# ICES-IOC Working Group on Harmful Algal Bloom Dynamics

## Summary Activity Report 2023-2025

IPHAB XVII Meeting 18th -20th March 2025

Prepared and submitted by WGHABD Chairs:

Dave Clarke (Ireland) and Lars Johan Naustvoll (Norway)

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**Executive Summary**

This report summarises the activities of the joint sponsored ICES-IOC Working Group activities for presentation and review at IPHAB XVII meeting, Paris, France 18th – 20th March 2025, and presents an overview of the preceding Terms of Reference (ToR) cycles for the periods 2021-2023 (ICES Resolutions Report) and the current cycle 2024-206 (ICES Resolutions and interim E-evaluation 2024 meeting report).

In 2024, the joint ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) held its annual meeting at the French Research Institute for Exploitation of the Sea (IFREMER), Nantes, France, both in-person and remote access format, from 16th to 18th April 2024, where a combined total of 35 participants attended over the three days. For the new three-year cycle (2024-2026), this Working Group is co-chaired by Dave Clarke, Ireland and Lars Johan Naustvoll, Norway. This meeting and its participants focused its discussions, presentations and progress which are directly linked to the previously agreed current cycle's Terms of Reference (ToR) descriptors which detail the ToR descriptor background, its expected duration, and expected Year 1 deliverables as detailed and approved in the ICES document WGHABD Terms of Resolutions 2024-2026 (page 11) and also in accordance with the described Year 1 summary of the identified work plan.

There was a number of additional presentations from chair invited guests to this meeting which covered a range of relevant topic areas to the Working Group including *Lingulaulax polyedra* blooms along the French Atlantic coast; update on Remote sensing tools and applications; new tools for investigating relationships between HAB and mixotrophy; AI for HABs, an early warning system; and updates from our joint co-sponsor IOC-UNESCO on Toxins database; HAB-Solutions (UN Decade of Ocean Science approved project) and update on GlobalHAB Scientific Steering Committee activities and outputs. New funded project on *Ostreopsis* – Ostreabila was also presented.

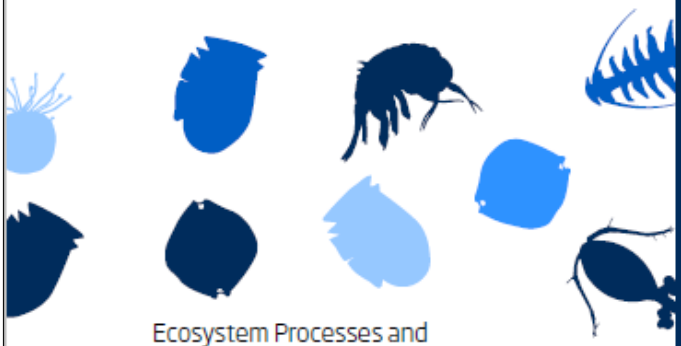
Additional WGHABD group summary outputs for 2023 – 2025 period include:

- Jointly convened Theme Session F 'Integration of molecular tools for biodiversity, risk assessment, ecosystem advice within a changing climate' Sept 2023 ICES ASC, Bilbao, Spain
- WGHABD poster (page 3) which was promoted in Sept 2024 at ICES ASC, Gateshead, UK.
- Joint convenor for Theme Session E 'From climate to microorganisms and fish: What can long-term time series tell us?' Sept 2025 at ICES ASC, Lithuania
- Current collaborative work with WG PME (Phytoplankton and Microbial Ecology) group on 'ICES Cooperative Research Report on phytoplankton and microbial trends in the North Atlantic: an update from 2012-2022'.
- Actively participate in ICES WG meetings (i.e. WGCHAIRS) and with EPDSG (Ecosystem Process Dynamics Steering Group
- ICHA 2023 workshop on HAEDAT & HAIS – 'The Power of Big Data for HAB Risk assessment and predicting HAB futures'
- In preparation - ICES Cooperative Research Report on HAEDAT metadata and ICES Scientific Report on WGHABD 2021-2023
- Upcoming annual WGHABD Meeting at Swedish Meteorological & Hydrological Institute (SMHI), Gothenburg, Sweden 8th – 10th April 2025

ICES CIEM
unesco Intergovernmental Oceanographic Commission

# WGHABD

## Working Group on Harmful Algal Bloom Dynamics



Ecosystem Processes and Dynamics Steering Group (EPDSG)

## OUR OBJECTIVE

WGHABD is an important forum for ICES and IOC-UNESCO to review and discuss HAB events and to provide annual advice and updates on the state of HABs in the region. The aim of the working group is to outline the various physical, chemical and biological interactions associated with harmful algal blooms (HAB) and to define the main gaps in research.

## OUR EXPERTISE

Our WG expert group members cover multiple areas of HAB science, monitoring and research including oceanographic, biological, ecological, molecular and modelling processes which all influence the dynamics of HABs and their subsequent impacts on marine ecosystems.
Through this established forum, we identify and discuss the various approaches and challenges to HAB research and monitoring.

## RESEARCH FOCUS

- Collect information about harmful algal events in the ICES area. This information is stored in a joint IOC-ICES-PICES database, HAEDAT, which is a part of the IOC International Ocean Data exchange (IODE).
- Deliver and discuss annual National reports and new findings on HAB events and bloom dynamics.
- Early Warning Systems for HAB forecasting
- Frequency of HAB distribution and impacts on plankton communities in a changing climate
- Produce protocols and guidelines for qPCR methodologies for the study and monitoring of HAB species using eDNA.

## OUR CHAIRS

Dave Clarke

Lars Johan Naustvoll

Scan and learn more about our work

**ICES-IOC WGHABD poster presented at ICES Annual Science Conference in 2024**

## Resolutions WGHABD Terms of Reference 2021-2023 Cycle

**2020/FT/EPDSG04** The ICES-IOC Working Group on Harmful Algal Bloom Dynamics, chaired by Dave Clarke, Ireland, will work on ToRs and generate deliverables as listed in the Table below.

| | Meeting dates | Venue | Reporting details | Comments (change in Chair, etc.) |
|---|---|---|---|---|
| Year 2021 | 20–23 April | Online meeting | Interim e-evaluation | |
| Year 2022 | 14–17 June | Weymouth, UK | Interim e-evaluation | |
| Year 2023 | 20-24 March | Stazione Zoologica, Naples, Italy | Final report by 1 May to SCICOM | |

### ToR descriptors

ICES-IOC WGHABD had a long discussion at the beginning of the 2020 meeting about developing a new suite of ToRs for the coming reporting cycle and how they would align with the UN Decade of Ocean Science for Sustainable Development. ToR h has been developed in the context of this longer-term view.

