

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* (S-HAB) met under the chairpersonship of Drs. Vera Trainer and Shigeru Itakura on October 11, 2013, in Nanaimo, British Columbia, Canada. The meeting was attended by members from Canada, China, Japan, Korea, and Russia. Other visiting scientists attended the meeting under their respective countries (*S-HAB Endnote 1*). The proposed agenda for the meeting (*S-HAB Endnote 2*) was reviewed by the Section and approved. A new set of S-HAB terms of reference (*S-HAB Endnote 3*) was reviewed.

Day 1, October 11, 2013

AGENDA ITEM 2

Country reports and HAE-DAT usage

USA

Dr. Jerry Borchert, Washington State Department of Health, sent a presentation to be given during the meeting. This presentation described an extreme year for paralytic shellfish poisoning (PSP) in 2012 with 9 cases of this illness reported from Puget Sound. The highest concentration of PSP toxins was 10,304 µg/100 g in mussels near Kingston. On the other hand, no concentrations of domoic acid in shellfish above the regulatory level of 20 ppm were observed either in Puget Sound or the outer Washington coast. Several closures due to diarrhetic shellfish toxins were observed in Washington State in 2012, the first year that formal monitoring occurred in the state. Of the 903 shellfish samples that were analyzed, 87 contained levels of toxins above the regulatory limit of 16 µg/100g. The highest concentration of 184 µg/100g was measured at Bellingham Bay in August 2012.

Japan

Dr. Shigeru Itakura reported that there were 270 cases of red tide in 2012, most of which were in the Seto Inland Sea and Kyushu area. For each of the red tides including those that produce toxins, the number of closures was as follows: PSP – 14 cases, DSP – 5 cases, red tides – 29 cases. A *Karenia mikimotoi* red tide was observed in 2012 from mid July to early August. An extensive survey was conducted to study the horizontal distribution of the winter (vegetative) population of *K. mikimotoi* in the water column of the Bungo-Suido, using the LAMP method. With the help of fish farmers, 82 stations were sampled on the West coast of Kyushu Island. On the East coast of Kyushu Island, 20 stations were sampled. Several positive samples were found in February on the West coast. In March, no positive samples were found. It is hypothesized that there may be a front in the area where resting cells are found. HAE-DAT 2009 data were presented showing the following for that year: red tide – 19 cases, PSP – 10 cases, DSP – 14 cases.

China

Prof. Mingyuan Zhu reported that

73 HAB events occurred, affecting 7971 km² in coastal waters of China in 2012. Most events occurred in the East China Sea (38 events). Professor Zhu showed a beautiful map of the distribution of HAB in China's coastal waters in 2012. *K. mikimotoi* was the main causative species (19 events). HABs caused by dinoflagellates appear to be increasing. More than 80% of HABs are now caused by dinoflagellates. He described abalone deaths and a macroalgae bloom in the Yellow Sea. This macroalgae bloom (green tide) has now occurred for the sixth consecutive year.

Canada

Dr. Nicky Haigh reported that fish killing HABs in Canada include *Dictyocha speculum* (April 2012), *Pseudopedinella pyriformis* (May 2012) and *Chattonella* cf. *marina* (Sept 2012). *Heterosigma akashiwo* (July 2012, August 2012, June 2013) occurred at 3 sites on the central coast followed by the west coast of

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Vancouver Island. *Pseudochattonella* cf. *verruculosa* (Sept. 2013) was also seen recently. Losses to salmon aquaculture in 2012 were approximately \$6 million.

As for shellfish toxins, there were several PSP-related closures in 2012. Highest PSP concentrations occurred on the west coast of Vancouver Island. For DSP, low levels of dinophysistoxins were measured but no closures occurred in 2012 or 2013. Dr. Haigh gave a summary of the Haida Salmon Corporation's "ocean fertilization experiment", which consisted of iron dumping off Haida Gwaii. The goal of this experiment was to increase plankton in order to increase fish stocks with the theory that carbon credits would result in economic benefit to local first nation. Domoic acid was present in northern Haida Gwaii in fall–winter 2012–2013 in shellfish samples. Maximum DA was just below 20 ppm but has persisted. *Noctiluca* was found but was not causing problems.

