

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

The Section on *Ecology of Harmful Algal Blooms in the North Pacific* (HAB-S) met from 9:00 to 18:00 h on October 24, 2010, in Portland, U.S.A. The meeting was attended by members from all PICES countries except China. Other scientists attending the meeting are named under their respective countries (*HAB-S Endnote 1*). The proposed agenda for the meeting (*HAB-S Endnote 2*) was reviewed and approved. Before reviewing the goals of the meeting, Co-Chair, Dr. Vera Trainer, introduced Professor Changkyu Lee (Korea) as the new HAB-S Co-Chair, and acknowledged outgoing Co-Chair, Professor Hakgyoon Kim (Korea) for his involvement in the Section.

AGENDA ITEM 2

National reports

Canada

Mr. Robin Brown reported that currently, the only interest by Canada in HAB events is related to the possible impact of *Heterosigma* blooms on returns of sockeye salmon stocks. There has been an overall long-term decline in returns and they were extremely low in 2009. In 2007 there was a *Heterosigma* bloom in the Strait of Georgia where these sockeye salmon entered the ocean as juveniles. The Pacific Salmon Commission held a workshop on declining sockeye salmon returns where Dr. Jack Rensel spoke of recent *Heterosigma* research and possible links to the decline. The report of this workshop has been published and is available at www.cohencommission.ca/ViewExhibit.php?id=76?. A federal judiciary inquiry into the reasons for the decline of sockeye salmon stocks in the Fraser River will be completed by the Cohen Commission in 2011. This may re-focus research on stock declines, but HAB research may not be considered as either very important or contributing to salmon stock declines.

Effective December 19, 2010, a re-organization of responsibilities for aquaculture will occur in Canada. The regulation of aquaculture fisheries will shift from provincial to federal jurisdiction under the Department of Fisheries and Oceans.

China

No report was available.

Japan

Dr. Shigeru Itakura related that there were two prominent species, *Heterocapsa circulaisquama* and *Chattonella antiqua*, in the waters of Japan from 2009–2010, *Heterocapsa circulaisquama* was first observed in October 2009 in Lake Kamo, a brackish lake where oyster farming takes place. Extensive damage to this fishery has resulted. The LAMP (loop-mediated isothermal amplification) method was developed for detection of *Heterocapsa circulaisquama* cells and they were detected via this method in 2010. It was found that temperatures >25°C and salinity >20 ppt provided the best growth of these cells. Body scales were also examined for identification purposes and to confirm the species. No fisheries damage occurred in 2010 even though cells were present at high concentrations.

Blooms of *Chattonella antiqua* were studied in Yatsishiro Bay in 2009 and 2010. Blooms of this species usually occur in the JP-04 region, but in 2009 and 2010 blooms occurred in the JP-05 region as well. Monitoring is done by fishermen who take water samples from their boats to count cells at sea and report concentrations via cell phone in real time.

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During this period, an estimated \$60 million of fisheries damage occurred from losses of amberjack, yellowtail, *etc.* despite rapid sampling and identification of cells by fishermen. Countermeasures are needed to mitigate the impacts of blooms, however, those tested to date (clay, chemicals) have proven to be ineffective for these blooms.

Korea

Dr. Changkyu Lee reported on the effect of unusual occurrences of *Cochlodinium polykrikoides* blooms in the East China Sea 2009 (August) possibly linked to low salinity (high rainfall in eastern China) off Jeju Island. *C. polykrikoides* concentrations of around 41,000 cells/L were found in August 2010 but no sustained bloom occurred that year as was seen in 2009. Overall, these blooms seemed to be less intense and smaller in scale than in previous years. *Gonyaulux*, *Alexandrium* and *Scropsiella* spp. were present in the more inshore regions. *C. polykrikoides* blooms are potentially linked to lower salinity. In 2004, *C. polykrikoides* was reduced in concentration in nearshore regions and possibly pushed offshore. An increase in *Gonyaulux* sp. was seen in the nearshore region in lower salinity waters. Lower salinity in inshore waters may reduce *C. polykrikoides* concentrations, as seen in high rainfall times such as in 2009 and 2010. Recent decreases in intensity, duration, and scale of *C. polykrikoides* blooms may be signaling a succession to other HAB species, including *Gonyaulux*, *Alexandrium*, *etc.* and this succession may require a shift in research efforts to new HAB species including *Pfiesteria*, *Prorocentrum* and others.

