GlobalHAB - the International SCOR-IOC Science Program on Harmful Algal Blooms

Activities 2021-2022 and Plans for 2022-2025

July 24th, 2022

GlobalHAB Scientific Steering Committee members 2020-2021:

Elisa Berdalet, Institute of Marine Sciences, CSIC, Spain, Chair
Po Teen Lim, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur, Malaysia, Vice-chair

Clarissa Anderson, Southern California Coastal Ocean Observing System, Scripps Institution of Oceanography, La Jolla, California, USA
Neil S. Banas, University of Strathclyde, United Kingdom
Jeong, Hae Jin, School of Earth and Environmental Science, College of Natural Sciences, Seoul National University, Seoul, South Korea
Bengt Karlson, Swedish Meteorological and Hydrological Institute, Västra Frölunda, Sweden
Malin Olofsson, Swedish University of Agricultural Sciences, Uppsala, Sweden
Heather A. Raymond, Ohio State University, College of Food, Agricultural, and Environmental Sciences, Ohio, US
Raffaele Siano, Ifremer, DYNECO Pelagos F-29280, Plouzané, France
Susie Wood, Cawthron Institute, Nelson, New Zealand
Aletta Yñiguez, Marine Science Institute, University of the Philippines, Diliman, Philippines

Dave Clarke, Marine Institute, Ireland, ICES representative after April 2020
Raphael Kudela, University of California, Santa Cruz, USA, liaison to GOOS Bio & Eco Panel (2017-on going)
Vera L. Trainer, National Oceanic and Atmospheric Administration, USA, ISSHA and PICES representative (2016-ongoing)
Joe Silke, Marine Institute, Ireland, IPHAB representative (2019-2023)
Marc Suddleson, liaison to NOAA, US, (2021 – ongoing)

Henrik Enevoldsen, IOC UNESCO, IOC Science and Communication Centre on Harmful Algae at the University of Copenhagen, Denmark (2016-
Patricia Miloslavich, Scientific Committee on Oceanic Research, USA (2020-)
Yun Sun, Junior Professional Officer, IOC Secretariat

The GlobalHAB Scientific Steering Committee (SSC) acknowledges the financial and logistic support received from SCOR and IOC during the 2021-2022 period and for the activities postponed to 2022 due to the Covid-19 pandemic.

1. Meetings of the GlobalHAB SSC

The GlobalHAB SSC held monthly virtual meetings and email until May 13-14, 2022, when an in person meeting too place in Glasgow, Scotland, UK.

A second partial renewal of the SSC took place on March 2022. Two new members, Malin Olofsson and Heather Raymond, replaced Tim Davis to lead the Freshwater Theme along with Susie Wood, who will step down in December 2022. A partial renewal is expected after December 2022, when the term of all SSC members will end.

Members of the SSC at the Merchants House of Glasgow and screenshots during the remote connection. Bottom image, from left to right, first line: Aletta Yñiguez, Elisa Berdalet, Heather Raymond; second line: Clarissa Anderson, Sun Yun, Malin Olofsson, Bengt Karlson, Neil Banas, Raffaele Siano, Dave Clarke. Po Teen Lim (top, right picture), Raphael Kudela (middle, right picture), and Marc Suddleson (not pictured) joined virtually.

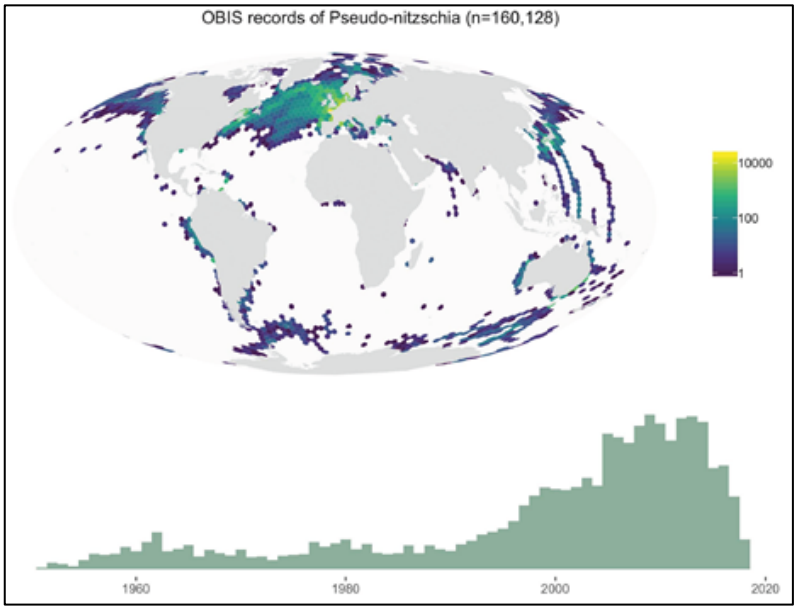
2. Science highlights in the 2021-2022 period

