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Report of the ICES/PICES/IOC-GEOHAB Workshop on Harmful Algae Blooms in a Changing World (WKHABCW)

18-22 March 2013

Friday Harbor Laboratories, USA



ICES

International Council for
the Exploration of the Sea

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Executive Summary

Highlights

The workshop Chaired by Mark Wells, Bengt Karlson and Raphael Kudela convened at the Whiteley Center, Friday Harbor Laboratories, University of Washington for a week of discussions and presentations. The 11 participants began the workshop by presenting their perspectives on the most pressing concerns about climate change effects on HABs. The following three topics then were considered through a combination of breakout and collective group discussions:

- 1) Assessment of the state of understanding of HAB's and climate change, focusing on the research topics of greatest need and likelihood of achieving over the next decade,
- 2) Description of two types of sentinel sites for observing change based on existing long term monitoring stations.
 - a) The first would be "observer" or "sentinel" sites, where a minimal set of parameters are added to those measured at most long term oceanographic monitoring sites. A second, shortened list of most key parameters were identified that could be measured in places where monitoring is not now done, or where instrumentation or expertise is limited. The goal at these sites is to detect change in HABs, by either capturing shifts in existing HAB frequency and intensities or the expansion of HABs into new areas.
 - b) The second set of sites, referred to as "super" sites, would be fewer in number and include a list of more sophisticated sampling goals. Beyond simply detecting change in HABs, these "super" sites would enable study of the ecological and oceanographic processes contributing to this change.
- 3) Detailed discussion on preliminary plans for an Open Science Symposium that focuses the HAB research community on: a) the bar needed to establish with high confidence that observed changes are due to climate change, b) to highlight the priority directions for HAB research on climate change related issues, and c) to attract new, non-traditional HAB researchers with new tools and expertise. The latter goal deals with the realistic outlook that funding for HAB research is not going to increase, but that there are fields of climate change research where the addition of HAB topics would both strengthen their goals while advancing HAB research in general.

Participants decided upon three approaches for communicating the workshop findings to the broader community. The first is as a journal publication (probably to Harmful Algae) that presents the detailed considerations covered during the workshop. The manuscript outline was prepared during the latter stages of the workshop and preliminary writing of this joint manuscript is underway. A second more condensed summary of the workshop findings will be prepared as a "commentary" type manuscript for Nature or Science that will help directs potentially interested non-HAB researchers to the main paper. Third, the background and central findings will be written for the broader public in an "opposite the editorial" (Op/Ed) format for newspaper and magazine distribution.

1 Welcome and opening of the Workshop

The WKHABCW met March 18-22, 2013 at the Whiteley Center, Friday Harbor Laboratories, University of Washington. There were 11 invited participants from 5 countries, listed in Annex I.

The meeting goal was to assess what is known with certainty about existing climate change effects on the distribution, character and intensity of Harmful Algal Bloom (HAB) events, assess what the most pressing research issues are that likely can be addressed over the next decade, and identify the infrastructure needs for making significant advances in our understanding of HABs.

This workshop was organized as a “grass roots” effort by the organizers with funding provided through PICES, NOAA and SCOR-GEOHAB. The participants prepared a written statement before the workshop on their perspectives on the most pressing and achievable research goals and needs.

2 Adoption of the agenda

The participants reviewed the agenda (Annex 2) and this was adopted without any change.

3 Terms of References

SSGHIE EG resolutions approved in 2011

ICES/IOC/PICES Workshop on “HABs in a Changing World” (WKHABCW)

2011/2/SSGHIE08 The ICES/IOC/PICES Workshop on “HABs in a Changing World”

(WKHABCW), chaired by Bengt Karlson*, Sweden, Mark Wells*, USA, and Raphael M. Kudela*, USA will be held at Friday Harbor Laboratories, Washington, USA on 18–22 March 2013 to:

- a) Review and consider recent research of climate effects on the ecology of HAB species and trophic interactions;
- b) Review and consider recent research on climate effects on the physiology/toxicity of HAB organisms;
- c) Review and consider recent research the impacts of projected changes in macro- and micro-nutrient distributions on HAB organisms.

Workshop participants will decide on the final topic areas after the initial discussions. The specific outcome of the workshop would be a participant-authored journal article communicating the synthesis of primary research directions to the broader HAB research community.

WKHABCW will report by 30 April 2013 (via SSGHIE) for the attention SCICOM.

4 Term of References A-C

4.1 Introduction

4.1.1 It was decided by the workshop participants to consider the three terms of references together.

- a) Review and consider recent research of climate effects on the ecology of HAB species and trophic interactions;
- b) Review and consider recent research on climate effects on the physiology/toxicity of HAB organisms;
- c) Review and consider recent research the impacts of projected changes in macro- and micro-nutrient distributions on HAB organisms.