Summary:

1. Diatom abundance was higher in 2010, but no dense blooms were observed. Why?
2. Since 2007 smaller blooms of *C. polykrikoides* have not been able to be detected via satellite.
3. There is a possible policy change occurring in Korea whereby fish farms will be moved to more offshore regions, potentially reducing inshore eutrophication.

Russia

Dr. Tatiana Orlova noted that the Vladivostok area is monitored three times per month, and includes cyst surveys and monitoring for toxins in mussels. A total of 20 bloom-forming species were recorded in 2009 and 2010, with most of these species being diatoms. Increases in dinoflagellates have generally been recorded since 2004 and changes in their summer period have been noted. A strong bloom of *Heterosigma akashiwo* was observed in Vladivostok and other areas in Peter the Great Bay in 2010. This event corresponded with hot and dry environmental conditions in the region. High chlorophyll concentrations of about 300 million cells/L were observed via satellite. In general, water properties for winter showed convection and water exchange between the shelf and the inner sea, while summertime stratification was normal, coinciding with peaks in rainfall.

U.S.A.

Dr. Trainer reported that on the west coast of the United States (Alaska, Washington, Oregon, California), PSP (paralytic shellfish poisoning) and ASP (amnesic shellfish poisoning) toxin monitoring was performed for shellfish only and that HAE-DAT reports were compiled annually by the National HAB office in Woods Hole, Massachusetts.

In Alaska, five cases of PSP were reported in 2010, resulting in two deaths. In Juneau concentrations reaching 2044 µg/100g were reported in cockles. PSP is the most serious HAB problem; only commercial shellfish are tested for the toxin, and there is a large native population that harvests for subsistence and personal use. The University of Alaska, Ketchikan, is running an Alaskan HAB monitoring program conducted by Kate Sullivan.

In Washington State, PSP closures are rare on the outer coast but more common in Juan de Fuca Strait and Puget Sound. In 2009, PSTs were measured in mussels and in 2010 very high levels of PSTs (3000 µg/100 g) were detected. No ASP closures were implemented on the outer coast in 2009 and 2010. Average upwelling index values equate to a highly retentive characteristic of the Juan de Fuca Eddy. In 2009, *Akashiwo sanguinea* was implicated in what is thought to be the largest number of deaths of marine birds due to this

organism recorded to date. Cells were detected in 2010 and large densities were found in Puget Sound. There is evidence of a shift from diatom dominance to dinoflagellate dominance (Roz Jester data) starting around 2004. The Puget Sound Sound Toxins monitoring program for HAB cell detection is in effect to provide an early warning to fish and shellfish farmers in the region. The ECOHAB-Heterosigma project is investigating toxic components and ecology of *Heterosigma* blooms in Puget Sound.

Oregon has a MOCHA (Monitoring the Oregon Coast for Harmful Algae) program which monitors for HAB species and toxins in its area. Oregon includes all events on datasheets when reporting to HAE-DAT.

California reported no PSP closures in 2010. Weekly Biotoxin Reports give qualitative assessments of phytoplankton, including HABs.

IOOS (Integrated Ocean Observing System), a network of regional ocean observing systems, includes a component to study HABs. U.S. official reports of proposed HAB research in the U.S. include the HAB RDDTT, HARNESS and ECOHAB.

AGENDA ITEM 3

Relations with international organizations

ICES report

Dr. Donald Anderson (WHOI) reported on the ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD). Their terms of reference are regularly discussed and a set of activities or subjects is discussed at each meeting. Meetings are at least 3.5 days in duration and include many countries (mostly from Europe). ICES HAE-DAT reports, unfortunately, have largely not been entered to date and pressure will be applied to those countries not entering reports. Printed reports have been completed for many countries but have not yet been input – mostly these are for recent years. New findings are reported in an informal format (a short 10 to 15 minute presentation). Recent year findings include:

- azaspiracid poisoning (AZP) found in Huelva, Spain but not the organism known to produce it, *A. spinosum*;
- a Scotland bloom of *Karenia mikimotoi*;
- a bloom of *A. fundyense* in the western Atlantic;
- *Pyrodinium bahamense* in Florida.

