

REPORT OF THE SECTION ON *ECOLOGY OF HARMFUL ALGAL BLOOMS IN THE NORTH PACIFIC*

The Section on *Ecology of Harmful Algal Blooms in the North Pacific* (hereafter HAB-S) met from 9:00 to 18:00 h on October 26, 2008, in Dalian, China. The HAB-S meeting was attended by members from Canada, China, Japan, Korea, Russia, and the United States of America (*HAB-S Endnote 1*). Other visiting scientists attended the meeting and are named below under their respective countries. The proposed agenda for the meeting (*HAB-S Endnote 2*) was reviewed and approved by the Section.

AGENDA ITEM 3

Future of HAB-S work

After giving a brief history of origins of HAB-S and its Terms of Reference (*HAB-S Endnote 3*), Co-Chairman, Dr. Vera Trainer, discussed the future of HAB-S work within PICES.

AGENDA ITEM 4

Country reports

Canada

Dr. Charles Trick informed the Section that Canada has no monitoring system for HAB phytoplankton species, and therefore, Canada cannot provide the necessary species information for PICES. Only harmful species for fish are reported, and these are not government sources. A total of 27 different *H. akashiwo* events have occurred in recent years, mostly on the outer coast of British Columbia. One event was responsible for causing 260 tonnes of dead salmon from aquaculture in northern British Columbia close to Alaska.

China

China's report, prepared by Dr. Jinhui Wang, was presented by Dr. Mingyuan Zhu. In 2007, 82 HAB events occurred in China, and similar to 'Red Tides', may or may not be toxic. The occurrences were 12% less than in 2006 (93 events), and affected an area of 11,610 km² (41% less than in 2006). Among them, 30 occurred in the HAB monitoring and management zone (as during 2006) or in nearby waters. Most HABs occurred in the East China Sea, also seen during 2006. This is the most eutrophicated region in China (riverine inputs are large from the Yangtze River). The HAB species consisted of non-toxic ones: *Skeletonema costatum*, *Chaetoceros* spp., *Prorocentrum triestinnum* and toxic ones: *Alexandrium* sp., *Karenia mikimoto*, *Phaeocystis* sp., *Gymnodinium* sp. Twenty-five toxic HAB events occurred, covering a total area of 1,906 km², a major decrease compared with 2006

Massive macroalgae blooms occurred from the end of May to August 2008: the area affected was 20,000 km², and the area covered was 400 km². The bloom species was identified as *Enteromorpha prolifera*, but some think *E. linza* was the dominant species. China has not experienced such a magnitude in the past, although it bloomed in 2007 in the same region. A total of 800 Kt of algae was physically removed from the Qingdao coastal area to ensure algae-free waters before the Olympic sailing events. The blooms came from the southwest Yellow Sea, floated on sea surface, kept growing and accumulated in coastal waters of Qingdao. Population dynamics (nutrient enrichment) was conducted, using mesocosm experiments (plastic bags and fishing nets), as well as in lab experiments. The control growth rate is relatively slow (3.85%); upon adding N, the growth rate increases. Released spores can germinate anywhere and attach to culture walls; a new sprout can grow to 50–70 cm in length in 10 days, and have a wet weight of approximately 0.4–0.7 g. Inorganic nutrient content was not very high; organic nutrients were not measured.

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We have no means to forecast such green tides, are not sure where they come from, why is they are now floating when normally they are an attached 'benthic' algae, what role physical and chemical environmental factors play in their development, what impact they have on the marine ecosystem, but we do know the algae are not toxic and are edible.

Japan

Dr. Shigeru Itakura stated that there were seven harmful algal event (HAE) regions in Japan. Major red tides occur in the western region of Japan. In 2007, paralytic shellfish poisoning (PSP) occurred 29 times, mostly in the northern part of Japan and 6 cases of diarrhetic shellfish poisoning (DSP) were reported. During August 2007, there was a large-scale offshore record outbreak of very toxic *Cochlodinium polykrikoides* in the Sea of Japan. The frequency of its occurrence is increasing in 2000s. In 2003 a large-scale bloom occurred along the coast of the Sea of Japan. Using microsatellite markers, genetic structures has revealed 3 populations of this species in Japanese waters. Satellite imagery cannot distinguish diatom blooms from blooms of *C. polykrikoides*, so verification is still needed from shipboard sampling. International cooperation with Korea was very useful. There were no reported cases of amnesic shellfish poisoning (ASP) in Japan.