| ToR | Description | Background | Science Plan Codes | Duration | Expected Deliverables |
|---|---|---|---|---|---|
| a | Deliver National Reports on harmful algal events and bloom dynamics for the years 2020, 2021 and 2022. | HAB events may affect human activities and marine ecosystems at different levels. Understanding can best be achieved by integrating multiyear data sets. This links to ICES Science Priorities *Ecosystem Science, Seafood Production, Conservation and Management Science.* | 1.3, 5.6, 6.5 | Year 1,2,3 | Yr 1-3 Summary of national reports in Annex in WGHABD annual scientific report. These will also support events reported in ICES-PICES-IOC HAEDAT database and annual HAEDAT maps that will be used. |
| b | Progress in the discovery of climate-driven changes in the distribution of planktonic and benthic HAB taxa (incl. cyanobacteria) will be reported by the WG members. In addition, the WG will have a yearly thematic focus on specific HAB topics in relation to climate change to improve | The effects of climate change on HABs is an area of interest due to potential negative impacts on the ecosystem and ecosystem services. The changing distributions of HAB species in the Arctic and increasing records of impacts from benthic HABs in Europe create unique | 1.3, 5.6, 6.5 | Year 1,2,3 | Yr 1: Update WG on the emerging issues with *Gambierdiscus*spp. and Ciguatera Fish Poisoning with a focus on environmental influences including climate. Report on the findings of CoClime project related to benthic HABs such as*Ostreopsis* spp and relevant activities |

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| | our foresight and engage more scientists during the reporting period 2021-2023.<br>Yr1: Climate-driven changes in benthic HABs<br>Yr2: HABs in the Arctic environment<br>Yr3: Hindcasting the past to understand the future | challenges and opportunities to study HAB dynamics in relation to climate change. New approaches have also been developed focusing on the sediment archive to understand the dynamics of HABs in the past. When merged with Earth System models, the ecological knowledge gained from these activities to improve our seasonal to decadal forecasting capabilities. This ToR links to Science Priorities *Ecosystem Science*, *Seafood Production*, *Conservation and Management Science* and will link to future ICES Science and advisory activities focussing on Climate Change and Arctic science. | | | under GlobalHAB.<br>Yr 2: Report new discoveries on the diversit and distribution of HABs ir the Arctic, with particular attention to fjord regions and their coastal resource and climate drivers that steer the community dynamics of functional groups in the Arctic.<br>Yr 3: Review the potential of sedimentary DNA and ancient DNA to study past HAB dynamics and search for commonalities with sedimentary cyanobacteri HAB reconstructions. |
| c | The ICES-PICES-IOC harmful algal event database (HAEDAT) will be updated by delegates on an annual basis. HAEDAT can be used to produce 'products' such as spatial descriptions of harmful algal events in the ICES area. Examples include maps of incidence of management actions associated with toxicity and/or mortalities which can be fed into ICES Ecosystem Overviews that can be updated annually or as required. The processes of using HAEDAT during the production of the IOC Global HAB report will be reviewed. The feasibility of compiling a parallel dataset of phytoplankton and toxicity data from selected stations in the ICES area as a supplement to event data and to build time series of HAB and toxicity occurrences will be investigated. | The ICES-PICES-IOC database plays a key role in the production of the first ICES Harmful Algal Event Status Report and remains an important source information about the global distribution of Harmful Algal Events. This will continue to be updated so that the ICES area can contribute to future HAB reporting initiatives such as updates to the IOC Global HAB Status Report, OSPAR assessments and more. This ToR links to Science Priorities Ecosystem Science, Seafood Production, Conservation and Management Science as well as contributing to the 'Safe Ocean' objectives of the UN Decade for Ocean Science for Sustainable Development. | 1.3, 5.6, 6.5 | Year 1,2,3 | Yr 1-3 Delegates update HAEDAT. Liase with IOC about HAEDAT as required.<br><br>Yr 1 Entry forms reviewed, particularly in relation to fish mortalities, and recommendations passed to IOC.<br><br>Yr 2 Identify time-series of phytoplankton counts and toxin concentrations and products to be generated.<br><br>Yr 3 Review of reporting products from HAEDAT and time series datasets. Presentation at ICHA conference.<br>Production of factsheets from the ICES area to promote information from HAEDAT. |
| d | In the aquatic environment globally, a wide range of natural | New toxin detection methods are continually in development, this | 1.3, 5.6 | Year 1,2,3 | Yr 1 &2: Members to update group on emerging toxin |

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| | compounds from microalgae, cyanobacteria and unknown sources are considered as toxins and pose a risk to food safety. Additionally, new discoveries continue to be made within existing toxin groups and new information can lead to a reassessment of the toxicity of known compounds. Many of these toxins are either novel to the ICES region or are not currently monitored, they include regulated and non-regulated groups of compounds. WGHABD will aim to synthesise information on the prevalence of these along with appropriate methods to detect them. | allows new information regarding harmful microalgal and cyanobacterial producers to be determined, allowing the identification and better management of risk to human health. During the coming reporting cycle, the WG will explore the expansion of toxin risks from known sources and highlight novel toxin detections and detection methods. This links to Science Priorities focussing on Ecosystem Science and Seafood Production and will also feed into the IOC Intergovernmental Panel on HABs (IPHAB) task team on Algal Toxins. | | | discoveries from their countries along with new toxin detection methods and/or toxic compounds discovered.<br><br>Yr 3: Produce a short synthesis of current thinking/knowledge within the North Atlantic ICES region for emergent toxins. This will feed into research direction, policy and future HAEDAT recordings/categories. |
| e | Report on new findings in the area of harmful algal bloom dynamics | The dynamics and impacts of HABs and the technologies to monitoring them are evolving rapidly. WG members report new findings on the topic of algal bloom dynamics in the ICES area. This ToR feeds into ICES Science Priorities *Ecosystem science, Emerging Technologies ar Techniques, Observation and Exploration.* | 1.3, 3.3, 4.1 | Year 1,2,3 | Yrs 1-3 A report on new findings in the area of harmful algal bloom dynamics will appear in the WGHABD science report. |
| f | Mortalities of both farmed and wild fish are common if episodic events throughout the ICES north Atlantic region. There are also a number of ongoing initiatives (IPHAB Task Team on fish killing microalgae, outputs from GlobalHAB Fish-Killing Algal Events symposium) which are focused on addressing issues of fish killing algae and associated faunal mortality events. Historical records tend to report fish mortalities circumstantially linked to only high biomass algal | Food security continues to be a science/strategic priority for ICES, with fish health implications for human consumers of seafood. The specific role of known ichthyotoxins versus non-specific lytic compounds causing gill damage remains to be fully elucidated. The role of harmful phytoplankton as a co-stressor in these circumstances has yet to b investigated. WGHABD will open discussions with WG PDMO to consider comparative overlap on thi topic. This ToR relates to ICES science priority Seafood Productio and is of relevance to the Aquaculture Steering | 5.6 | Year 1,2,3 | Yr 1 Review outputs from IPHAB, GlobalHAB Colloquium on Fish Killing Microalgae. Discuss with AQUA SG and align and review options for contributions for ICES Aquaculture Overviews.<br><br>Yr.2. Open dialogue with WGPDMO to review plankton as a co-stressor for CGD with a view to potential shared or back-to-back meeting to explore areas of common interest and synergies.<br><br>Yr.3. Potential shared day with WGPDMO to review phytoplankton as |