Russia

Dr. Tatiana Morozova reported the HAB monitoring program in Russia is in Peter the Great Bay in the western part of the Sea of Japan. Cyst surveys are done 2× per year with 3× per month HAB monitoring through much of the year. In 2012–2013, 12 bloom-forming species were observed. Most were diatoms. A bloom of *Noctiluca scintillans* was observed in 2012. A bloom of *H. akashiwo* occurred in June 2012. Three ribotypes of *Ostreopsis* were noted in Peter the Great Bay. Russian ribotypes are similar to those from Jeju Island and other areas of the Japan coast. DSP toxins exceeded the regulatory level of 16 µg/100g, with the primary toxin DTX-1.

AGENDA ITEM 3

Harmful Algal Event Database (HAE-DAT) report from the joint Harmful Algal Bloom Programme

Dr. Henrik Enevoldsen could not attend the PICES meeting, but sent a presentation to be given at the S-HAB meeting on his behalf. HAE-DAT decadal maps for PICES member countries have now been created and have been posted on the IFREMER website. The goal of HAE-DAT decadal maps of HAB events is to provide a global and immediate view of harmful events around to whole world for the past decade. One dot per map is created for each toxin syndrome. The product was developed by IFREMER (France) with IOC using Google maps. All PICES member countries are currently adding events and the database should be updated to 2008 this year. This data set is now available on the web at

<http://envlit.ifremer.fr/var/envlit/storage/documents/parammaps/haedat/>

A number of questions relating to the presentation were posed by S-HAB members about the new web maps:

- Where are red tides with damage listed?
- Where are fish kills listed?
- Please send a list of entries for which you need area codes.
- Please add acknowledgement of PICES, add a PICES logo, and add agencies who contribute.
- How do we find the metadata?

AGENDA ITEM 4

Report on ICES meeting and joint workshop on HABs and climate

Dr. Mark Wells was not able to attend the S-HAB meeting, so Dr. Charles Trick gave the report. A more rigorous assessment of purported links between anticipated climate-driven changes and HABs will be accomplished in two stages. Stage I is a 5-day international conference that was held in March 2013, co-organized by Drs. Mark Wells (PICES S-HAB) and Bengt Karlson (ICES/IOC-WGHABD) and jointly sponsored by PICES, IOC/SCOR, NOAA, GeoHAB (and ICES). A focused group (~15) of key individuals with different expertise that bears strongly on climate change/HAB linkages reviewed what is known and unknown about HAB/climate linkages. A seminal paper identifying the keystone parameters and research infrastructure needed to test these purported linkages is underway. Stage II will be an Open Science Conference

to define the organizational structure and Steering Committee for a broad open International Science Meeting on HABs and climate change that would be planned for 2015. This is tentatively proposed to be linked to the international Symposium on the “*Effects of climate change on the world’s oceans*” in Brazil in 2015.

During the Stage I workshop, three core questions were discussed:

1. What do we know about how the given parameter affects HAB species?
2. What do we know of importance in terms of these parameters?
3. Which of these unknowns are the most pressing questions and how should we go about addressing them?

An important aspect of the group’s deliberations was consideration of how HAB science has progressed over the last few decades. It was agreed that there is a need for new research tools that help move science forward as well as a need for long-term collection of HAB relevant datasets across diverse geographical and oceanographic regimes. It was suggested that HAB “observer sites” be established.

