poll, participants identified several top priorities to strengthen the One Health approach in the Mediterranean, including improving coordination and cooperation across sectors and borders, enhancing communication and awareness among stakeholders and the public, strengthening systems thinking, and educating medical professionals on environmental-health linkages.

The exchange of expertise and experiences marks just the beginning, paving the way for continued dialogue,

Fig. 1. The attending members of the MedHAB network (IMREDD, Nice, France). From left to right: Mohammed Kuhail (student), Sahil Makkar (student), Rachel Clausing, Antoine Lafitte, Margarita Fernandez, Haifa Achouri, Nikita Rose, Daniela Maric Pfannkuchen, Marie-Yasmine Bottein, Guillaume Barnouin, Ana Baricevic (in the back), Panagiota Katikou (in the front), Ismael Amany, Nathalie Hilmi, Adriana Zingone, Stefano Accoroni.

Fig. 2. Examples of working groups exploring hazard categories during the workshop: the biological hazards working group is shown at the top (A), and the chemical hazards working group at the bottom (B).

joint reports and outreach documents, and collective action to bridge gaps across disciplines, hazards, stakeholder groups, and countries. Building on this momentum, a report exploring the application of the One Health approach in the Mediterranean, with a specific focus on marine and coastal environments, was published by Plan Bleu (2026). Participants also intend to develop a joint opinion paper to further disseminate the key outcomes and recommendations.

The MedHAB network holds online meetings every other month and welcomes anyone interested in contributing. For participation or inquiries, please contact marie-yasmine.bottein@univ-cotedazur.fr.

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Call for Editor(s)-in-Chief for the Next Global HAB Status Report

Harmful algal blooms (HABs) are constantly evolving in distribution, frequency, and impacts, affecting ecosystems, public health, food security, and coastal economies worldwide. In scientific literature, it is frequently suggested that HABs are increasing globally, often in connection with climate change, yet robust evidence for a consistent, global-scale increase is limited.]The first Global Harmful Algal Bloom Status Report [1] (Figure 1), published in 2021 by the Intergovernmental Oceanographic Commission of UNESCO (IOC) in collaboration with ICES, PICES, IAEA, and ISSHA, examined exactly this question. Although regional changes were identified, no global trend could be demonstrated.

The first GHSR, led by Gustaaf Hallegraef and Adriana Zingone, represented a major milestone for the HAB community. For the first time, a coordinated global effort was able to combine regional expertise with systematically compiled event records to provide a transparent, data-informed appraisal of HAB occurrence and impacts at the planetary scale. The report showed the geographic heterogeneity in HAB occurrence, highlighted important data gaps, and established a baseline against which future assessments can be developed. Equally importantly, it demonstrated the value of sustained collaboration under the framework of the IOC-FAO Intergovernmental Panel on Harmful Algal Blooms (IPHAB). Now, the time has come to develop the next GHSR.

The Harmful Algae Event Database (HAEDAT), together with the HAB node of the Ocean Biodiversity Information System (OBIS) and the IOC Taxonomic Reference List of Harmful Microalgae, formed the backbone of the first GHSR. Established more than 25 years ago, HAEDAT has been instrumental in accruing sufficient data to perform a global assessment. Leading up to the publication of the first GHSR, a concerted push was made to enhance the available data resolution by organizing several workshops focused on data entry into HAEDAT. Currently, HAEDAT is undergoing an update (completed with generous funding from NORAD/Norway) that will bring this crucial resource back in line with modern website and database architecture.

The HAEDAT update is nearing completion (Figure 2), and its relaunch will be accompanied by efforts to strengthen national editorial engagement and data reporting. These efforts will directly support the next GHSR's. During an online session of IPHAB Task Teams, held on 24–25 February 2026, the first steps were taken to begin the preparation of the next phase of the GHSR. Two complementary products are foreseen. An interim thematic GHSR will be prepared for publication in 2027, followed by a fully revised global assessment to be released in 2030, coinciding with the end of the UN Decade of Ocean Science for Sustainable Development.

The 2027 GHSR will focus on local and regional trends that are either new or were not addressed in the 2021 assessment, highlighting developments of global relevance emerging in certain regions. Examples include the expansion of *Gambierdiscus* spp. beyond the Pacific and Caribbean regions, the spread of *Ostreopsis* blooms along the French Atlantic coast, the increasing presence of *Alexandrium catenella* in Alaskan Arctic ecosystems, and the exceptional bloom of *Karenia cristata* in South Australia. These are only a few tentative examples of recent events that illustrate how local developments signal broader shifts in HAB dynamics and impacts. The final thematic focus of the next GHSR will be co-designed by members of IPHAB and the Editor(s)-in-Chief of the next GHSR.