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| | blooms of "fish-killing" species. The impact of sublethal effects, however, of harmful phytoplankton as multi-stress contributors to fish morbidity, e.g. in complex gill disorders (CGD) of farmed fish has yet to be fully investigated. Delegates will update the WG on progress with external initiatives, and clarify mechanisms for reporting fish mortality events (overlap with HAEDAT ToR c), build communication links and synergy with WG Pathology and Diseases of Marine Organisms (WG PDMO), and contribute to ICES aquaculture overviews. | Group. | | | a stressor on assessment of CGD. Production of review article based on experiences from both WGs. |
| g | This ToR will support the implementation of automated observation systems for harmful algal bloom observations to improve early detection and warnings of HABs in the ICES area. Automated samplers are becoming more common in the ICES area however some are still 'novel' technologies. Delegates will share experiences with these new technologies to contribute to the integration of these techniques into HAB monitoring and research programmes. | Early detection of harmful algal blooms is needed for HAB warnings to protect human health, the aquaculture industry etc. Standard methods include manual sampling and microscope analyses of samples. Novel technology, i.e. imaging flow cytometry, is available for automated sampling and automated analysis of plankton composition and abundance. At present three at least different systems are available commercially. An ICES-IOC-SCOR GlobalHAB automated plankton observations symposium planned for June 2020 has been postponed until 2021, this will bring together people working in this new area to consolidate experiences in implementing this technology. These feeds into the *Observation and* | 3.3, 4.1, 5.6 | Year 1,2,3 | Yr 1 Report progress with the GlobalHAB automated plankton observations workshop.<br><br>Yr 2 Report the outcomes of the GlobalHAB automated plankton observations workshop postponed until 2021.<br><br>Yr 3 Contribution of a chapter to an Ocean Best Practice manual on automated phytoplankton observations using imaging flow cytometry.<br>Produce an overview of experiences of Harmful Algal Bloom observations using imaging flow cytometry. |

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| | | *Exploration, Emerging technologies and Techniques* and *Seafood Production.* | | | |
| h | Produce protocols and guidelines for qPCR methodologies for the study and monitoring of HAB species using eDNA | The use of environmental DNA approaches are becoming routine for microbial community and species distribution studies. Work undertaken in the previous two reporting cycles have lead WGHABD to identify the qPCR method based on eDNA as the most appropriate method for HAB species ecological studies and monitoring. WGHABD have taken a longer term view here with this ToR and see it lasting two reporting cycles. The final outcome will be agreement on common protocols and assays and on the potential of applying of qPCR in routine HAB monitoring. This has direct relvance to ICES Science priorities *Ecosystem Science* and *Emerging Techniques and Technologies.* | 1.6, 1.8, 4.4 | Year 1,2,3 | Yr 1 – review qPCR strategies along with metabarcoding approaches across the ICES countries for the field detection and ecological studies of HAB species.<br><br>Yr 2 – Organisation of a qPCR meeting with expert outside the WGHABD (PICES etc) to discuss and elaborate common qPCR strategies and protocols (ICHA 2022/2023 Hiroshima, Japan).<br>Yr 3 – Discussion with other ICES WG working groups about the eDNA approaches and presentation of the specificity of the WGHABD strategy.<br><br>*For next reporting cycle*<br>Yr 4 – Production of guidelines and protocols for the ICES area for qPCR methods.<br>Yr 5 – Discussion and feedback from the monitoring systems about the feasibility of the application of the protocols.<br>Yr 6 – Organisation of a practical qPCR workshop to show the chosen protocols. |
| i | To ensure the WG's visibility and the promotion of its work, a website will be developed and deployed for public access for the purposes of disseminating its activities where it will be updated and further developed on an annual basis. Further media platforms including social media will be looked at as further vectors as pathways for information dissemination. WGHABD will liaise with ICES | WGHABD has close links with IOC and PICES and thus a requirement was identified for promoting and disseminating the outputs of the Working Group and to have a visible presence on a number of media platforms where users can access information relating to the group activities, monitoring stations, research and publications all in one place. This will be an important promotion of | | Year 1,2,3 | Yr 1. Discuss with ICES options around website, which is envisaged to be developed through Marine Institute, Ireland. Ensure relevant links to ICES and IOC are included.<br><br>Yr 2 Deploy website and review material to be included on website.<br><br>Yr 3 Update website and review activity. |

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| throughout with links to the ICES sharepoint WGHABD webpage. The website will be used as a portal and will have links to data products from HAEDAT (ToR C) as well as other ICES and IOC sources | the work of ICES-IOC WGHABD and links with other scientific bodies and panels such as IOC UNESCO, SCOR GlobalHAB and more. This feeds into the vision and mission of of ICES through the provision of information, advice and guidance. |

## Summary of the Work Plan

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| Year 1 | Present national reports, new findings and update HAEDAT database. Review the role of environmental drivers on benthic HABs in the ICES area. Review HAEDAT reporting forms and report to IOC with recommendations. Update WG on emerging toxins and report on external initiatives focused on fish killing microalgae. Report on progress with workshop on automated imaging technologies and review molecular methodologies used for the detection of HABs within the WG. Develop WGHABD website. |
| Year 2 | Present national reports, new findings and update HAEDAT database. Report new findings about the diversity and distribution of HAB species in the Arctic. Identify time series of phytoplankton counts and toxicity data to support HAEDAT data and products. Open dialogue with WG PDMO to discuss activities around CGD. Report progress with automated imaging workshop. Organise qPCR methodologies meeting with external partners to discuss approaches and protocols for qPCR methodologies. Deploy WGHABD website. |
| Year 3 | Present national reports, new findings and update HAEDAT database. Review potential of sedimentary eDNA to inform on impacts of climate change on HABs. Review products from HAEDAT and presentation at ICHA conference in 2023. Produce document on status of emerging toxins in the ICES area. Contribution to Ocean Best Practices Manual on automated imaging technology. Discussion with other ICES WGs about their eDNA strategy. Potential shared day with WG PDMO about role of phytoplankton in CGD. |

