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

**on Harmful Algal Blooms**

Rome, 27-29 March 2023

Item 4.7.7 of the Provisional Agenda

**REPORT OF THE IPHAB TASK TEAM ON FISH KILLING MICROALGAE AND ECOSYSTEM EFFECTS**

At IPHAB-XV, Decision IPHAB-XV.8 endorsed the continuation of the Task Team on Harmful Algae and Fish Kills with modified mandate and terms of reference as the Task Team on Fish Killing Microalgae and Ecosystem Effects (FKMEE), co-chaired by Prof Dr Allan Cembella (Germany) and Dr Kazumi Wakita (IOC/WESTPAC-HAB), with members L. Guzmán (Chile), P. Hess (France), B. Karlson (Sweden), P.T. Lim (Malaysia, GlobalHAB-SSC), C. McKenzie (Canada), L.-J. Naustvoll (Norway), M. Wells (PICES), and A. Yñiguez (Philippines). The Task Team has been supplemented by international advisors and experts E. García-Mendoza (Mexico), G. Hallegraeff (Australia), H. Hégaret (France), M. Iwataki (Japan) and J. Mardones (Chile).

The revised Terms of Reference (ToR) for the FKMEE Task Team were to:

1. support and assist in the coordination of relevant advanced technical workshops with ICES-IOC-PICES and WESTPAC to better define global understanding of the causes of fish kill events and operational approaches to development of early warning systems, and monitoring, forecasting and mitigation strategies, with focus on fish aquaculture in coastal zones;
2. prepare a state-of-knowledge white paper on research priorities and knowledge gaps to be addressed from a global viewpoint based upon the symposium recommendations (Puerto Varas, Chile 2019);
3. based upon the defined global priorities considered and the themes defined for the symposium noted in ii) prepare a comprehensive global synthesis publication (e.g., UNESCO Monographs/IOC Manual and Guides series), with chapters focusing on processes and mechanisms, and including future perspectives on climate change effects and advanced technologies for monitoring and mitigation of fish-killing algal blooms and their effects;
4. complete a manuscript on fish killing microalgae and causative mechanisms of fish mortalities in coastal north European waters for inclusion in a peer reviewed journal;
5. coordinate with and upon request support the IOC/WESTPAC-HAB activity on causative mechanisms of fish kills, including those in relation to harmful substances in the environment, including multiple stressors and cyanobacterial toxin effects on fish health;
6. promote comparative studies of HABs causing fish mortalities in coordination with GlobalHAB, e.g. by comparing bloom dynamics and forcing factors of blooms and ecosystem effects of blooms in different geographical regions;
7. report to IPHAB-XVI with the objective to develop a long-term broad-scale strategy for implementation by resource managers and the aquaculture and fisheries industries in affected countries with focus on development and application of mitigation strategies;
8. In 6 months develop a succinct list of challenges, objectives and actions with respect to the Task Team topic that will address the UN Decade of Ocean Science for Sustainable Development objectives and challenges and to present these at an IPHAB intersessional on-line consultation September 2021 with a view to formulate an IPHAB strategic framework for UN Decade initiatives;

All of the ToR were addressed by the TT although implementation activities (e.g., meetings, workshops, collaborations) were severely affected by Covid implications and lack of travel authorization and limited funding from national and international resources. Nevertheless, the FKMEE TT has achieved some solid accomplishments during the 2021-2023 Interim period.

**ToR i)** the TT decided to defer convening a dedicated advanced technical workshops with ICES-IOC-PICES and WESTPAC; instead sessions relevant to fish-killing algae were addressed in several regional and global international meetings with involvement of FKMEE members:

**Virtual ICHA19 conference, La Paz, Mexico (2021)**

Organized Special Sessions on Ichthyotoxic HABS (A. Cembella (IOC-IPHAB TT), B. Krock-Germany, H. Hégaret-France, J. Mardones and P. Díaz-Chile, E. García-Mendoza-(host)Mexico) and contributed to and reviewed 36 submitted presentation abstracts and several short papers for the published conference proceedings.

Participated in the Workshop –Round Table Industry & Insurance Perspectives (co-organized by M. Wells and C. Trick), special session on Socioeconomic impacts of HABs, and the Symposium on Early Warning Systems for HAB events (sponsored by FAO and IAEA; 8 case studies)

**Decade Action Incubator 12: Fostering transformative HAB Sciences for Societal Applications (UNESCO, WESTPAC), Bangkok, Thailand (2021)**

Convened (K. Wakita-Japan; P.T. Lim-Malaysia) the symposium on decade action on HAB sciences with a heavy focus on fish-killing algal blooms and their effects on socioeconomic factors for the Asia-Pacific region. Several peer-reviewed publications may be linked to the framework of this meeting. Details of the complete WESTPAC activities will be presented separately at IPHAB-XVI.