Dr. Anderson presented HAB-S with a number of opportunities to collaborate with ICES including: HAIS/HAEDAT data integration, workshops, special sessions at existing meetings, exchange of new findings reports and exchange of country reports.

NOWPAP report

Dr. Yoshida Takafumi (CEARAC) reported that the 2005 version of NOWPAP's HAB integrated report will be updated in the 2010–2011 biennium. NOWPAP will expand the target areas for investigation including in China, a larger area in the Republic of Korea, and the area north of Japan. A website for *Cochlodinium* information has been created and is available in the languages of NOWPAP member countries. Eutrophication status has been updated for areas of the Yangtze River estuary (China), northwest Kyusyu (Japan), Jinhae Bay (Korea), and Peter the Great Bay (Russia). A proposal by NOWPAP to hold a remote sensing training course with IOC-WESTPAC and PICES on "Remote sensing data analysis" was accepted and the course will take place prior to 2011 PICES Annual Meeting.

IOC report

Dr. Trainer, reporting on behalf of Drs. Henrik Enevoldsen and Monica Lion (IOC), noted the ongoing collaboration between the IOC/UNESCO HAB Programme and HAB-S regarding the compilation of harmful algal event data in HAEDAT, capacity development, and new areas of cooperation. Possible new foci for HAB-S, where there is potential for interaction with IOC groups and activities in 2011 include:

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- Taxonomic issues (IPHAB Task Team and IOC HAB Centre)
- HAB Observation Systems (IPHAB Task Team and GEOHAB)
- HAB and Remote Sensing (GEOHAB-IOCCG Working Group)
- HAB ecology topics (any of the GEOHAB Core Research Projects)
- HAB modelling (GEOHAB Modelling WG)
- Review of quantitative methodologies (IOC M&G 55 and associated Editors)
- Harmful phytoplankton that could potentially be transported or introduced by ballast water (ICES-IOC-IMO WGBOSV and ICES-(IOC) WKHABL)

AGENDA ITEM 4

Report on the PICES Seafood Safety Project

Dr. Charles Trick (Canada) provided a summary of HAB-S activities under the PICES Seafood Safety Project (funded by the Ministry of Agriculture, Forestry and Fisheries of Japan). The goals of the project are to build HAB capabilities in non-PICES member countries, to collect data, and to provide training courses in developing countries for monitoring, analysis, and management of HAB species, toxins and fisheries. Training consists of a tiered monitoring approach starting with analysis of phytoplankton, then, if warranted, toxin content in phytoplankton and finally, if warranted, toxin content of shellfish. Selected sites are chosen based on: (1) existing HAB problems that have resulted in fisheries losses, (2) support from the government of the selected country, and (3) potential for sustainable monitoring in the future. The first country to hold a HAB training class was the Philippines in 2009, followed by Guatemala in 2010, and the third (to be geographically distinct from the first two) will be the Cook Islands-Kiribati Islands-Samoa (which has *Ciguatera*-related problems) in 2011.

AGENDA ITEM 5

Report on the GEOHAB Ocean Science Meeting on Benthic HABs

Dr. Trick (Canada) reported on the GEOHAB-sponsored Open Science Meeting that took place in Honolulu, U.S.A. in June 2010. The meeting dealt with the taxonomy of benthic HABs, toxin comparison, regulation, nutrient controls, habitat comparisons, grazing effects, phylogenetic comparisons and ecological models. The linking of toxins to specific species, the expansion of ciguatoxins, and the frequency of outbreaks (1400 cases/100k pop. in the Cook Islands, 800 cases/100k pop. in Samoa, and 400 cases/100k pop. in the Marshall Islands) were also discussed. Other issues included nutrients and land use practices, loss of habitat/land, and loss of coral and its replacement by coralline algae, seagrass, and algal turf. It was noted that variable substrates create a problem describing the density of benthic HABs (per unit area, volume, *etc.*). Nutrient loading resulting in loss of coral plus replacement and leading to water quality issues was also addressed. Other areas of concern were toxin regulation, that many species can produce ciguatoxins, variable influence of toxin content and toxicity by habitat, and seasonal cycles of toxin content that have no relation to biomass of organisms.