## Supporting information

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| Priority | Harmful algal blooms can negatively impact ecosystems and ecosystem services within the ICES area. ICES-IOC WGHABD has developed a suite of ToRs that address the rising issues associates with HABs in the North Atlantic. The current activities of WGHABD address multiple science priorities within ICES. These are Ecosystem Science, Observation and Exploration, Emerging Techniques and Technologies, Seafood Production and Conservation and Management Science. In addition, WGHABD is also involved with a number of global initiatives via the IOC Intergovernmental Panel for HABS and the IOC Global HAB Status Report which is placing ICES Science on a global stage. |
| Resource requirements | The research programmes which provide the main input to this group are already underway, and resources are already committed. Some countries have not attended in recent years due to limiting resources. |
| Participants | WGHABD is normally attended by some 20–25 members and guests. |
| Secretariat facilities | None. |
| Financial | No financial implications. |

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| Linkages to ACOM and groups under ACOM | Output from HAEDAT and ICES Harmful Algal Event Status report will provide material for ACOM should requests for advice require consideration of impacts from HABs. |
| Linkages to other committees or groups | There is a working relationship with WGPME, WGZE, WGITMO and WG BOSV. During the coming reporting cycle linkages with WG PDMO will be strengthened and relationship with the Aquaculture Steering group enhanced. |
| Linkages to other organizations | WGHABD is co-sponsored by the IOC and works closely with it under a number of HAB initiatives. |

## Resolutions WGHABD Terms of Reference 2024-2026 Cycle

**Working Group on Harmful Algal Bloom Dynamics (WGHABD)**, co-chaired by Dave Clarke, Ireland, and Lars Johan Naustvoll (Norway )will work on the following ToRs for the 2024-2026 cycle, and generate deliverables as listed in the Table below.

| | Meeting dates | Venue | Reporting details | Comments (change in Chair, etc.) |
|---|---|---|---|---|
| Year 2024 | 16th – 18th April | Ifremer, Nantes, France | Interim e-evaluation | |
| Year 2025 | 8th - 10th April | SMHI, Gothenburg, Sweden | Interim e-evaluation | |
| Year 2026 | April - TBC | Marine Institute, Galway, Ireland | Final report by 1 May 2026 to SCICOM | |

### ToR descriptors[1]

| ToR | Description | Background | Science Plan Codes | Duration | Expected Deliverables |
|---|---|---|---|---|---|
| a) | Deliver National Reports on harmful algal events and bloom dynamics for the years 2023, 2024 and 2025 | HAB events may affect human activities and marine ecosystems at different levels. Understanding can best be achieved by integrating multiyear data sets. This links to ICES Science Priorities *Ecosystem Science, Seafood Production, Conservation and Management Science.* | 1.3, 5.6, 6.5 | Year 1,2,3 | Yr 1-3 Summary of national reports in Annex in WGHABD annual scientific report. These will also support events reported in ICES-PICES-IOC HAEDAT database and annual HAEDAT maps that will be used |

[1] Avoid generic terms such as "Discuss" or "Consider". Aim at drafting specific and clear ToR, the delivery of which can be assessed

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| b) | Identify and access the interactions of HAB dynamics with multidimensional environmental stressors on marine faunal mortalities and morbidity | Marine mortalities are a common factor linked to HAB events within the ICES region and thereby collectively reported within HAEDAT under ToR (c). Unfortunately, combining mass mortalities invariably associated with high biomass blooms (either toxigenic or not), tends of obscure the distinction of mechanisms of action causing mortalities. Within this ToR, fish-killing algal blooms will be considered in the functional content of caged-fish aquaculture, wild fish populations and other collateral damage to marine fauna and coastal ecosystems. Particular focus will be directed on defining the specific mode of action of dynamic ichthyotoxic blooms on salmonid aquaculture, the major fish aquaculture group impacting socioeconomic interests in the ICES region. Evidence that multifactorial environmental stressors, plausibly linked to climate change and/or anthropogenic factors, can amplify and attenuate the effects of HABs on fish mortalities and health status. | 5.6 | Year 1,2,3 | Activities under this ToR would be networked with initiatives under the IOC-IPHAB Task Team on Fish-Killing Algae and Ecosystem Effects, ICES WG on Pathology and Diseases of Marine Organisms (WG PDMO) and ToR on HAEDAT and emerging toxin detection methods |

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| c) | The ICES-PICES-IOC harmful algal event database (HAEDAT) will be updated by delegates on an annual basis. HAEDAT can be used to produce 'products' such as spatial descriptions of harmful algal events in the ICES area. Examples include maps of incidence of management actions associated with toxicity and/or mortalities which can be fed into ICES Ecosystem Overviews that can be updated annually or as required. The processes of using HAEDAT during the production of the IOC Global HAB report will be reviewed. The feasibility of compiling a parallel dataset of phytoplankton and toxicity data from selected stations in the ICES area as a supplement to event data and to build time series of HAB and toxicity occurrences will be investigated. | The ICES-PICES-IOC database plays a key role in the production of the first ICES Harmful Algal Event Status Report and remains an important source information about the global distribution of Harmful Algal Events. This will continue to be updated so that the ICES area can contribute to future HAB reporting initiatives such as updates to the IOC Global HAB Status Report, OSPAR assessments and more. This ToR links to Science Priorities Ecosystem Science, Seafood Production, Conservation and Management Science as well as contributing to the 'Safe Ocean' objectives of the UN Decade for Ocean Science for Sustainable Development. | 1.3, 5.6, 6.5 | Year 1,2,3 | Yr 1-3 Delegates update HAEDAT. Liaise with IOC about HAEDAT as required.<br><br>Yr 1 Entry forms reviewed, particularly in relation to fish mortalities, and recommendations passed to IOC.<br><br>Yr 2 Identify time-series of phytoplankton counts and toxin concentrations and products to be generated.<br><br>Yr 3 Review of reporting products from HAEDAT and time series datasets. Presentation at ICHA conference. Production of factsheets from the ICES area to promote information from HAEDAT. |

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| d) | HABs: Mitigation and Bloom Control | Progressive climate-driven changes over the next decades are expected to increase demand on wild fisheries and aquaculture-based food supplies to maintain food security. The pressures on coastal systems also continue to increase with the expansion of coastal communities and tourism. Both of these needs are threatened in many regions of the world by increasingly problematic HABs. Moreover, the increasing reliance on aquaculture as a food resource is in contrast to a decrease in the willingness for insurers to provide coverage for the aquaculture industry as aggregate HAB-related losses drive them from the marketplace. There is thus an escalating industry and societal desire to have safe and effective bloom control options that can minimize or prevent HAB problems. Despite great advances in our understanding of HAB dynamics and our ability to detect and quantify HABs and their toxins, however, there are only a few successful examples where HAB control approaches have been implemented on a significant scale in natural marine waters. Part of this disconnect between needs and solutions stems from concerns by the public, the HAB research and management community, and diverse marine stakeholders over the | 2.1, 2.7 | Year 1,2,3 | Yr 1-3: Activities under this ToR will be to review and report on global progress on HAB control, emphasizing approaches that have moved from the laboratory to small-and large-scale field applications. This effort will work closely with the PICES HAB Section, which also has a strong interest in HAB control. |