The central links between climate change and HABs were considered first in terms of the known changes in physical parameters what is known about how these parameters affect the broad range of HAB organisms and their competitive success. The key underlying foundation of HAB occurrences pens upon the HAB species “getting there”, is being adapted well enough to “remain there” over the course of the season, and ultimately to “stay there” for multiple seasons. Three broad classes of HABs were discussed;

- 1) Toxic-HABs that impact human health (marine and freshwater cyanohabs) or have demonstrable ecosystem effects (e.g. domoic acid effects on marine mammals and birds, cyanohab effects on livestock).
- 2) Fish-Killing-HABs, whereby the causative organisms may be dinoflagellates (e.g. brevetoxins), raphidophytes (e.g. *Heterosigma*) and other genera that affect both wild fish and aquaculture operations.
- 3) High Biomass-HABs, whether derived from natural or anthropogenic processes, that can cause hypoxia, produce large quantities of foam leading to bird deaths and potential human impacts, generate anti-tourism effects (noxious), stimulate pathogenic bacteria activity, or negatively affect aquaculture operations.

Participants identified a fourth type of potentially emerging HAB-type concern as nutritionally inadequate blooms (NIPs). In this case, anthropogenically or naturally generated largely mono-specific blooms for prolonged periods may lead to depletion of one or more essential fatty acids in lower trophic levels with possible cascading effects on fecundity and survival throughout the foodweb. However, given the absence of key data on these potential effects, participants did not specifically address this issue in the climate change discussions.

The deliberations focused on the observed and predicted climate changes in the physical and chemical conditions in aquatic systems identified in the AR4 IPCC Synthesis Report on climate change, and what is known about these effects on the physiology of both general phytoplankton as well as HAB species. The central questions asked were: what do we know about how the given parameter affects HAB species, what do we not know of importance in terms of this parameters impacts, and which of these unknowns are the most pressing questions and how should we go about addressing them? Participants recognized that much of the past HAB research has focused on the specifics of HAB organisms rather than addressing how HAB organisms interact with non-HAB species. Given that any changes in HAB occurrences associated with climate change will represent a shifting balance between HAB species within the broad-

er phytoplankton community, there needs to be a fundamental shift in HAB research to take into account these interactions.

The key factors considered included direct temperature effects on HAB and non-species, including cellular growth rates, nutrient uptake rates, toxin production, and cellular lipid compositions among other factors. Interlinked with temperature was increased degrees and duration of stratification of the water column, with its effects on not only nutrient inputs but also stability of the system against change. Changes in nutrient availability were considered, due to linked-changes in stratification but also as a result of changing precipitation characteristics with its effects on nutrient transport from terrestrial environments to coastal waters. Changes in precipitation were particularly important in terms of altering anthropogenic inputs associated with the increasing population of the coastal zones over the next few decades. The effects of ocean acidification on HAB species success and cellular toxin production and accumulation were discussed. A limited degree of evidence so far indicates that this may be a significant driving factor for altering the impacts of HABs with climate change. Discussion over the impacts of climate change on grazing pressure and mortality was less certain, given the considerably lower degree of our understanding of how mortality impacts bloom signatures. A shift towards “jellyfish” dominated predation has been predicted but very little is known about how this may disproportionately affect HAB species. Changing light regimes associated with increasing or decreasing cloud cover and increasing stratification was the only factor participants found unlikely to have a specific HAB associated impact. Although there will be clear impacts on the plankton community composition and production overall, based on available data it appears that HAB species would not be selected for or against by these changes. A complete discussion of these findings will be presented in a manuscript for submittal for publication in *Harmful Algae*.

New approaches to HABs and climate change research were considered by the participants. In addition to establishing “super” sites for studying the in situ dynamics among HAB and non-HAB species, several other approaches were identified. These included the “common garden” style culture experiments, where many laboratories situated around the globe conduct identical experiments using precise established procedures to test the effects of one or more parameters on a single species isolated from local waters. This approach provides the ideal mechanism for evaluating species response as well as characterizing the inter-strain variability. Other methods included cross-sectional research programs such as mesocosms and other enclosures using standardized methods, design, analysis, and assessment. Participants also identified a strong need to develop measures for dealing with HAB outbreaks, including proactive (avoidance), abatement (halting) and mitigation (reduced impact) strategies. In addition, there is a need for virtual assessment approaches to understand past outbreaks and forecasting future outbreaks built upon detailed conceptual or heuristic models.

Measuring the change in HAB frequency, intensity, and spatial distributions associated with climate change necessitates a network of monitoring stations. Recognizing limitations forced by funding and expertise, participants segment these monitoring sites into “Observer” sites and “Super” sites; the former being designed to simply detect the presence of HABs and the basic environmental parameters associated with their outbreaks while the latter would help inform on the ecology and oceanography of the system that led to the HAB formation. A list of key parameters was identified by participants for each type of monitoring site along with appropriate sampling strategies and frequencies. There was particular concern given to selecting easily

measured parameters for sites where instrumentation or expertise is lacking so that the network of Observer sites could be broadened greatly. In addition a list of existing known long term datasets was developed that would be appropriate to identifying the past distribution and frequency of HAB events that could serve as ideal reference points moving forward into the future.