2.1. Publication of the "Best Practice Guidelines for the Study of HABs and Climate Change", Mark Wells, Michele Burford, Anke Kremp, Marina Montresor, Grant Pitcher and Gires Usup (eds). Available at: https://unesdoc.unesco.org/ark:/48223/pf0000380344

HABs impact human societies and ecosystems, and there is concern that climate-driven changes in aquatic systems will increase the frequency, distribution, and intensity of these ecological events. Developing a foundation for HAB prediction under accelerating shifts in environmental conditions requires a quantitative, mechanistic-based understanding of

climate-HAB linkages. Addressing this challenge requires a common strategy based on the multidisciplinary knowledge gained in recent years and new methodologies.

The intent of these guidelines is to communicate standardized strategies, tools, and protocols to assist researchers studying how climate change drivers may increase or decrease future HAB prevalence in aquatic ecosystems. The guidelines are designed and published as an on-line resource to the HAB/climate change research community which is invited to contribute in future updates of the document.



OBIS maps and time series of records of potentially toxic and non-toxic species of the genus Pseudo-nitzschia *between 1950 and 2019, obtained by merging the datasets specifically established within HABMAP-OBIS with all data from other sources that are present in OBIS. These data suggest, but do not demonstrate, increasing frequencies of* Pseudo-nitzschia *blooms over time.*

Funds for the working meeting of the editorial team to start the organization of the Manual in April 2018 were provided by GlobalHAB. The final edition received the support of IOC. The initiative of the Best Practices Manual for HAB and Climate Change is in line with the activities of SCOR WG149 that is focusing on Changing Ocean Biological Systems (COBS) and particularly on "How will biota respond to a changing ocean?" (https://scor149-ocean.com/).

2.2. Communications about the GlobalHAB program at international scientific events:

* Presentation of the GlobalHAB program at the "Reunión Ibérica de Biotoxinas Marinas y Fitoplancton Nocivo" REDIBAL", by Elisa Berdalet, plenary session.

E. Berdalet. *"The GlobalHAB (IOC-UNESCO and SCOR) program: International coordination for sound knowledge of HABs and management of their impacts"*, 29/06/2021, Lisbon, Portugal, virtual meeting.

* Presentation of GlobalHAB Scientific Steering Committee updates by Dave Clarke, at:

- Annual meeting of the ICES-IOC Working Group on Harmful Algal Bloom Dynamics, 14th – 17th June 2022, Centre for the Environment and Fisheries Science, Weymouth, UK
- Workshop on Modelling and Prediction of Harmful Algal Blooms 9th-12th May 2022, University of Strathclyde, Glasgow, UK (see section 3.2)

2.3. Publication of the "IOC-UNESCO. 2022. Multiple Ocean Stressors: A Scientific Summary for Policy Makers. P.W. Boyd, S. Dupond, K. Isensee (eds). Paris, UNESCO. 20 pp. (IOC Information Series, 1404) doi:10.25607/OBP-1724.
Available at: https://unesdoc.unesco.org/ark:/48223/pf0000380891

Figure 1. Value chain that emerges from addressing questions, helping to structure the development of science into multiple ocean stressors, resulting in increased understanding to inform management strategies and policy action needed to achieve a healthy, sustainable, resilient ocean.

The document is "*a call to action underlining the urgency to understand, model and manage multiple ocean stressors now. We cannot manage what we do not understand, and we cannot be efficient without prioritization of ocean actions appropriate to the place and time.*" and "it supports the UN Decade of Ocean Science for Sustainable Development".

Raphael Kudela and Henrik Enevoldsen (GlobalHAB) participated as author and Production Editor, respectively. The work presented in this publication by members (Boyd, Dupont) of the SCOR COBS (Changing Ocean Biological Systems), benefited in part, from funding provided by national committees of the Scientific Committee on Oceanic Research (SCOR) and from a grant to SCOR from the U.S. National Science Foundation (OCE-1840868).