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| | | balance between the benefits and unintended environmental consequences. However, the societal, economic, geographic, and environmental impacts from marine HABs have increased in many areas over the last 30 years, as has the demand for acceptable, effective, and scalable HAB control approaches. | | | |
| e) | Report on new findings in the area of harmful algal bloom dynamics | The dynamics and impacts of HABs and the technologies to monitoring them are evolving rapidly. WG members report new findings on the topic of algal bloom dynamics in the ICES area. This ToR feeds into ICES Science Priorities *Ecosystem science, Emerging Technologies and Techniques, Observation and Exploration.* | 1.3, 3.3, 4.1 | Year 1,2,3 | Yr 1-3 A report on new findings in the area of harmful algal bloom dynamics will appear in the WGHABD science report. |
| f) | Early Warning Systems: for HAB forecasting | Early warnings of HABs are important for society, e.g. for the aquaculture industry, tourism, and desalination plants. A combination of early detection of HAB organisms with models forecasting growth and advection of HABs are already in operation or in development in some ICES countries. Novel methods for observations combined with high resolution physical oceanographic models and AI-based forecasting are in development or pre-operational. | 1.1, 2.5, 4.2 | Year 1,2,3 | Yr 1. An overview of existing HAB early warning systems in the ICES region is compiled.<br>Yr 2. Focus topics:<br>1.How do we move from "nowcasts" to "forecasts"<br>2.Challenges of obtaining/incorporating industry data<br>3.Automated systems vs microscopy<br>Yr 3. Focus topic: The potential for AI in supporting early warning systems<br>Deliverable in the form of a manuscript submitted to a scientific journal. |

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| g) | HAB distribution and frequency in a changing climate | Plankton are sensitive indicators of short- and long-term change, and as such, are classed as an Essential Ocean / Climate Variable (EOV, ECV). Climate change consequences stemming (but not limiting) from elevated seawater temperatures, changes in pH, salinity, nutrients and weather patterns (such as winter storms) are expected to influence plankton dynamics. There is also the potential for changes in planktonic diversity due the threat of the occurrence of non-native/invasive species. This ToR will investigate and review case studies on present and potential future changes of phytoplankton abundance, diversity, and distribution in the ICES NE Atlantic Arc region with respect to climate change. | 1.1, 2.1, 2.5 | Year 1,2,3 | Yr 1: Collate regional/country timeseries data on phytoplankton diversity and abundance.<br><br>Yr 2: Examine trend data for HAB causative dinoflagellate species<br><br>Yr 3: Examine trend data for other HAB species<br>Deliverable: Summary overview document with potential case studies |

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| h) | Produce protocols and guidelines for qPCR methodologies for the study and monitoring of HAB species using eDNA | The use of environmental DNA approaches are becoming routine for microbial community and species distribution studies. Work undertaken in the previous two reporting cycles have led WGHABD to identify the qPCR method based on eDNA as the most appropriate method for HAB species ecological studies and monitoring. WGHABD have taken a longer-term view here with this ToR and see it lasting two reporting cycles. The final outcome will be agreement on common protocols and assays and on the potential of applying of qPCR in routine HAB monitoring. This has direct relevance to ICES Science priorities *Ecosystem Science* and *Emerging Techniques and Technologies.* | 1.6, 1.8, 4.4 | Year 1,2,3 | Yr 1 – Production of guidelines and protocols for the ICES area for qPCR methods.<br>Yr 2 – Discussion and feedback from the monitoring systems about the feasibility of the application of the protocols.<br>Yr 3 – Organisation of a practical qPCR workshop to show the chosen protocols. |

## Summary of the Work Plan

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| Year 1 | **PRESENT NATIONAL REPORTS, NEW FINDINGS AND UPDATE HAEDAT DATABASE WITH REGIONAL HAB EVENTS ON ANNUAL BASIS. REVIEW HAEDAT REPORTING FORMS AND REPORT TO IOC WITH RECOMMENDATIONS.**<br>**COLLATE AND PRESENT INFORMATION ON IDENTIFYING THE INTERACTIONS OF HAB DYNAMICS WITH ENVIRONMENTAL CO-STRESSORS ON OBSERVED/REPORTED MORTALITIES – PARTICULARLY FISH CAGED AQUACULTURE.**<br>**PRODUCTION OF GUIDELINES AND PROTOCOLS FOR THE ICES AREA FOR QPCR METHODS.**<br>**COLLATE REGIONAL/COUNTRY TIMESERIES DATA ON PHYTOPLANKTON DIVERSITY AND ABUNDANCE.**<br>**AN OVERVIEW OF EXISTING HAB EARLY WARNING SYSTEMS IN THE ICES REGION IS COMPILED.**<br>**REVIEW AND REPORT ON GLOBAL PROGRESS ON HAB CONTROL/BLOOM MITIGATION** |
| Year 2 | Present national reports, new findings and update HAEDAT database with regional HAB events on annual basis. Review products from HAEDAT and presentation at ICHA conference in 2025.<br>Discussion and feedback from the monitoring systems about the feasibility of the application of the qPCR protocols.<br>Define the specific mode of action of dynamic ichthyotoxic blooms on salmonid aquaculture, the major fish aquaculture group impacting socioeconomic interests in the ICES region.<br>Examine current and potential application of in-situ remote sensing platforms for HAB species detection and their accuracy when compare.<br>Examine trend data for HAB causative dinoflagellate species.<br>Review and report on global progress on HAB control/bloom mitigation.<br>Focus topics: 1.How do we move from "nowcasts" to "forecasts" 2.Challenges of obtaining/incorporating industry data 3.Automated systems vs microscopy |

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| Year 3 | Present national reports, new findings and update HAEDAT database with regional HAB events on annual basis<br>Organisation of a practical qPCR workshop to demonstrate the selected and validated protocols.<br>Present evidence that multifactorial environmental stressors, plausibly linked to climate change and/or anthropogenic factors, can amplify and attenuate the effects of HABs on fish mortalities and health status.<br>Examine trend data for other HAB species with the deliverable: Summary overview document with potential case studies.<br>Review and report on global progress on HAB control/bloom mitigation.<br>Automated systems vs microscopy - Focus topic: The potential for AI in supporting early warning systems. Deliverable in the form of a manuscript submitted to a scientific journal. |