AGENDA ITEM 5

Report on new MAFF project on Marine Ecosystem Health and Well-Being

Drs. Wells and Trainer on are the [project Science Team](#). The target countries and focus areas are: Indonesia (aquaculture), Guatemala (aquaculture and wild fisheries), Palau (wild fisheries). The project strategy will be a combination of workshops and social impacts studies. Workshops will be held 2–3 times at each site. A primary goal will be to conduct research on ecosystem health and human well-being. The project output will be the development of a manual for each site. Dr. Trainer, Trick and Makino will visit Guatemala in January 2014 for the initial scouting meeting.

AGENDA ITEM 6

Review of the 2012 workshop, “*The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011*”

Several countries have entered their relative intensity data for both toxin-producing and fish-killing HABs for representative outer coast and inland waters areas. These data have been made into “heat maps” which show the relative intensity of HAB occurrences from 2000–2012 and allow for country comparisons. Dr. Thomas Therriault (Science Board Chariman-elect) proposed that there might be a home for these data in FUTURE, perhaps as a collaboration with Working Group (WG 28) on the *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*. In addition, Working Group (WG 27) on *North Pacific Climate Variability and Change* and (WG 29) on *Regional Climate Modeling* are all producing products related to ocean conditions. They will have the products that we need to link these “heat maps” of HAB relative abundance over the past decade to try to answer the environmental pressures that might influence the intensity of HABs.

Day 2, October 12, 2013

AGENDA ITEMS 9–13

Special presentations

Below are special presentations that were given on the second day of the S-HAB meeting.

Tatiana Morozova: “*Diarrhetic shellfish toxins (DSTs) in Primorye, Russian Federation*”

DSTs in molluscs in 2008 showed high levels around Vladivostok. The highest concentration was 108 µg/kg. In 2009, concentrations in June were 319 mg/g – some of the highest in mussels. Guidance level is 160 µg/kg. In 2012, *Crenomytilus grayanus* showed high DSTs with high numbers of *Dinophysis* present in July 2012. Pectenotoxin, yessotoxin and azaspiracid-2 were measured. The highest concentration of DSTs measured was

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430 µg/kg. Several *Dinophysis* species are present and the highest density measured is 12,000 cells per L.

Joo-Hwan Kim (Myung-Soo Han's student): "*Improvement of aPCR methods for quantification of H. akashiwo cysts*"

These cysts are very small and have similar morphology to other cells in the sediment. The previous quantification method is most probable number (MPN) method which has the potential to over or underestimate numbers of cysts in sediment. The qPCR method has unsolved problems – DNA debris in sediment and extracellular DNA debris. Kim *et al.* used the PowerSoil DNA isolation kit and found the presence of many clustered cysts. At 75°C, distilled water was most effective for removing DNA debris.

Satoshi Nagai: "*Easy detection of multiple HAB species by nucleic acid chromatography*"

This technology is from the Kaneka Corporation. Single cell PCR is possible. This method can detect target species from natural plankton assemblages, but some nonspecific bands occur. It is useful to distinguish among *Alexandrium* species and is essentially a detection chip for nucleic acid chromatography. It needs only 3 µl of PCR product. Five to six different genes can be detected per chip by multiplex PCR. No false positives are apparent.

Ichiro Imai: "*Prediction of toxic algal bloom occurrences and adaptation of scallop aquaculture industry to blooms for minimizing economic losses in Hokkaido, Japan*"

Scallop production in China is 1 million tons per year. The world's second biggest producer is Japan at 500,000 tons per year. Most scallops (80%) are produced in Hokkaido. However, PSP contamination closes this fishery. There is an urgent need for prediction of PSP in the Okhotsk Sea. In a PSP year, there is a weak Soya warm current and smaller difference in the water level along the coastline. Using knowledge of these environmental factors conducive to PSP, successful forecasting was possible in 2011 (no PSP!). Successful prediction of PSP in 2012 was possible using this method. There was high density of *A. tamarense* in early June. The local government issues these predictions which are used by local fishermen. Harvesting and shipping occurs from December–April, prior to the high PSP season (mitigation).