3. *New GlobalHAB activities implemented in 2021-2022*

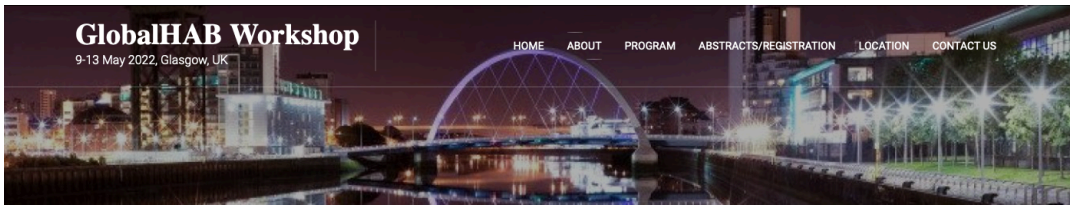
Several activities had been planned by the GlobalHAB program for the 2020-2021 period, which, unfortunately were postponed due to the Covid-19 pandemic. When submitting this report, the following activities have been conducted or will be conducted before the end of 2022.

3.1. June 2021 - November 2021. GlobalHAB Webinar Series - Modelling and Prediction of Harmful Algal Blooms

In **June 2021**, an online series of open seminars and discussions have started to address the challenge of predicting HABs. This monthly series was delivered by six experts and the topics covered size-based models, acclimation models, model validation, and machine learning. The detailed schedule is listed below.

Date	Time	Speaker	Title
29 June 2021	9 am US Western = 12 pm US Eastern = 5 pm UK = 12 am China	Jim Cloern	Phytoplankton Community Variability: Some Rules and Rule Breakers
15 July 2021	9 am US Western = 12 pm US Eastern = 5 pm UK = 12 am China	Androniki Tamvakis	Using Machine Learning algorithms for HAB prediction
31 Aug 2021	5 am US Western = 8 am US Eastern = 1 pm UK = 8 pm China	Aletta Yniguez	Using the individual-based approach for HAB modelling: from HAB species to shellfish toxicity
20 Oct 2021	9 am US Western = 12 pm US Eastern = 5 pm UK = 12 am China	Michael Parsons	Modeling considerations for benthic HABs
3 Nov 2021	9 am US Western = 12 pm US Eastern = 5 pm UK = 1 am China	Onur Kerimoglu	Accounting for flexible phytoplankton physiology, and relevance to modelling HABs
16 Nov 2021	9 am US Western = 12 pm US Eastern = 5 pm UK = 1 am China	Rick Stumpf	Making Useful Models for Forecasting Harmful Algal Blooms

3.2. 9-12 May 2022. "***Modeling and prediction of harmful algal blooms, from event response to multi-decadal projections***"



The GlobalHAB/Euro Marine Workshop was held on 9-12 May 2022, University of Strathclyde, Glasgow, UK.

The typical HAB is a regional- or local-scale phenomenon, a "perfect storm" of environmental conditions, ocean transport and mixing patterns, and microbial ecology. Because of this complexity, prediction of HABs is a grand challenge that requires multidisciplinary dialogue among physical scientists, biologists, computer modellers, and technologists, as well as community stakeholders and the government and industry end-users of prediction systems. This 4-day workshop brought together **39 scientists from 17 countries** for a combination of oral and poster presentations, round-table discussions, and tutorials, in order to increase awareness of the range of modelling and observational tools that are in our community toolbox, and help scientists and technologists develop creative approaches to meeting the needs of coastal communities, governments, and industry worldwide. An update of the GlobalHAB program was included (see section 2.2.).

Discussions consisted of

- Engaging with stakeholders (facilitated by Aletta Yñiguez and Dave Clarke)
- Scalable solutions: bringing large-scale community tools to local applications (facilitated by Clarissa Anderson)
- Building blocks of early-warning systems (facilitated by Dave Clarke)
- Combining automated plankton observations and modelling (facilitated by Bengt Karlson)
- New directions in mechanistic plankton modeling: where do HABs fit in? (facilitated by Neil Banas, Onur Kerimoglu, and Bingzhang Chen)
- HAB model-observation systems for 2050: anticipating future societal needs and assessment tools (facilitated by Clarissa Anderson)