## Supporting information

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| Priority | The current activities of this Group will lead ICES into issues related to the ecosystem effects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.<br>Harmful algal blooms can negatively impact ecosystems and ecosystem services within the ICES area. ICES-IOC WGHABD has developed a suite of ToRs that address the rising issues associates with HABs in the North Atlantic. The current activities of WGHABD address multiple science priorities within ICES. These are Ecosystem Science, Observation and Exploration, Emerging Techniques and Technologies, Seafood Production and Conservation and Management Science. In addition, WGHABD is also involved with a number of global initiatives via the IOC Intergovernmental Panel for HABS and the IOC Global HAB Status Report which is placing ICES Science on a global stage. |
| Resource requirements | The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible. |
| Participants | The Group is normally attended by some 20–25 members and guests. |
| Secretariat facilities | None. |
| Financial | No financial implications. |
| Linkages to ACOM and groups under ACOM | Output from HAEDAT and ICES Harmful Algal Event Status report will provide material for ACOM should requests for advice require consideration of impacts from HABs. |
| Linkages to other committees or groups | There is a close working relationship with all the groups within EPDSG, in particular with WG PME, WG ZE, WG ITMO and WG BOSV. During the coming reporting cycle linkages with WG PDMO and WG OH will be strengthened and relationship with the Aquaculture Steering group enhanced. |
| Linkages to other organizations | WGHABD is co-sponsored by the IOC and works closely with it under a number of HAB initiatives including Task Teams under Intergovernmental Panel on HABs and links to GlobalHAB Scientific Steering Committee |

# E-evaluation Interim Report 2024 Meeting, Nantes, France

## 1) Working group information

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| **Expert group name** | WGHABD |
| **Resolution code** | 2023/MT/EPDSG04 |
| **Names of chairs** | Dave Clarke, Ireland |
| | Lars Johan Naustvoll, Norway |
| **Year of term** | 1/3 |
| **Year of evaluation** | 2024 |
| **Meeting venue(s) and dates during evaluation year** | 2024 meeting held at French Research Institute for Exploitation of the Sea (IFREMER), Nantes, France between 16th – 18th April 2024. This meeting was attended by 35 participants (physical attendees and remote combined) and was hosted by WGHABD members Maud Lemoine and Rafaelle Siano. |
| **Name(s) of person(s) completing form** | Dave Clarke, Ireland & Lars Johan Naustvoll, Norway |

## 2) General summary of progress at meeting: (300 word limit)

The joint ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) held its annual meeting at the French Research Institute for Exploitation of the Sea (IFREMER), Nantes, France, both in-person and remote access format, from 16th to 18th April 2024, where a combined total of 35 participants attended over the three days. For the new three-year cycle (2024-2026), this Working Group is co-chaired by Dave Clarke, Ireland and Lars Johan Naustvoll, Norway. This meeting and its participants focused its discussions, presentations and progress which are directly linked to the previously agreed current cycle's Terms of Reference (ToR) descriptors which detail the ToR descriptor background, its expected duration, and expected Year 1 deliverables as detailed and approved in the ICES document WGHABD Terms of Resolutions 2024-2026 and also in accordance with the described Year 1 summary of the identified work plan.

There was a number of additional presentations from chair invited guests to this meeting which covered a range of relevant topic areas to the Working Group including *Lingulaulax polyedra* blooms along the French Atlantic coast; update on Remote sensing tools and applications; new tools for investigating relationships between HAB and mixotrophy; AI for HABs, an early warning system; and updates from our joint co-sponsor IOC-UNESCO on Toxins database; HAB-Solutions (UN Decade of Ocean Science approved project) and update on GlobalHAB Scientific Steering Committee activities and outputs. New funded project on *Ostreopsis* – Ostreabila was also presented

The WGHABD group was welcomed, and the meeting opened by Dr. Philipp Hess, director of research unit PHYTOX, IFREMER, and current chair of the Intergovernmental Panel on Harmful

Algal Blooms (IPHAB)), who also facilitated a tour of the new PHYTOX laboratory building at IFREMER, Nantes.

**3) Follow up required** (state yes or no and if yes state if follow-up is required with steering group chair, secretariat or both) **No**

### 4) Progress made in relation to term of reference

| ToR | ToR Description (copy from resolution) | Progress in relation to ToR (maximum 200 words per ToR) | Status of term of reference (select text |
|---|---|---|---|
| a) | Deliver National Reports on harmful algal events and bloom dynamics for the years 2023, 2024 and 2025 | Group members presented and discussed their regional national HAB event reports 2023, in particular any observed changes in number and/or type of HAB event occurrence. Summary of national reports are in WGHABD SharePoint. Regional HAB event data is also inputted in the ICES-PICES-IOC Harmful Algae Event Database (HAEDAT) for HAB events (in conjunction with ToR c)) which populate data in the Harmful Algal Information System (HAIS) and the annual HAEDAT maps produced by IODE project office. | on track |
| b) | Identify and access the interactions of HAB dynamics with multidimensional environmental stressors on marine faunal mortalities and morbidity | Discussions and presentations focused on high biomass blooms and fish killing events, in particular those which are recorded in HAEDAT. Impact of sublethal effects of fish-killing" HA as multi-stress contributors to fish morbidity or mortality is often ignored. Generally weak linkages between HAB dynamics and contributions to fish mortalities. Data availability, type of data and standardization is very deficient in the ICES region. This makes it challenging with an overall analysis and understanding of the challenges. Update the WG on progress with external initiatives and clarify mechanisms for reporting fish mortality events (connected to the ToR c), improve communication and synergy and contribute to ICES aquaculture overviews.<br>Northeastern and northwestern Atlantic and adjacent marginal seas – fish-killing HABs affect and have highest impact on aquaculture salmonids<br>No systematic evidence of increasing trends in fish-killing HABs over the last three decades but increasing production creates higher losses<br>Generally weak linkages between HAB dynamics and toxigenicity or biophysical contributions to fish mortalities | on track |
| c) | The ICES-PICES-IOC harmful algal event database (HAEDAT) will be updated by delegates on an annual basis. HAEDAT can be used to produce 'products' such as spatial descriptions of harmful algal events in the ICES area. Examples include maps of incidence of management actions associated with toxicity and/or mortalities which can be fed into ICES Ecosystem Overviews that can be updated annually or | Update on status of annual national reports and their input to the HAEDAT. Increasing data capture through better follow-up of countries within the Northern Atlantic area region. Discussion around entry form and documentation, with focus on the definition, recording and how to input fish killing, high biomass and cyanobacteria events. There is a need for a Metadata overview for HAEDATt. There are somewhat different interpretations of data to be included when recording the event, this will be clarified through IOC UNESCO Task Team on HAIS and GHSR | on track |