Korea

Korea's report, prepared by Dr. Yangsoon Kang, was given by Co-Chairman, Dr. Hak-Gyoon Kim. Overall, HAB events seem to have decreased since 2004. No negative fisheries impacts of *C. polykrikoides* blooms were observed in 2008, but duration of the blooms was up to 50–60 days.

Very clean transparent waters are found offshore, and colder waters (< 20°C) caused a change in species composition in 2008 compared to 2007. It is thought that *C. polykrikoides* blooms in 2008 were dependent on benthic sources, not on offshore initiation, as in other years. In 2008, there was a long drought with no occurrence of typhoons and no heavy rains.

Russia

Dr. Tatiana Morozova reported that the target area for observations is Amurskii Bay, Sea of Japan/East Sea where DSP, ASP, PSP are monitored. Over the past 17 years (1991–2007), from a total of 42 HAB species identified, 13 are known as potentially toxic species; 41 bloom events have been recorded (but no known fisheries or human poisoning has occurred). Most HABs occur during July–August (dinoflagellates), and November (*Pseudo-nitzschia* blooms). There are no known data on fisheries damage. Russia is now using an enzyme-linked immunosorbent assay (ELISA) to screen for ASP and PSP toxins.

U.S.A.

Dr. Trainer informed the Section that HAE-DAT reporting is done by managers in U.S. West Coast states who send the information to the National HAB office in Woods Hole Oceanographic Institution. Only PSP and ASP (no DSP) testing is currently being done in U.S. No red tides have been reported. Fish-killing toxins are usually reported by private fish farmers. An Alaska phytoplankton monitoring program was started in 2008 by the University of Alaska in collaboration with shellfish growers.

AGENDA ITEM 5

Relations with international organizations and other HAB-S-related activities

IOC

Dr. Monica Lion, representing the IOC, reported that the Harmful Algal Event Database (HAE-DAT) was now ready for on-line input of new data. The next step was to check old data, and to invite IOC ANCA, FANSA and HANA editors to include their data. PICES focal point contacts have been invited to include new data from 2000. There were still some bugs in data products, especially maps, but everything was expected to

be resolved very soon. Data were not yet open for the general public, but the on-line website for audiences to observe products is now available at www.iode.org/haedat/.

Dr. Lion also discussed work of the IPHAB/IODE Task Team on the development of the Harmful Algal Information System (HAIS). The establishment of HAIS builds on the evolution over the past 15 years of a number of separate databases and products developed in partnership between IOC, ICES, PICES and ISSHA. In 2007, the IOC Intergovernmental Panel on HAB (IPHAB) recommended the development of such a database as a service to scientists, managers, the marine sector, education sector, politicians, and general public. The context for the Task Team was to have a voluntarily group of experts to discuss and agree on main HAIS elements and functions, following the terms of reference from IPHAB and IODE.

The outline of the HAIS Elements is:

- HA events with ICES, PICES, *et al.* (HAEDAT) [www.iode.org/haedat/],
- Biogeography with ISSHA (HABMAP) and OBIS,
- Taxonomy with IOC Taxonomic Reference List of Toxic Plankton Algae [<http://www.bi.ku.dk/ioc/>], World Registry of Marine Species (WoRMs) and EoL,
- References with ASFA (HAB-Dir) [<http://ioc.unesco.org/hab/HAB-BIB.htm>] and OceanDoc,
- Expert Directory with IODE [<http://www.OceanExpert.net>],
- Monitoring and management design with ICES (MONDAT), User interface with Encyclopedia of Life (EoL).

A draft document on HAIS was now ready, and PICES HAB-S members were invited to review it and send their comments to the Task Team (and/or Dr. Lion).

NOWPAP CEARAC

Dr. Takafumi Yoshida reported on the Northwest Pacific Action Plan's Special Monitoring and Coastal Environmental Assessment Regional Activity Centre (NOWPAP CEARAC). Thirteen regional sea programs were established under the United Nations Environment Program (UNEP).