Tutorials consisted of

- Getting started with machine learning using tidymodels in R (Johnathan Evanilla, Kasia Kenitz, and Bingzhang Chen)
- Satellite methods (Clarissa Anderson)
- Getting started with Individual-based modeling (Aletta Yñiguez)

Organising committee:
Representing GlobalHAB: Neil Banas (U Strathclyde, UK), Clarissa Anderson (Scripps/SCCOOS, USA), Dave Clarke (Marine Institute, Ireland), Aletta Yñiguez (U Philippines Diliman), Bengt Karlson (SMHI, Sweden)
Local committee: David McKee, Bingzhang Chen, Paul Udom (U Strathclyde), Sofie Spatharis, Martin Llewellyn (U Glasgow), Keith Davidson, Dmitry Aleynik (SAMS)

Sponsors:
The workshop was supported by GlobalHAB, NOAA's National Centers for Coastal Ocean Science (NCCOS) Competitive Research Program (CRP), NOAA's Integrated Ocean Observing System (IOOS), and EuroMarine. A follow-on, one-day event on Industry Perspectives supported by the Sustainable Aquaculture Innovation Centre deepened the engagement between workshop participants, the Scottish aquaculture industry, and companies building systems and monitoring technology to support that industry.

3.3. August 22 - 26, 2022. A *Mini-symposium on automated in situ observations of plankton*, will be hosted at Kristineberg Marine Research Station, Sweden.

Aims and background
Harmful Algal Blooms are affecting aquatic ecosystems and human societies. Biotoxin-producing HABs species and species causing fish mortalities are problems for aquaculture, fisheries and also for tourism. HABs have caused mortality of marine mammals and pose a threat to human health. Ecosystem-disruptive HABs and high-biomass HABs may cause anoxia in deep water and some HABs result in a decrease in coastal water quality and fouling of beaches. High-frequency *in situ* observations of HABs and predators of HAB species are needed to be able to understand HAB dynamics, to develop predictive models of HABs and to produce well-founded warnings for HABs. In recent years, novel *in situ* instrumentation have been developed for automated high-frequency HAB detection in near-real time. In addition, instruments for observing grazers, i.e. microzooplankton and multicellular zooplankton have been developed. These instruments are now being adopted in research and piloted in monitoring programmes. Some of the instruments are becoming available commercially. The aim of the symposium is to bring together experts on, and users of, automated *in situ* imaging systems to present methods, recent results and to share experiences. Another aim is to carry out a comparison of results when analysing plankton communities quantitatively. Early career scientists are particularly encouraged to attend the symposium and a special follow-on workshop on data processing and report/article writing.

A hybrid symposium
Part of the symposium will be available on line. An evening session is planned for presentations made by participants not on-site. Presentations from the morning sessions will be recorded and published at an IOC web site, link to be communicated later. Training sessions in the afternoons will not be recorded, but instruction videos will be published on line.

Dates
Symposium: 22-26 August 2022
Small group of participants processing generated data: 27-18 August 2022

Venue
Kristineberg Marine Research Station, Fiskebäckskil, Sweden
This is well-equipped field station is located at the mouth of the Gullmar fjord on the Swedish west coast, adjacent to the North Sea. More information is available at https://www.gu.se/en/kristineberg

Information is shown at:
http://www.globalhab.info/activities/globalhab-activities

4. Activities by the GlobalHAB endorsed projects

The GlobalHAB program is implemented also thanks to the international community working on HABs. GlobalHAB acknowledges the contributions of the endorsed projects to achieve the GlobalHAB scientific objectives, and encourages new endorsements. The GlobalHAB SSC agreed to make an effort to contact the international community working on HABs to apply for endorsement of their proposals to GlobalHAB as shown in the GlobalHAB webpage (http://www.globalhab.info/activities/globalhab-endorsed-projects).

In the 2021-2022, the activities conducted by the GlobalHAB endorsed projects include:

4.1. Addressing industry and global insurance needs: impacts of HABs on fish farms. A special session was held duting the International Conference on Harmful Algae (ICHA19), October 10-14, 2021; session on Oct 12, 14:00-16:00 La Paz time.
Convenors: Vera Trainer (NOAA, US), Keith Davidson (SAMS, UK), Mark Wells (Univesity of Maine, US) and Charles Trick (The University of Saskatchewan, Canada).