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| | as required. The processes of using HAEDAT during the production of the IOC Global HAB report will be reviewed. The feasibility of compiling a parallel dataset of phytoplankton and toxicity data from selected stations in the ICES area as a supplement to event data and to build time series of HAB and toxicity occurrences will be investigated. | | |
| d) | HABs: Mitigation and Bloom Control | A presentation overview of the status on mitigation, control and prevention for HAB management. Several of the other ToR will directly or indirectly cover aspects of mitigation (e.g. EWS). This ToR d) identifies the types of control – biological, chemical and physical and potential environmental impacts. There will be different focus within the ICES regions and other regions. PICES region has a focus on "control", whereas Europe has focus on "mitigations". "Prevention" is more on management options but should be based on available HAB knowledge and published event dynamics. | on track |
| e) | Report on new findings in the area of harmful algal bloom dynamics | The participants presented new findings and projects from there areas, as part of their national reports or under this ToR. Specific new findings included report on new findings/worked in the area of HAB dynamics of Spain in 2023; PST index update on winter *Alexandrium blooms* in Cape Code; Synthesis of toxic *Alexandrium catenella* in the Alaskan Artic; and *Lingulodinium polyedra* blooms along the French Atlantic coast | on track |
| f) | Early Warning Systems: for HAB forecasting | Presentation given on existing HAB early warning systems (EWS) within the ICES region (DISCO, HAB-FISH,HAB-Mussel, HAB – high biomass) and Cyanobacteria examples and where AI models using observational data are used the use of instruments for automated classification of species. A more detail and status of existing tools are aligned for further work. The work will continue the work from FAO-IOC-IAEA technical guidance on EWS and the current work from the IOC-UNESCO EWS group. | on track |
| g) | HAB distribution and frequency in a changing climate | A presentation, showing examples of changes in the phytoplankton community and several harmful algae species, where "new"/southern species are appearing in new regions. Climate changes results in physical and chemical changes effecting the local phytoplankton community and may potentially allow new species (HAB) to establish in new areas causing harmful effects. Initiating work on identifying time series on phytoplankton that could be used and also identifying work conducted by PICE and IOC Trends PO group in this area. | on track |
| h) | Produce protocols and guidelines for qPCR methodologies for the study and monitoring of HAB species using eDNA | A status update in the work with guidelines for qPCR methods in HAB studies and monitoring was given. A workshop has been held in Hiroshima, Japan, to compile existing knowledge, further develop standardized protocols and assessment of target species. Organized by Raffaele Siano (GlobalHAB), aimed to foster the integration and the application qPCR/dPCR methodologies to improve HAB monitoring and to develop early risk alert systems | on track |

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| | Four virtual workshops were conducted during the last year by international experts on application of these molecular tools on HAB research and monitoring; in-person workshop in Hiroshima (Japan) on November 3-5, 2023, prior to the International Conference on Harmful Algae (ICHA2023, November 5-10, 2023). A position paper detailing best practices, methods and guidelines for qPCR detection of HAB species is currently in preparation. The group is also identifying knowledge gaps in the qPCR area for HAB detection and recommendations for incorportaing into monitoring programmes.<br>This ToR is in Year 4 of 6,and follows on from the previously agreed Resolution for 2021-2023 cycle | |

## 5) Are changes to any term of reference required* (yes/no)

**NB: Changes to existing ToR are subject to approval by the Science Committee*

Yes – minor text changes to ToR's b) and d) following discussion on how best these will be approached from the WG, as detailed in part 6) below

## 6) Please enter proposed rewording of any term of reference in the following table.

| ToR | Reworded ToR<br>(maximum 60 words) | Justification for proposed changes |
|---|---|---|
| b) | Marine mortalities are a common factor linked to HAB events within the ICES region and thereby collectively reported within HAEDAT under ToR (c). Within this ToR, fish-killing algal blooms will be considered in the functional content of caged-fish aquaculture, wild fish populations and other collateral damage to marine fauna and coastal ecosystems. Particular focus will be directed on defining the specific mode of action of dynamic ichthyotoxic blooms on salmonid aquaculture, the major fish aquaculture group impacting socioeconomic interests in the ICES region | Based on the provided overview of multidimensional environmental stressors, it has been revealed that this topic will cover many different aspects and, topics that are currently addressed in several other ICES WG. In addition, the data availability and format are not clear. Fish-killing HAB/events are still important topic. To improve data availability the WG should focus on the improving reporting of High-biomass and Fish-killing HA in the HAEDAT, through a better understanding and definition of the mechanisms. |
| d) | Progressive climate-driven changes over the next decades are expected to increase demand on wild fisheries and aquaculture-based food supplies to maintain food security. The needs are threatened in many regions of the world by increasingly problematic HABs. There is an escalating industry and societal desire to have safe and effective bloom control options that can minimize or prevent HAB problems. Despite great advances in our understanding of HAB dynamics and our ability to detect and quantify HABs and their toxins, however, there are only a few successful examples where HAB control approaches have been implemented, due to public concerns. the societal, economic, geographic, and environmental impacts from marine HABs have increased in many areas over the last 30 years, as has the demand for acceptable, effective, and scalable HAB control approaches. | The original description covers Prevention, Mitigation and Control og HAB. The WGHABD already handled many aspects of the mitigation strategies though other ToR's and will be followed up in these. The Prevention is more linked to environmental management option, based on HAB knowledge. The WGHABD sees a need to compile knowledge on control actions, status and assessment of risk associated with such measures. The work plan will be 1) A overview of actions 2) assessment of risk 3) Relevance for ICES areas 3)Final report governing control methods, risk and relevance within ICES areas. |

### 7) Next meeting: location and dates

Swedish Meteorological & Hydrological Institute (SMHI), Gothenburg, Sweden 8th – 10th April 2025.

### 8) Please submit one or more science highlights that came out of your latest expert group meeting. Please read the guidelines for submitting science highlights here! The following template may be used for submitting science highlights via this form or to the ICES Science Highlights SharePoint page.