Vera Pospelov: "*Resting cysts of C. polykrikoides in surface sediments from aquaculture sites of southern S. Korea*"

Cochlodinium cyst abundance matched very well with sites where vegetative (swimming) cells have been found. She requested preserved cyst reference material or high quality images to assist with identification. On the northernwestern side of Vancouver Island – many "strange" cysts were found. Dr. Nicky Haigh commented that the species of *Cochlodinium* in British Columbia, Canada, is *C. fulvescens*.

During the S-HAB meeting, two poster presenters gave brief talks:

Svetlana Esenkulova: "*Isolation of HAB species affecting aquaculture on west coast of Canada*"

Both water samples and sediment from bloom areas are collected for culture establishment.

Chang-Hoon Kim: "*Water quality improvement by polychaete rock worm in integrated culture with olive flounder*"

An integrated multi-trophic aquaculture approach to mitigating nutrient to coastal waters using the polychaete rock worm was described.

AGENDA ITEMS 14 AND 15

Proposals for the future

Our quick exchange of new findings was focused on the S-HAB contribution to FUTURE. For FUTURE to have any realistic hope of achieving meaningful predictions/forecasts of future ecosystem states, it is critical that the link between environmental conditions and the nature of primary production be characterized.

The more proactive climate/ecosystem models reduce primary producers into 2 or 3 “boxes”, based largely on size or specific function — it is critical that they now incorporate consideration of ecosystem disruptive primary producers, including:

- High biomass, monospecific blooms (phytoplankton, macroalgae, hypoxia),
- Toxic blooms (toxic diatoms, fish-killing species, toxic dinoflagellates),
- Food-web disruptive blooms (species that facilitate jellyfish blooms),
- Nutritionally-inadequate blooms (physiological or species driven changes in production of essential fatty acids).

We must go beyond the current focus on carbon processing/climate linkages to ecological/climate linkages — requiring an entirely new approach.

Effective modeling/forecasting of ecosystem changes associated with climate change will require establishing the “windows” of opportunity for ecosystem disruptive blooms. S-HAB will focus its efforts for FUTURE in the following areas:

- We cannot predict HABs or Ecosystem Disruptive blooms - We can only establish how these blooms may change temporally or geographically (aka. Environmental “Market” Reports).
- S-HAB is well positioned to provide key input to help define the edges of these “windows” which, when linked with appropriate physical and human dimension models, can provide “Market Forecast” outcomes.
- PICES S-HAB workshop and session outputs include characterizing the ecophysiology of key HAB species in the PICES region.
- HAE-DAT (Global database on HAB events) will provide valuable trend datasets.

AGENDA ITEM 16

Topic Session and Workshop for PICES-2014

In addition to a 1-day S-HAB meeting, a 1-day Workshop on “*Mitigation of Harmful Algal Blooms: Novel approaches to a decades long problem affecting the viability of natural and aquaculture fisheries*” and a ½ day Topic Session on “*Emerging issues with lipophilic shellfish toxins*” were proposed by S-HAB members for PICES-2014 (*S-HAB Endnote 4*). The S-HAB meeting will include member country reports for HAB events in 2008–2009 and a discussion on HAE-DAT use. Countries are requested to input HAB events data to HAEDAT for 2000–2009 directly to the online database.

AGENDA ITEM 17

Proposals to the Science Board

Funds are requested for:

- a. 1 invited speakers for the proposed Workshop on “Mitigation of HABs”.
- b. 1 expert speaker for the proposed Topic Session on “Lipophilic toxins”.
- c. PICES/NOWPAP sponsored PICES Scientific Publication on “Economic and social impacts of HABs on aquaculture and fisheries”.
- d. 1 S-HAB member to attend the annual IPHAB in Paris, France in April 2013 (Dr. Charles Trick).
- e. a “Climate and HABs” steering committee member to attend the IPHAB meeting in April 2013 (Mark Wells) and for the Open Science Meeting in 2015.
- f. S-HAB members on the task team to develop a period Global Harmful Algal Bloom Report: Vera Trainer (USA) and Shigeru Itakura (Japan) – it is not known when this task team will meet.
- g. Recommended PICES members of the Global HAB Scientific Steering Committee for the Global HAB Programme are Charles Trick (Canada) and Ichiro Imai (Japan). It is not known when this SSC will meet.