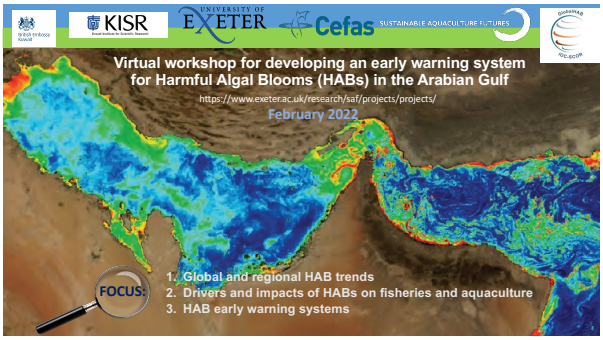
In this ICHA19 side session a discussion HAB scientists, the insurance industry and on-the-ground aquaculture industry representatives discussed future research directions and how to work together to address impacts of HABs on aquaculture, risk thresholds, early warning and mitigation cost benefits.

4.2. UN Decade Action Incubator 12 "Fostering transformative HAB sciences for societal applications". Friday 26 November 2021, 1030-1230 (UTC+7, Bangkok time). Conveners: Kazumi Wakita (Tokai University, Japan), Po Teen Lim (University of Malaya, Malaysia). The meeting was held with attendance of 77 participation from 9 WESTPAC member states.

HAB research priorities, challenges and future works were discussed and the key points of discussion during the session were summarized as below:

1. Continue with the effort in capacity building in HAB sciences through various training workshops and promoting more involvement of social scientists.
2. Promote application of advanced techniques in HABs monitoring and early warning system.
3. Promote sharing of good practices of HAB monitoring, mitigation and adaptation.
4. Encourage the application of mitigation measures to minimize impact especially to mariculture industries with due consideration on its social acceptance.
5. Strengthen coordination with other national and regional HABs program and IPHAB in development of UN Decade actions on HAB.

4.3. Workshop-based scoping study for developing an early warning system for Harmful Algal Blooms (HABs) in the Arabian Gulf. The virtual workshop was held in 22 and 23 February 2022, coordinated by Dr Ross Brown (University of Exeter, UK) and Dr Qusaie Karam (Kuwait Institute for Scientific Research, Kuwait) sponsored by the UK and Kuwait Governments.



The aims of the activity were to explore existing knowledge and data on HABs and impacts on fisheries and finfish aquaculture in the Arabian Gulf. The first day was focused on

understanding the susceptibility of the Arabian Gulf and adjoining sea areas to HABs and impacts on fish health and food safety; the second day was centered on developing early warning systems (EWS) for HABs for mitigating impacts on fisheries and aquaculture.

The program, videos and proceedings of the workshop are available at the GlobalHAB webpage.

5. New GlobalHAB activities to be implemented in 2022-2023

The following activities organized by GlobalHAB to be conducted within the coming 2022-2023 period are:

5.1. Research on *Sargassum* Influxes. Since the launch of GlobalHAB in 2016, *Sargassum* influxes were considered an emerging HAB case and a GlobalHAB Subcommittee was established to identify, in collaboration with the international community, the main research questions to understand the population dynamics of *Sargassum*. The subcommittee participated in several virtual meetings organized by UNEP and GESAMP during the 2019-2021 period, and identified the myriad of diverse ongoing initiatives addressing research questions, monitoring, prevention, use and mitigation of *Sargassum* beaching impacts in the Caribbean Sea area and Africa. The subcommittee is analysing the most appropriate and cost-effective action where GlobalHAB in collaboration with GESAMP and the EuroSea European project, and other entitites investigating *Sargassum* arrivals contribute to provide tools to cope with this important problem in tropical areas. The initial idea of holding an Open Science Meeting could be replaced by a hybrid (virtual and in presence) workshop or an alternnative activity. GlobalHAB will provide futher information on this in autumn 2022.

5.2. Scientific Summary for Policy Makers about HABs and Climate change. A document has been elaborated by the GlobalHAB SSC members, coodinated by Po Teen Lim. The aim is to have it ready at the end of 2022.

5.3. Symposium in Xiamen and session summary for HAB session "HABs under changing climate" (https://melmeeting.xmu.edu.cn/xmas/session.asp). Po Teen Lim will present the program GlobalHAB in this HAB session to be held in January 9th-12th 2023.

Convenors: Po Teen Lim (University of Malaya), DaZhi Wang (Xiamen University), HaiFeng, Gu (Third Institute of Oceanography, MNR, Xiamen), YingZhong Tang (Institute of Oceanology, Chinese Academy of Science, IO-CAS).