**Symposium on Decadal Variability of the North Atlantic and its Marine Ecosystems (ICES, IMR-Norway, NAFO)**

Contributed to the Theme Session 2: Decadal change and trends in North Atlantic/sub-Arctic plankton and their ecosystems by providing elements on fish-killing microalgal events in the ICES region (A. Cembella-IPHAB TT, B. Karlson-Sweden, L.J. Naustvoll-Norway) to the joint ICES WG presentation (coordinated by B. Karlson, Sweden; D. Clarke, ICES-IOC WG HABD Chair). This presentation made effective use of data mining of the HAEDAT database and decadal scale national reports of the ICES region.

**ToR ii** the state-of-knowledge white paper on research priorities and knowledge gaps to be addressed from a global viewpoint from the symposium recommendations (Puerto Varas, Chile 2019) has not yet been submitted to IPHAB as planned. This document is in advanced stage of preparation and will be subsequently transformed into a peer-reviewed manuscript for a high-impact journal (expected before ICHA20 conference, Hiroshima, Japan, 2023).

**ToR iii** due to lack of time commitments by invited authors the TT decision to prepare a comprehensive global synthesis publication with multiple chapters (e.g., UNESCO Monographs/IOC Manual and Guides series) has been deferred until after the reception of the White Paper and global synthesis publication can be judged.

**ToR iv** this regional review manuscript on fish killing microalgae and causative mechanisms of fish mortalities in coastal north European waters is expected for inclusion in a Special Issue of a peer-reviewed journal, pending addition of recent perspectives of the socio-economic issues and new developments in EWS for fish-killing HABs in the North Atlantic and adjacent waters.

**ToR v** the coordination of the TT activities among ICES, PICES and WESTPAC members has markedly improved following the co-chair structure (A. Cembella; K. Wakita) with better global exchange of knowledge and information, particularly from Asia-Pacific and North Atlantic/European regions.

**ToR vi** activities to promote comparative studies of HABs causing fish mortalities in coordination with GlobalHAB, e.g. by comparing bloom dynamics and forcing factors of blooms and ecosystem effects of blooms in different geographical regions, have been successful at the review and data integration level but major field initiatives directed via GlobalHAB to conduct case studies are subject to financial and expedition resource limitations.

**ToR vii** the objective to develop a long-term broad-scale strategy for implementation by resource managers remains part of the long-term goal of the FKMEE TT, which has been addressed to some extent by the recent focus on development of operational EWS. Here the TT has made a major contribution as *Chapter 5. High Biomass Blooms Causing Fish Kills and other Environmental* Impacts (McKenzie, Cembella, Goes, et al. 2022), *Joint FAO/IOC/IAEA Technical guidance for the implementation of early warning systems for harmful algal blooms (FAO, IOC, IAEA, 2022)*. The focus on incorporating EWS into fish-killing bloom management should continue to be a top priority of the TT pending extension of its mandate through the next intersession.

**ToR viii** members of the FKMEE TT (e.g. A. Cembella; B. Karlson, M. Wells) have been active in the development of initiatives to address the UN Decade of Ocean Science for Sustainable Development from the perspective of focused challenges specific to fish killing algal blooms, impacts, monitoring and surveillance, and mitigation. These include participation in the strategy meeting in Helsingør, Denmark (2022) to plan the first IPHAB-coordinated initiatives and continuing on-line networking prior to IPHAB XVI.

Members of the TT have contributed as co-authors to numerous peer-reviewed journals and reviews on aspects of fish-killing microalgae, many with acknowledgements to ICES\_IOC WG HABD, HAEDAT, IPHAB-IOC. These include but are not limited to the Special Issue on Global HAB Status Report (*Harmful Algae*, 2020-2021), Special CoCliME Issue (*Harmful Algae*, 2022-2023), and reports on new species from Russia and Japan and socioeconomic impacts of fish-killing blooms from the WESTPAC (*Harmful Algae*, 2022)

The identification of the role and mechanisms of fish-killing algal toxins, with defined potency, molecular targets and induced mortality and morbidity cascades, is a critical focus of the FKMEE TT. It is important to distinguish these true toxins from other collateral damage to fish by exposure to high biomass HABs. The FKMEE TT is coordinating with the Task Team on Biotoxin Monitoring, Management and Regulations to define fish-killing toxin groups in the Toxins Database; the emerging list includes amphidinols, brevetoxins, *Karenia brevisulcata* toxin, karlotoxins, palytoxins, prymnesins, and saxitoxins, but remains to be populated with reliable potency data for various analogues of potential regulatory concern. Members of the FKMEE TT are participating in the *Catalyst Seeding Program*, New Zealand – France (2022-23) to develop *in vitro* bioassays for fish-killing toxin screening.

The FKMEE TT proposes to continue with modified ToR towards IPHAB XVII with the same basic structure and core membership. These modifications should include increased focus on customization of EWS for fish-killing blooms which often tend to be high-biomass but with rapid acute and irreversible effects (i.e. dead fish) and must be monitored differently than those causing shellfish toxicity. The socio-economic dimension must be considered in more detail (not just the scientific challenges on bloom dynamics), particularly with respect to recruitment failure, multi-factor stressors and high risk to fish aquaculture requiring high capitalization and adequate insurance coverage to sustain operations following major bloom events.