*We dedicate our participation at this conference and
our continued work as members of the Section on
Harmful Algae to the memory of our esteemed
colleague, Professor Mingyuan Zhu.*

S-HAB Endnote 1

S-HAB participant list

Members

Chunjiang Guan (China)
Hao Guo (China)
Ichiro Imai (Japan)
Shigeru Itakura (Japan, Co-Chairman)
Satoshi Nagai (Japan)
Tatiana Morozova (Russia)
Vera Trainer (USA, Co-Chairman)
Charles Trick (Canada)
Takufumi Yoshia (Japan)
Mingyuan Zhu (China)

Observers

Svetlana Esenkulova (Canada)
Nicky Haigh (Canada)
Myung-Soo Han (Korea)
Chang-Hoon Kim (Korea)
Jin Ho Kim (Korea)
Joo-Hwan Kim (Korea)
Vera Pospelova (Canada)
Tamara Russell (Canada)
Tom Therriault (Canada)

S-HAB Endnote 2

S-HAB meeting agenda

1. Welcome, goals of HAB Section meeting, review of terms of reference (Shigeru Itakura)
2. Country Reports (2012-13) and HAE-DAT (year 2009) reports
Korea (Changkyu Lee) - CANCELLED
USA (Jerry Borchert, Dr. Charles Trick, speaker)
Japan (Shigeru Itakura)
China (Ruixiang Li)
Canada (Charles Trick)
Russia (Tatiana Orlova & Tatiana Morozova)
3. The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and country maps (Henrik Enevoldsen & Vera Trainer)
4. Report on ICES Meeting and Joint Workshop on HABs and Climate (Charles Trick)
5. Report on New MAFF project, Marine Ecosystem Health and Human Well Being (Charles Trick)
6. Review of Workshop, *"The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011"* (Charles Trick)
7. Assignments for the evening (ALL)
8. Welcome and review of previous day (Shigeru Itakura)
9. Diarrhetic shellfish toxins in Primorye, Russian Federation (Tatiana Morozova)
10. Improvement of previous qPCR method for quantification of *Heterosigma akashiwo* cyst (Joo-Hwan Kim)

11. Easy detection of multiple HAB species by nucleic acid chromatography (Satoshi Nagai)
12. Prediction of toxic algal bloom occurrences and adaptation of scallop aquaculture industry to blooms for minimizing economic losses in Hokkaido, Japan (Ichiro Imai)
13. Spatial distribution and identification of resting cysts of *Cochlodinium polykrikoides* in surface sediments from the aquaculture sites of southern South Korea (Vera Pospelov)
14. HOT Topics – short discussions of hot topics or novel, interesting findings (ALL)
15. Final discussion of Proposals for the Future and Review of assignments (ALL)
16. Discussion about Sessions and Workshops for 2014 (ALL)
17. Proposals to Science Board

S-HAB Endnote 3

New Terms of Reference for the Section on *Ecology of Harmful Algal Blooms in the North Pacific*

Summary

There is a strong need to ascertain what currently is known about the environmental conditions that favor initiation and maintenance of different types of harmful algal bloom (HAB) events, and the natural vs. anthropogenic driving mechanisms that influence their prevalence. This critical assessment will serve as a springboard to focus attention on the research issues of greatest importance over the next decade. It also will help to proactively identify the fundamental parameters and research infrastructure needed to effectively hindcast current changing HAB distributions; the first step in gaining the capacity to forecast future HAB patterns in a changing climate.