One of the main outcomes of the workshop discussions was identifying the need for a Open Science Meeting on global change impacts on rain and freshwater HABs, to be held in 2014-2015. The goals of this workshop would be to promote research in the topics identified by this group to be of high priority over the next decade, to bring new people and expertise into the field (i.e. to make other climate change researchers aware of the HAB-related questions where there expertise and new methods may find a rich ground for research), and to help the have community identify the types of information needed to unequivocally demonstrate a linkage between HABs and climate change. Several meeting designs were discussed and a steering committee to organize the meeting was established.

5 Recommendations

5.1 Proposed ICES/IOC/PICES SCIENTIFIC SYMPOSIUM ON HARMFUL ALGAE AND GLOBAL CLIMATE CHANGE

WKHABCW recommends the following steps be taken:

- 1) In cooperation with ICES, PICES, IOC, SCOR, GOOS and GEO-HAB/GobalHAB to convene an open *Scientific Symposium on Harmful Algal Blooms and Climate Change* in 2014 or 2015 to:
 - a) provide examples of locations and events where climate change may be affecting HABs and their impacts;
 - b) identify and promote research on critical topics/aspects of the broader field of HAB research to advance our knowledge of the impacts of climate change on the global scale;
 - c) attract and retain new expertise from other scientific disciplines;
 - d) evaluate the use of new technologies for the collection and analysis of long-term data on appropriate parameters;
 - e) develop the HAB component of global climate observing systems;
 - f) foster framework activities to facilitate identifying and responding to climate change-driven effects on HABs, including risk assessment with associated , probabilities and uncertainties.;
 - g) develop best practise recommendations for research and monitoring to fill critical knowledge gaps;
- 2) The steering committee for an open scientific symposium on harmful algal blooms and climate change should be co-chaired by a representative of the PICES HAB Section, the Chair of the IOC-ICES WGHABD, and the Chair of the GEOHAB SSC and other members to be identified in consultation with the ICES, the IOC-IPHAB Chair and the Secretariats of the sponsoring organizations.
- 3) To instruct the IPHAB Task Team on HAB Observation and Forecasting Systems to review the current technologies for HAB sensors and observing systems and recommend a globally distributed network HAB observing assets in coordination with 1) e. and working within the existing plans for global observing systems.
- 4) IPHAB Nations are requested to establish long-term sampling sites capable of detecting the emerging presence of new HABs or changing characteristics in existing HABs. These sites could include a recommended minimum set of parameters or a more comprehensive set that allows investigation of the selective processes leading to HAB development.
- 5) To request the ICES/IOC WGHABD to review and advise on the progress of the preparations for the open science meeting on Harmful Algal Blooms and Climate Change.
- 6) To invite the SCOR Working group 137 and PICES Working Group 27 on North Pacific Climate Variability and Change, the ICES/PICES Strategic Initiation on Climate Change Impacts on Marine Ecosystem, and representation from the GEO Blue Planet and GOOS to contribute advice and resources to help implement the objectives above

6 Closing of the workshop

The Chairs thanked the participants for their input and closed the workshop on Friday 22 March

Annex 1: List of participants

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Annex 2: Agenda

- 1) Produce an expert assessment of what is known and uncertain about the linkages between climate change and purported changes in the character, distribution, and intensity of HABs,
- 2) Produce a review/opinion paper or a high profile journal that will:
 - a) help to guide planning for HAB research holding the greatest promise for advancing our understanding of any climate linkages,
 - b) to provide funding agencies, managers, and interested stakeholders a cutting edge assessment of current knowledge and key gaps in our understanding,
 - c) to identify a limited number of candidate sentinel sampling/monitoring sites for detecting change, if we don't have adequate coverage already, with a prioritized list of variables as part of the assessment, and
 - d) to attract interest in non-HAB researchers who are developing new tools or approaches (molecular, cellular, sensor) that would help HAB researchers capture and incorporate current advances in other fields.
- 3) Plan an open science meeting for 2015 on HABs and climate change that focuses primarily on the key areas participants feel are likely to provide the most insight.

Annex 3: Group picture

**THE ICES-PICES-IOC-GEOHAB WORKSHOP ON HARMFUL ALGAE BLOOMS IN A CHANGING WORLD, WKHABCW,
18-22 March 2013 , Friday Harbor Laboratories, USA**



Participants of the WKHABCW in 2013. Left to right: Stewart Bernard, Don Anderson, Vera Trainer, Angela Wulff, Charles Trick, Bengt Karlson, Theodore Smayda, Raphael Kudela, Mark Wells, Akira Ishikawa and William Cochlan.