Session Description: Harmful Algal Blooms (HABs) occur due to the proliferation of harmful microalgae in the aquatic ecosystems, resulting in deleterious effects on the coastal communities. This included the contamination of commercially important shellfish, massive mortality of farmed or wild finfish, and damage to the value of the marine ecosystem. The increasing impacts of HABs on the socio-economy and public health are tremendous, affecting regionally and globally, partly because of the emergence of new HAB events in areas with no prior record, also, involving novel toxic species. Owing to the increasing HAB occurrence and intensity, sustainable development of the rapidly growing aquaculture industries in many coastal countries has been hindered by HAB-related fish kill and shellfish toxicity events. In this proposed session, we will focus on several aspects of HABs: 1) dynamics of HABs, from molecular to ecological levels; 2) physiological and molecular responses of HAB species to biotic and abiotic drivers; 3) monitoring and forecasting of HABs using novel tools and

instrumentation for early detection and warning; 4) development and application of techniques to mitigate and minimize the impact of HABs. Trends of HAB events (species, occurrence, and frequency) under the changing climate will also be a topic of interest in this session. Presentations related to the collaborative effort to strengthen regional and international collaborations and joint research efforts in addressing the expanding HAB issues in the region are also welcomed.

5.4. A quantitative PCR (qPCR) workshop. The activity, organized by Raffaele Siano, aims to promote the use of eDNA approaches in monitoring harmful algae and specifically the use of qPCR for species detection. The workshop will convey international experts on HAB qPCR approaches in order to foresee to which extent eDNA and qPCR can be used in HAB monitoring. Virtual meetings will be organised before the in person meeting in October 2023, in China or Malaysia (TBD). There will be 15 participants of different counties and continents. A 1st virtual meeting: brainstorming to discuss the main indeas will be held in Fall 2022 and a 2nd meeting for preparing the workshop in May 2023.

5.5. GlobalHAB International Workshop on Solutions to Control HABs in Marine and Estuarine Waters

A workshop on **solutions to control HABs** in marine and estuarine waters that will build on lessons learned from freshwater HAB control is planned.

Organizers: Vera Trainer[1], Quay Dortch[1], Marc Suddleson[1], Zhiming Yu[2], Tae-Gyu Park[3], Natsuko Nakayama[4], Don Anderson[5], Heather Raymond[6]

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[3]*Southeast Sea Fisheries Research Institute,* National Institute of Fisheries Science (NIFS), Tongyeong, Republic of Korea

[4]*Environmental Conservation Division, Environment and Fisheries Applied Techniques Research Department, Fisheries Technology Institute,* Japan Fisheries Research and Education Agency (FRA), Hatsukaichi, Japan

[5]Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, US

[6]Ohio State University, Columbus, Ohio, 43210, US

Possible sponsors: GlobalHAB, ICES/PICES, NOAA. Working on endorsement from the UN Decade of Ocean Sciences for Sustainable Development.

Timeframe: 2023. The workshop can be linked to the International Conference on Harmful Algae (ICHA 2023) planed in October 2023 in Hiroshima, Japan and to the PICES\ICES joint conference in Seattle (Fall 2023). However, on the 4th July 2022, ICES announced the postponement of this joint ICES-PICES meeting and issued the following statement:

> *'The joint ICES–PICES conference 2023 has been postponed. An ICES Annual Science Conference (ASC) will instead be organized in 2023. We are in negotiations with a possible venue and more information will be provided as soon as possible.*
>
> *We will soon open a call for theme session proposals on our website.*
>
> *The postponement is based on ICES Council decision that places a temporary suspension of Russian participation in ICES activities.'*

6. Funding considerations and future funding plans

SCOR authorized GlobalHAB to use the remaining funds, $33,000 USD in 2021-2022, to conduct the actitivies postponed due to the Covid19. This extension allowed conducting the planned activities and produce the scientific outcomes papers, new knowledge, training and coordination to implement the GlobalHAB science plan.

Similarly, GlobaHAB got permision to use the funds until 2024 from NOAA's National Centers for Coastal Ocean Science (NCCOS) Competitive Research Program (CRP) via the US National HAB Office through the IOC Science and Communication Centre on Harmful Algae at University of Copenhagen, Denmark, for the postponed activities due to Covid-19.

GlobalHAB helps the organizers of the new planed activities to obtain new funds for their implementation.