AGENDA ITEM 6

Future of HAB work within PICES

After Dr. Trainer reviewed the terms of reference for HAB-S (*HAB-S Endnote 3*), discussion revolved around suggestions for future work by HAB-S. Example topics for discussion and syntheses might include:

- Mitigation to reduce the impact of HABs,
- Numerical model development of bloom initiation and transport for predictions and forecasts,
- Relationship between oceanographic processes and HAB formation (*e.g.*, How physics and nutrients, including trace metals, are related to bloom formation),
- Organism identification using molecular biological techniques,

- Changes to certain monitoring techniques (*e.g.*, cell numbers and/or toxin levels),
- Species introductions including issues of anthropogenic sources (*e.g.*, ballast water) or natural systems (*e.g.*, species range extension).

Other future work:

- Together with TCODE, develop a metadatabase that describes HAB monitoring and research efforts in each PICES member country.
- Support the harmonization of methods for identifying HAB species. This could include intercalibration workshops co-sponsored by PICES and ICES.
- Develop early warning systems for the detection of HABs. This could include discussion of ocean observing systems and techniques.
- 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.*

AGENDA ITEM 7

Events at PICES-2010

Summaries of the MEQ Topic Session (S9) on “*Conceptual and numerical models of HAB dynamics*” and the MEQ Workshop and laboratory demonstration (W3) on “*New technologies and methods in HAB research and monitoring: I. HAB species detection*” can be found in the Session Summaries section of the PICES 2010 Annual Report.

AGENDA ITEM 8

Proposals for 2011

- A ½-day Topic Session on “*HABs in a changing world*”, convened by Drs. Mark Wells (U.S.A.) and Tatiana Morozova (Russia) (see *HAB-S Endnote 4*). Travel funds are requested for 2 invited speakers.
- A 1-day Workshop on the “*Incorporation of satellite remote sensing into monitoring of HABs*” co-chaired by Drs. Tatiana Orlova (Russia), Yoshida Takafumi (CEARAC), and Vera Trainer (U.S.A.) to be preceded by a training course on satellite remote sensing for early career scientists (*HAB-S Endnote 4*). Funding is requested for at least 1 workshop speaker from the eastern Pacific. HAB-S also requests that the training course be held the week prior to the PICES Annual Meeting, ideally in Khabarovsk.
- A 1-day HAB-S meeting, including national reports for HAB events in 2006–2007 and a discussion of HAE-DAT use. Countries are requested to input HAB event data to HAE-DAT for 2000–2006 directly to the online database. HAB-S requests funding for an IOC representative (Henrik Enevoldsen, Monica Lion) to attend the next PICES Annual Meeting to discuss HAE-DAT, country maps and decadal reports.
- HAB-S requests participation by a manager/scientist(s) from China with access to HAB monitoring data to input data to HAE-DAT.
- Funds for 1 HAB-S member to attend the ICES Annual Science Meeting in Gdansk, Poland.

HAB-S Endnote 1

HAB-S participant list

Members

William Cochlan (U.S.A.)
Ichiro Imai (Japan)
Shigeru Itakura (Japan)
Changkyu Lee (Korea)
Tatiana Morozova (Russia)
Tatiana Orlova (Russia)
Vera Trainer (U.S.A.)
Charles Trick (Canada)
Yasunori Watanabe (Japan)
Mark Wells (U.S.A.)