Recent products include:

1. HAB Reference database,
2. HAB Integrated Report,
3. Homepage and *Cochlodinium* pamphlet (5 languages),
4. Booklet of Countermeasures against HABs,
5. HAB Case Studies Database and Reports.

HAB case studies are conducted in NOWPAP CEARAC member states using target sea areas where HABs frequently occur. Case study reports are then sent to NOWPAP CEARAC and updated each year, and the most effective and labor saving ways are developed to update the information.

Detection of HABs using remotely-sensed imagery

Dr. David Foley (U.S.A.) presented an overview of NOAA's CoastWatch Program which provides satellite-based oceanic data and products for near-real-time monitoring of U.S. coastal waters in support of environmental science, management, and hazard response (<http://coastwatch.pfel.noaa.gov/>). The Program would be especially relevant for providing satellite imagery for spatial extrapolation of *in situ* data related to HABs. Data sets of interest would be: *in situ* oceanographic measurements, *in situ* water quality, remotely sensed measurements, atmospheric models, and oceanic models.

PICES Seafood Safety (MAFF) Project

Dr. Trainer provided an update of the PICES Seafood Safety Project. This project began in March 2007 with funding from the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF). With assistance from IOC,

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over 20 questionnaires were submitted to IOC member countries with Pacific coastlines. These questionnaires requested information regarding the need for training in monitoring seafood safety in each country. An initial focus will be in southeast Asia, and the criteria for country selection is: (1) fisheries loss due to HABs, (2) support from the selected country's government, and (3) ability to sustain the learnings. Based on these criteria, the Philippines was chosen as the country where the first training workshop will be held in January 2009. HAB-S requests assistance from PICES in drafting an MOU with this country.

AGENDA ITEM 6

Workshops and meetings at PICES-2009

The following recommendations were proposed for PICES XVIII:

- A 1½-day workshop on the “*Cyst forming HAB species*” co-chaired by Dr. Changkyu Lee (Korea) and Dr. Charles Trick (Canada) to include a 1-day cyst identification demonstration. The abstract for this workshop is in *HAB-S Endnote 4*.
- A 1-day HAB-S meeting, including country reports for HAB events in 2006–2007 and discussion of HAEDAT use. Countries are requested to input HAB event data to HAE-DAT for 2000–2005 directly to the online database. HAB-S wishes to have presentations from PICES modelers during the HAB Section meeting in order to strengthen our collaborations in the future.
- A ½-day topic session, “*Mitigation of harmful algal blooms*”, organized by Dr. Hak-Gyoon Kim and Dr. Mark Wells (*HAB-S Endnote 5*).

AGENDA ITEM 7

Items with financial implications and recommendations

HAB-S:

- requests travel funds for 3 scientists (2 specialists (Dr. Jack Rensel, U.S.A. and a specialist from Korea) for the Topic Session and 1 specialist for the Workshop at PICES-2009). See *HAB-S Endnote 5*.
- recommends 2 new members. This is necessary due to changes in key people responsible for HAB data in these PICES member countries, and to bring young scientists into the Section. These scientists are Dr. Akira Ishikawa (Laboratory of Biological Oceanography, Mie University, Japan) and Dr. Weol-Ae Lin (Aquaculture Environment Institute, NFRDI, Korea).

AGENDA ITEM 8

Summaries of the HAB-S Topic Session and Workshop at PICES XVII

Summaries of the HAB-S Topic Session and Workshop at PICES XVII can be found in the Session Summaries section of the PICES 2008 Annual Report.

AGENDA ITEM 9

Other business

HAB-S proposes to contact the invited speakers for past Annual Meeting HAB workshops on *Pseudo-nitzscha* and *Alexandrium*, *Dinophysis* and *Cochlodinium*, *Heterosigma*, and *Karenia* and *Prorocentrum* to determine their interest in writing Wikipedia-type pages, including complete references, for the PICES or IOC website. This goal replaces the past years' suggestion of a PICES special report on selected HAB species.