- Continue PICES member country data entry into the joint ICES-PICES harmful algal event database to allow global comparison of changes in harmful algal bloom occurrences;
- Convene workshops and sessions including joint sessions with other international organizations to evaluate and compare results and maintain an awareness of state-of-the-art advances outside the PICES community;
- Convene a joint PICES/ ICES workshop to assess the purported links between climate change and HAB character, frequency and severity, and publish a comprehensive review paper that identifies the near- and long-term research priorities and the monitoring structures needed to effectively hindcast and forecast future HAB events;
- Produce and post on the PICES website papers that document the unanimous HAB Section opinion on timely subjects related to HABs, including topics related to FUTURE such as how human activities (increased cultural eutrophication and climate changes including temperature, changes in stratification and ocean acidification) might affect harmful algal bloom incidence and magnitude.

S-HAB Endnote 4

**Proposal for a 1-day MEQ/FUTURE Workshop on
“Mitigation of Harmful Algal Blooms: Novel approaches to a decades long problem affecting
the viability of natural and aquaculture fisheries” at PICES-2014**

Co-convenors: Mark L. Wells (USA), Charles Trick (Canada), Shigeru Itakura (Japan), Changkyu Lee (Korea)

Harmful Algal Blooms have substantial economic, societal, and human health impacts in coastal waters worldwide, from equatorial to high latitude environments. Our increasing reliance on the economic services of coastal waters is threatened by the apparent increasing frequency and severity of HABs globally. Currently, clay dispersal in Korean waters is the only pragmatic operational program for mitigating HAB effects on coastal aquaculture operations. The trade-off, namely smothering of benthos with rapid sedimentation of clays, is not acceptable in many nations, leaving them with any mitigation strategies. This full day workshop will open with presentations on current rules for testing and implementing mitigation strategies in PICES nations to set the stage for considering HAB mitigation. Participants then will deliberate on novel physical, chemical, and biological control strategies and research paths that have potential for minimizing or eliminating HAB effects without significant coincident impacts on ecosystem health. The aim of the workshop is to develop independent evaluation of mitigation strategies that are effective, transformative and sustainable for individual PICES nations, and to provide a framework to advance the scientific collaborations and funding strategies to move mitigation research into the 20 century.

**Proposal for a 1/2-day MEQ Topic Session on
“Emerging Issues with Lipophilic Shellfish Toxins” at PICES-2014**

Co-convenors: William Cochlan (USA) and Ichiro Imai (Japan)

While primarily associated with blooms in Europe and some Asian coasts, lipophilic toxin events are increasingly shaping the phytoplankton communities in PICES nations. We anticipate that these toxins will be a FUTURE problem for all PICES member nations and threaten the sustainability of aquaculture. Tumor-promoting, mutagenic and immunosuppressive effects, shown in animals to be associated with lipophilic shellfish toxins, including okadaic acid (OA) and the dinophysistoxins (DTXs), have not yet been quantified in humans. However there is speculation that chronic exposure may increase the risk of gastrointestinal cancers. The lipophilic toxins in shellfish can be divided into four groups of toxins with different chemical structures and biological effects: OA and its derivatives, the DTXs; the pectenotoxins (PTXs); the yessotoxins (YTXs); and the azaspiracids (AZAs). These toxins can often be found in combination in shellfish. Some western Pacific nations have a long history of problems with some of the lipophilic toxins, but new toxins, such as azaspiracids, have recently appeared. In addition, the Salish Sea (US and Canada) has recent reports of illnesses due to DTXs. PICES member nations are initiating lipophilic toxin analysis as a more standard part of their seafood safety testing. We propose to consider research details that broaden our knowledge on the three primary ecological questions: how did these lipophilic toxin-producing species enter into PICES waters and what regulates toxin production? What factors have allowed these species to out compete natural phytoplankton populations? And will these lipophilic toxin-producing species remain in our coastal waters? These discussions will be guided by FUTURE science themes, with special attention to potential linkages to climatic and anthropogenic influences, to enable forecasting of these harmful events.