No highlights submitted

### 9) List of Participants

| Name | Institute | Country (of institute) | Email |
|---|---|---|---|
| Dave Clarke | Marine Insitute | Ireland | dave.clarke@marine.ie |
| Lars Johan Naustvoll | Institute of Marine Research | Norway | larsjn@hi.no |
| Maud Lemoine | French Research Institute for Exploitation of the Sea (IFREMER) | France | maud.Lemoine@ifremer.fr |
| Morgan Le Moigne | French Research Institute for Exploitation of the Sea (IFREMER) | France | morgan.le.moigne@ifremer.fr |
| Raffaele Siano | French Research Institute for Exploitation of the Sea (IFREMER) | France | raffaele.Siano@ifremer.fr |
| Adam Lewis | Centre for Environment, Fisheries and Aquaculture Science (CEFAS) | England & Wales, UK | adam.lewis@cefas.co.uk |
| Per Andersen | Aarhus University Bioscience | Denmark | pean@ecos.au.dk |
| Marnix Poelman | Wageningen University & Research (WUR) | Netherlands | marnix.poelman@wur.nl |
| Don Anderson | Woods Hole Oceanographic Institute (WHOI) | US | danderson@whoi.edu |
| Cynthia McKenzie | Northwest Atlantic Fisheries Centre, Fisheries and Oceans (DFO) | Canada | Cynthia.McKenzie@dfo-mpo.gc.ca |
| Henrik Enevoldsen | IOC-UNESCO | France | h.enevoldsen@unesco.org |
| Yun Sun | IOC-UNESCO | France | |

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| André Gonçalves | Portuguese Institute of the Sea and the Atmosphere (IPMA) | Portugal | andre.goncalves@ipma.pt |
| Bengt Karlson | Swedish Meterological & Hydrological Institute (SMHI) | Sweden | bengt.karlson@smhi.se |
| Allan Cembella | Alfred Wegener Institute (AWI) | Germany | allan.cembella@awi.de |
| Kenneth Mertens | French Research Institute for Exploitation of the Sea (IFREMER) | France | kenneth.mertens@ifremer.fr |
| Nicolas Chomérat | French Research Institute for Exploitation of the Sea (IFREMER) | France | nicolas.chomerat@ifremer.fr |
| Véronique Séchet | French Research Institute for Exploitation of the Sea (IFREMER) | France | veronique.sechet@ifremer.fr |
| Victor Pochic | French Research Institute for Exploitation of the Sea (IFREMER) | France | victor.pochic@ifremer.fr |
| Jean-Baptiste Bérard | French Research Institute for Exploitation of the Sea (IFREMER) | France | jean-baptiste.berard@ifremer.fr |
| Marc-André Cormier | Christ Church College, University of Oxford, department of Earth Sciences | England, UK | marc-andre.cormier@earth.ox.ac.uk |
| Philip Hess | French Research Institute for Exploitation of the Sea (IFREMER) | France | philipp.hess@ifremer.fr |
| Sarah Swan | Scottish Association for Marine Science (SAMS) | Scotland, UK | Sarah.swan@sams.ac.uk |
| Esther Garcés | Institut de Ciències del Mar, CSIC | Soain | esther@icm.csic.es |
| Margarita Fernández Tejedor | Institute of Agrifood Research & Technology (IRTA) | Spain | margarita.fernandez@irta.cat |
| Magda Vila | Spanish National Research Council (CSIC) | Spain | magda@icm.csic.es |
| Yolanda Pazos | Technological Institute for the Control of the Marine Environment of Galicia (INTECMAR) | Spain | ypazos@intecmar.gal |
| Justyna Kobos | University of Gdańsk | Poland | justyna.kobos@ug.edu.pl |
| Peter Miller | Plymouth Marine Laboratory (PML) | England, UK | PIM@pml.ac.uk |
| April McKinney | Agri-Food & Biosciences Insitute, (AFBINI) | Northern Ireland, UK | April.McKinney@afbini.gov.uk |

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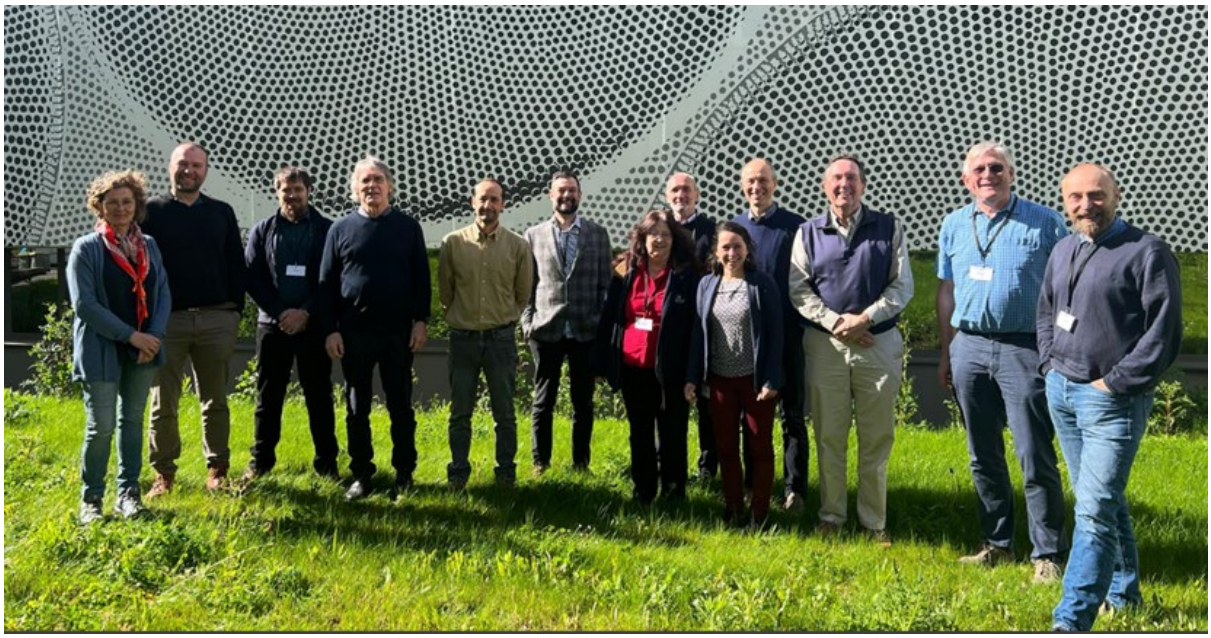
|---|---|---|---|
| Alexandra Silva | Portuguese Institute of the Sea and the Atmosphere (IPMA) | Portugal | amsilva@ipma.pt |
| Marie-Yasmine Bottein | Universite Cote d'Azur | France | marie-yasmine.bottein@univ-cotedazur.fr |
| Sirje Sildever | sirje.sildever@taltech.ee | Estonia | sirje.sildever@taltech.ee |
| Katie Thomas | Blue Lion Labs | Canada | katie@bluelionlabs.com |
| Beatriz Reguera | instituto español de oceanografía (IEO-CSIC) | Spain | beatriz.reguera@ieo.csic.es |



WGHABD meeting, Nantes, France, April 2024 participants, from left to right: Morgan Le Moigne, Marnix Poelman, Adam Lewis, Allan Cembella, André Sobrinho Gonçalves, Dave Clarke, Cynthia McKenzie, Per Andersen, Maud Lemoine, Henrik Enevoldsen, Don Anderson, Bengt Karlson and Lars-Johan Naustvoll.