HAB-S Endnote 1**HAB-S participation list**Members

William Cochlan (U.S.A.)
 Shigeru Itakura (Japan)
 Hak-Gyoon Kim (Korea, Co-Chairman)
 Olga Lukyanova (Russia)
 Michail Simokon (Russia)
 Vera Trainer (U.S.A., Co-Chairman)
 Charles Trick (Canada)
 Yasunori Watanabe (Japan)
 Mark Wells (U.S.A.)
 Mingyan Zhu (China)

Observers

Robin Brown (Canada)
 Rongshuo Cai (China)
 David G. Foley (U.S.A.)
 Hao Guo (China)
 Ruixiang Li (China)
 Weol-Ae Lim (Korea)
 Monica Lion (IOC)
 Tatiana Morozova (Russia)
 Takafumi Yoshida (NOWPAP CEARAC)

HAB-S Endnote 2**HAB-S meeting agenda**

1. Introduction
2. Approval of agenda
3. Discussion of the future of HAB-S work within PICES
4. Country reports
5. Relations with international organizations and other HAB-S-related activities
6. Workshops and meetings at PICES-2009
7. Items with financial implications
8. Summaries of the HAB-S session and workshop at PICES XVII
9. Other business

HAB-S Endnote 3**Terms of Reference**

1. To develop and implement annual bloom reporting procedures that can be consistent with ICES procedures and therefore incorporated into HAEDAT. This will be important in assessing impacts of HAB events and as a research tool to look at patterns that will lead to prediction capability.
2. To exchange national reports of HAB incidents and development in order to inform HAB Section members of new toxins, new developments, and new approaches. Both toxin producing and nontoxic (but harmful) algal species should be included.
3. To focus on specific needs for scientific advice among PICES member countries by identifying topics of interest, and providing syntheses of the available scientific information on those selected topics. Example topics for discussion and syntheses might include:
 - a. Mitigation practices to reduce the impact of HABs.
 - b. Numerical model development of harmful algal bloom initiation and transport for predictions and forecasts.
 - c. Relationship between oceanographic processes and HAB formation (*e.g.*, How the physics of nutrients, trace metals tie into bloom formation)
 - d. Organism identification using molecular biological techniques.
 - e. Discussion of possible changes to certain monitoring techniques (*e.g.*, cell numbers vs. toxin levels).

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- f. Species introductions including issues of anthropogenic sources (*e.g.*, ballast water) or natural systems (*e.g.*, species range extension).
4. Together with TCODE, to develop a metadatabase that describes HAB monitoring and research efforts in each PICES member country.
5. Support the harmonization of methods for identifying HAB species. This could include intercalibration workshops co-sponsored by PICES and ICES.
6. Development of early warning systems for the detection of HABs. This could include discussion of ocean observing systems and techniques.
7. To educate the community (managers, students) about HAB organisms. For example, an in-depth study of selected HAB species (top ten) could include information about physiology, taxonomy, *etc.*

HAB-S Endnote 4

Proposal for a ½-day MEQ Workshop and 1-day lab demonstration on “Cyst forming HAB species” at PICES-2009

Analogous to the seeds of terrestrial plants, phytoplankton cysts are the hardy resting forms that allow phytoplankton (usually flagellates) to survive during extreme environmental conditions. These cysts fall out of the water column into sediments often after large blooms, thereby forming seed beds. Characterization of the distribution of seed beds in coastal waters can assist with forecasting the intensity of HAB events. However, proper identification is often difficult as many cysts can look alike. In this workshop, we will focus on new methods for identification of cysts as well as findings on their ecology and physiology. We encourage presentations on known distributions in coastal waters (cyst mapping), and studies on their ecophysiology.

Convenors: Changkyu Lee (Korea) and Charles Trick (Canada)

Proposed invited speaker: Kazumi Matsuoka (Japan)

HAB-S Endnote 5

Proposal for a ½-day MEQ Topic Session on “Mitigation of harmful algal blooms” at PICES-2009

Mitigation includes any method that can reduce the impact or severity of HABs. These methods include both physical means, such as dispersal of clay to cause flocculation of cells from surface waters, and preventative means, such as better monitoring of coastal waters, allowing selective closures of shellfish beds (in contrast to coastwide closures). The capability for mitigation and the choice of mitigative tools depend upon the bloom-forming species, the severity of the event, and the frequency and intensity of monitoring in a region. Presentations will represent the comprehensive nature of HAB mitigation within the Pacific rim nations.

Convenors: Hak-Gyoon Kim (Korea) and Mark Wells (U.S.A.)

Proposed invited speakers: Jack Rensel (U.S.A.) and a speaker from Korea (TBD)