The IPHAB Task Team now invites nominations, including self-nominations, for the appointment of one or

Fig. 1. Cover page of the first Global HAB Status Report.

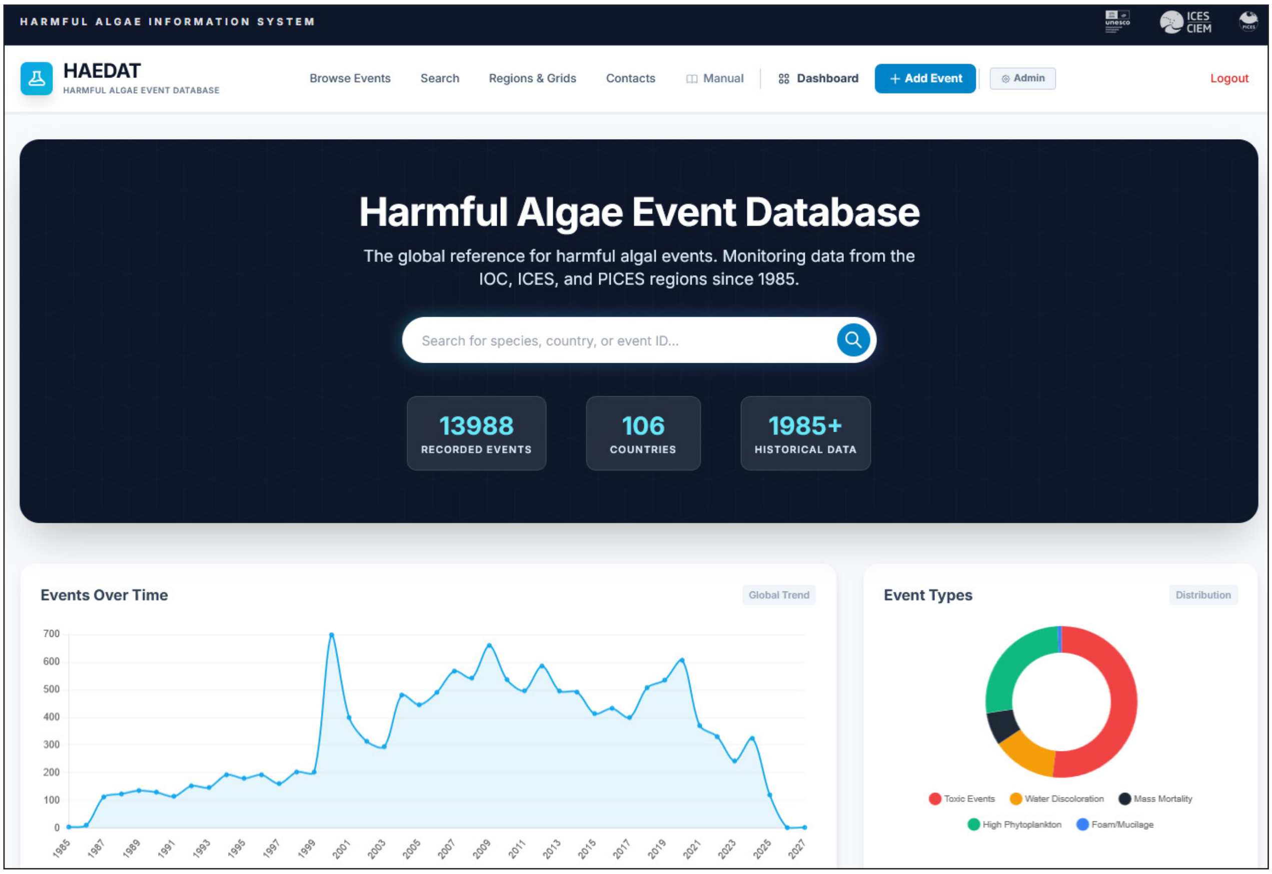

Fig. 2. Landing page of the renewed Harmful Algae Event Database.

more Editor(s)-in-Chief to lead the preparation of the upcoming GHSR. The Editor(s)-in-Chief will define the scientific scope, coordinate contributing authors and regional inputs, oversee the integration and analysis of HAEDAT and related HAIS datasets, and ensure that interpretations and conclusions are grounded in the available evidence. Close collaboration with all IPHAB Task Teams, regional HAB networks, and the IPHAB Secretariat will be integral to this role.