Observers

Nicolaus Adams (U.S.A.)
Donald Anderson (U.S.A.)
Brian Bill (U.S.A.)
James Birch (U.S.A.)
Robin Brown (Canada)
Stewart Johnson (Canada)
Sangjin Lee (Korea)
Emily Olesin (U.S.A.)
Jay Parsons (Canada)
Jack Rensel (U.S.A.)
Steve Rumrill (U.S.A.)
Yoshida Takafumi (Japan)

HAB-S Endnote 2

HAB-S meeting agenda

1. Welcome and introduction of Dr. Lee as new HAB Section co-chair (Trainer and Lee)
2. National Reports
 - Canada (Trick)
 - China (Wang)/HABs in the Coastal Waters of China in 2009 (Zhu)
 - Japan (Itakura)
 - Korea (Lee)
 - Russia (Orlova)
 - U.S.A. (Trainer)
3. Relations with international organizations
 - Report on ICES HAB working group and potential areas of collaboration (Anderson)
 - NOWPAP/CEARAC report (Takafumi)
 - Joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and proposal for the future (Trainer)
4. PICES Seafood Safety Project (Trick)
5. Report on GEOHAB Open Science Meeting on Benthic HABs (Trick and Cochlan)
6. Future of HAB work within PICES

HAB-S Endnote 3**HAB-S 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 (for example, cell numbers vs. toxin levels).
 - 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**Proposals for a ½-day MEQ Topic Session on “HABs in a changing world” at PICES-2011**

The impacts of regional and global climate change and other anthropogenic forcing on the initiation, frequency and severity of Harmful Algal Blooms (HABs) are widely anticipated but difficult to identify. Often these “blooms” reflect subtle adjustments in the relative proportion of HAB species within a larger, more abundant phytoplankton community. In others, new blooms may reflect the possible climate-driven range extension of HAB species, but direct evidence that previous environmental conditions were unfavorable for bloom development normally is lacking. Ascribing HAB events to specific, but slowly evolving driving forces will demand comparative observations among similar but geographically separated ecosystems. This session invites papers that focus on emerging toxic and ecosystem disruptive HAB events as well as changing plankton assemblages that are evolving towards more frequent or intense HAB incidents. We particularly invite papers addressing long-term time series data, land use changes, effects of macro- or micro-nutrient stress on cell physiology, trophic interactions, and the impacts of changing riverine runoff, ocean development (*e.g.*,

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aquaculture, wind turbines), and ocean acidification. The goal of the session is to help formulate a better understanding of conditions enhancing the success of HAB species.

Recommended conveners: Mark Wells (U.S.A.) and Tatiana Morozova (Russia)

Suggested speakers: Gustaaf Hallegraeff (Australia), Mingjiang Zhou (China; land use changes)

Proposals for a 1-day MEQ Topic Workshop on “*Incorporation of satellite remote sensing into monitoring of HABs*” at PICES-2011

Monitoring of harmful algal blooms and the environmental factors associated with their occurrence often benefits from the addition of a satellite remote sensing perspective, but the use of satellite data is hindered by the lack the training needed to make effective use of the available data sets. The goal of the workshop is to teach participants the basic skills needed to work independently to acquire, analyze and visualize data sets derived from a variety of satellite sensors that may include SeaWiFS, MODIS, MERIS, AVHRR, and CZCS. The workshop will focus some attention on using the Ocean Color Web Data Server and developing some programming skills that will enable researchers to make use of satellite image data to answer important oceanographic questions. This workshop may include such themes as the fundamentals of bio-optics, pigment algorithms, primary production algorithms and, to a lesser extent, the underlying physical principals leading to the measurement of sea surface temperature, ocean wind speed and ocean topography. A series of lectures will detail research and monitoring efforts that use remote sensing for the study of harmful algal blooms in PICES member countries. This workshop will follow the NOWPAP/PICES/WESTPAC training class on satellite remote sensing for the study of harmful algal blooms.

Recommended conveners: Tatiana Orlova (Russia), Yoshida Takafumi (NOWPAP/CEARAC), Vera Trainer (U.S.A.)

Potential speakers: Raphael Kudela (U.S.A.), Bruce Monger (U.S.A.), Rick Stumpf (U.S.A.), Ken Furuya (Japan), Alexanin (Russia)