Given the scale and visibility of the GHSR, we seek candidates with extensive experience in HAB research and experience working across institutions, regions, and networks. The role requires the ability to foster a collaborative and inclusive data aggregation process, a commitment to balance and community representation, and the personal and institutional capacity to dedicate substantial time over the coming years. The position is undertaken as a service to the international HAB community and is therefore pro bono.

Candidates may express interest through three complementary routes: 1) nomination by the Chairs of IPHAB Task Teams and regional groups; 2) self-nomination following this call in Harmful Algae News; 3) in response to direct invitation to self-nominate from the IPHAB Task Team. The deadline for receipt of nominations is 15 May 2026. Interested candidates are invited to contact me (*maarten.derijcke@vliz.be*) for further information and to submit nominations.

Applications should include a brief statement of interest, a curriculum vitae, and an outline of the candidate's vision for the 2027 interim report and the subsequent 2030 revision. The Editor-in-Chief will be selected by a committee composed of the Chairs of the Task Team, the Chairs of IPHAB, and the IPHAB Secretariat.

The Global HAB Status Report is a collective endeavor. Its strength lies in the willingness of the international community to share data, expertise, and perspectives across regions and disciplines. With the 2027 thematic assessment and the 2030 global revision, IPHAB reaffirms its commitment to providing authoritative, data-driven syntheses that support science, management, and policy in a rapidly changing ocean.

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IOC Courses 2026

IRTA-IOC Science and Communication Centre on Harmful Algae International Phytoplankton Intercomparison (IPI) test 2026

Registration open until 31 March 2026

Annually from January to January, IRTA in collaboration with the IOC Science and Communication Centre on Harmful Algae will conduct a proficiency test on marine phytoplankton abundance and composition amongst laboratories.

The IPI proficiency testing scheme is open for participation to all relevant laboratories globally. This test is divided into two main competency areas and each participant must complete them both to obtain the required certification:

Taxonomical knowledge – in the form of a "Taxonomic assessment", This test will be set up on the IOC distant learning web platform called 'OceanTeacher'. Participants will need to log on with a username and password and answer the questions online.

Sample Abundance and Composition – a number of samples inoculated with known quantities of a mixture of phytoplankton species or/and natural field samples will be sent to each laboratory. The number and type of samples will be adapted to be relevant to the participants each year. Information about the programme and logistics in *https://hab.ioc-unesco.org/ipi-exercise/*

The Institute of Agrifood Research and Technology (IRTA, Spain), in collaboration with the IOC Science and Communication Centre for Harmful Algae, Denmark, is organizing the International Phytoplankton Intercomparison 2026. ***Registration open until the 31st of March 2026*** in: *https://otga.wufoo.com/forms/m1sf4rew165zqw7/*

IOC Identification Qualification in Harmful Marine Microalgae 2026

Registration open until 15 June 2026

Since 1993 the IOC has conducted training courses on harmful microalgae. The purpose has been to improve the taxonomic and identification skills of the participants for research purposes and for practical monitoring of harmful algal blooms.

From 2006 the IOC training in HAB identification has been offered within a new framework which gives accreditation. The present course includes now a practical exam at the end of the course with an ***IOC Certificate of Proficiency in Identification of Harmful Algae*** issued to participants who pass the exam. The IOC courses have become a reference for laboratories to be approved for carrying out regulatory monitoring for harmful microalgae.

The IOC Science and Communication Centre on Harmful Algae, University of Copenhagen, Denmark is organizing the 2026 course.

The course includes 100 hours of teaching and is divided into two parts. 1) The first part of the course is an internet teaching programme on the Ocean Teacher platform giving general introductions to the various groups of harmful algae; this part is mainly for self-study and estimated to 40 hours of reading. 2) The second part is a practical course in species identification. Part 2 includes 60 hours of teaching and a microscope will be available to each participant during the entire period.

The course is aimed at participants who have some years of practical experience in identification of microalgae. The number of participants is limited to 16. If there are more applicants than available seats, priority will be given to applicants who have direct research or management responsibilities with regard to the occurrence of harmful algae.

Dates: Part 1 will be available on the 'International Oceanographic Data Exchange' (IODE) teaching platform 'Ocean Teacher' from August onwards; part 2 takes place from 12-24 October 2026.

Venue (Part 2): IOC Science and Communication Centre on Harmful Algae, Department of Biology, University of Copenhagen, Denmark, c/o Danhostel, Lejrskolevej 4, 3400 Hillerød.

Application: Deadline for application is 15 May 2026, see link to application form below.

Language: English.

Course lecturers: Dr. Santiago Fraga, Dr. Jacob Larsen, Dr. Nina Lundholm, Professor Øjvind Moestrup.

Enquiries may be sent to Jacob Larsen, *jacobl@bio.ku.dk*.

Information on the programme, registration, and logistics: *https://hab.ioc-unesco.org/training-course-announcements-copenhagen*.

Forthcoming Events

13th International Conference on Modern and Fossil Dinoflagellates (5–10 July, 2026, Bremen, Germany) is now open for registration

Karin Zonneveld, Francesca Sangiorgi, and the scientific committee of the “Dino 13” conference are honoured to invite you to Bremen to exchange knowledge on dinoflagellates and their cysts through scientific talks, forum discussions, workshops, and poster sessions at the MARUM – Zentrum für Tiefseeforschung.

The "Dino" conferences have a long tradition of bringing together scientists from all disciplines who investigate dinoflagellates and their cysts. These conferences aim to exchange the most recent knowledge on all aspects of dinoflagellate research, spanning from the earliest known dinoflagellates to modern assemblages. This includes investigations of, for example, (harmful) dinoflagellate blooms, the ecology of modern and ancient dinoflagellates; naturally and anthropogenically induced transport and distribution of dinoflagellates and their cysts in modern and past environments; life cycles; life strategies; dinoflagellate evolution and that of their ancestors; the use of modern techniques to characterize species; as well as the characteristics and (palaeo-)environmental information incorporated in the molecular fingerprint of their cell and cyst walls.

Details about the conference, registration, abstract submission, accommodation and side program can be found at: *https://www.marum.de/en/13th-International-Conference-on-Modern-and-Fossil-Dinoflagellates.html*

International Conference on Molluscan Shellfish Safety (ICMSS)

This is to announce that ICMSS 2026 registration is open at www.icmss.net with Early Bird Registration available until the end of March, with 175 days to go until the main event. This is to be held in the lovely historical City of **Exeter, SW England, UK, 6-11 September, 2026** and hosted by Cefas.

The theme of this year's event is "One Health" and there will be a large focus in the scientific sessions on HABs, toxins, viruses, bacteria, industry and innovation and water quality. There will also be a series of practical workshops, poster sessions and multiple opportunities for networking with a wide range of visiting international scientists and policy makers.

The website contains all the information you need for registration, abstract submission, committee information, venue, travel, accommodation and the social programme.

- Register Now - this is on the main Home Page - takes you through to the University of Exeter Webshop site, where you can register, select social excursion option and then pay - as well as select diet requirements, attendance at the Ice breaker on the Sunday, select Gala dinner menu choices and so on.
- Abstract submission is live, which takes you through a designated and highly effective Oxford abstract submission process. There are options to select Oral or Poster presentations.
- Key note speakers are all in place, and will provide a fantastic introduction to each of the major sessions.
- Significant discounts are available for students and LMIC attendees
- Travel info is updated and full of info for those of you travelling to Exeter.
- Accommodation - links to multiple options for participants to select.
- All info on social excursions are described with photos - and there are some great ones we promise.

Any questions - feel free to email us on *hello@icmss.net*

Best wishes
The Local Organising Committee

Contact person:
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Professor F.J.R. ("Max") Taylor (1939 – 2026)

Max Taylor in Sherkin Island, 1987. Photo S. Fraga

We are deeply saddened to report the passing of Prof F.J.R. (Max) Max Taylor, who died on 18 February 2026. Max was a pioneering figure in harmful algal research and one of the most influential protistologists of his generation, whose work laid essential foundations for modern dinoflagellate taxonomy, systematics, and ecology. Over a long and distinguished career, he contributed profoundly to our understanding of the diversity, life histories, and evolutionary relationships of marine microalgae, and played a central role in shaping the development of harmful algal bloom research at the international level. He was also a dedicated mentor and collaborator, generously supporting colleagues and inspiring many students and early-career researchers who continue to build on his legacy. His scientific contributions, clarity of thought, and commitment to advancing the field have left a lasting imprint on the community. A full tribute to his life and work will follow in a forthcoming issue of Harmful Algae News.

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