

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 chairmanship of Drs. Vera Trainer and Changkyu Lee from 14:00 to 18:00 h on October 13, 2011, in Hiroshima, Japan. The meeting was attended by members from Canada, China, Japan, Korea, Russia, and the United States of America. 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.

AGENDA ITEM 2

Country reports and HAE-DAT usage

Canada

In 2011, a diarrhetic shellfish poisoning (DSP) event resulted in 60 illnesses on Salt Spring Island, British Columbia. This incident showed that toxic shellfish transported to other areas of Canada could result in a country-wide problem. A *Heterosigma akashiwo* bloom occurred at Departure Bay in 2007 and 2011. The year 2011 showed a more intensive bloom compare to 2007. Domoic acid in mussel tissue had a bit higher toxic level in 2007. More paralytic shellfish toxins closures were observed in 2011 than 2007

China

In China, three types of problematic tides are observed: Red tide, Green tide, and Brown tide. Most notable were *Cochlodinium polykroides* (Southern China) and *K. mikimotoi* blooms in 2012.

Japan

In 2011 there were 245 cases of harmful algal bloom events including 387 in the East, 98 on Seto Inland, and 110 on Kyushu Island. There were 20 cases of fisheries damage, 18 PSP toxin closures and 14 DSP toxin closures. An interesting correlation with the effect of the tsunami in Japan was observed after the Tohoku earthquake in 1960. During the following year, a large PSP event resulted in 1 death and 10 illnesses. Over 8–10 times higher numbers of cysts were observed after the tsunami. A 2012 *Karenia* bloom resulted in a large economic damage of over 14 billion USD on the west side of the Shikoku area. Unusually heavy rainfall was the most important factor. In the early phase, the bloom was in 5–8 m layer of the water column; in the later phase, the bloom was in the surface layer, as determined by a vertical profiler.

Korea

Cochlodinium polykrikoides was observed at 41 cells/mL in 2010 and 1 cell/mL in 2011. In 2012, large *C. polykrikoides* blooms were associated with very high water temperatures (7–12°C in August), and higher salinity water compared to other years. A continuous *C. polykrikoides* bloom in 2012 pointed to the possibility that this strain may have had different genetic characteristics. Usually *C. polykrikoides* dies at temperatures below 20°C but several thousand cells were observed even below 20° in 2012. In 2012, the total number of HAB events was 33, with fish kill events totaling 20 and non-fish kill events at 13. An ongoing project involves monitoring around Jeju Island whose biogeography, favorable substrate and genetic diversity makes it an ideal study site. Monitoring of benthic dinoflagellates from macroalgae by scuba has shown some ciguatoxin-producing species in Korean waters.

Russia

Okadaic acid in bivalve tissues from Amurskii Bay ranged from 54.46 to 247.1 µg/ kg in June 2012. The level of okadaic acid was >160 µg/ kg in May, June, and November. Five species of *Pseudonitzschia* were observed in Amurski Bay waters in 2012. Epiphytic dinoflagellates observations included 2 species. Mycocytes and trichocysts were concentrated in the upper area *Ostreopsis* cells. Potentially toxic dinoflagellates were observed in Amurskii Bay and Peter the Great Bay.

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USA

The Alaska Harmful Algal Bloom (AHAB) monitoring partnership is a volunteer-based program that provides early warning of HABs to shellfish growers in Alaska. Weekly phytoplankton monitoring joined with on-site microscopy allows volunteers to identify HAB species in a timely fashion. In Washington State, the Department of Health, Washington Sea Grant, and the NOAA Marine Biotoxins Program are working together to develop an early warning system, called SoundToxins, for HABs in Puget Sound. This program has helped to identify problem sites for new *Dinophysis* blooms that produce diarrhetic shellfish toxins. Monitoring toxins in shellfish has shown that diarrhetic shellfish toxin 1 and not okadaic acid, is the primary toxin in shellfish in this region. The Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) sponsored "Living Laboratory Ecosystem Approach" is characterizing toxins produced by *Heterosigma akashiwo*, a flagellate that causes millions of dollars loss to the net-pen salmon fishery. In 2012 in Oregon, a small number of *Pseudo-nitzschia* were observed, and some paralytic shellfish toxins. In northern California, *Gonyaulax spinifera* caused a massive dieoff of invertebrates, including sea stars and abalone. A major kill of chinook salmon (larger fry) in Alaska was observed, possibly due to HABs.

AGENDA ITEM 3

S-HAB new Terms of Reference

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. S-HAB revised Terms of Reference can be found in *S-HAB Endnote 3*.

AGENDA ITEM 4

The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and country maps

Dr. Henrik Enevoldsen (IOC) could not attend the PICES meeting, but sent a presentation to be given at the HAB-S meeting on his behalf. HAE-DAT decadal maps for PICES member countries have now been created and will soon be posted on the ICES 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 map is created per toxin syndrome. The product was developed by IFREMER (France) with IOC using Google maps API. To date, PICES member countries have entered 375 events (USA), 285 events (Japan), 262 events (Canada), Korea (8 events), Russia (3 events) and China (2 events). All PICES member countries are currently adding events and the database should be updated to 2007 this year.

AGENDA ITEM 5

Report on ICES meeting and areas of ICES/PICES collaboration

A more rigorous assessment of purported links between anticipated climate-driven changes and HABs will be accomplished in 2 stages:

Stage I. A 5-day international conference is planned for March, 2013, co-organized by 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 will review what is known and unknown about HAB/Climate linkages. This will result in production of a seminal paper identifying the keystone parameters and research infrastructure needed to test these purported linkages.

Stage II. The above conference will define the organizational structure and Steering Committee for a broad International Open Science Meeting on HABs and Climate Change that would be planned for the following year (2014, 2015).

The 2013 ICES-IOC WGHABD meeting will be held in Belfast, Northern Ireland from April 9–12, 2013. PICES travel support will be requested for a S-HAB member to participate in this meeting and IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB) for followup on the HAB workshop report, the Fish-Killing Algae report and for planning of the Open Science Meeting on HABs and Climate Change.

AGENDA ITEM 7

Topic Session and Workshop for PICES-2013

In addition to a 1-day S-HAB meeting, one Workshop and one Topic Session were proposed by S-HAB members for PICES-2013 (*S-HAB Endnote 4*). S-HAB meeting will include member country reports for HAB events in 2007–2008 and a discussion on HAEDAT use. Countries are requested to input HAB event data to HAEDAT for 2000–2008 directly to the online database.

A proposed 1½-day Workshop will focus on “*The economic impacts of harmful algal blooms on fisheries and aquaculture. Part I: What is known*”; Co-convenors: Vera Trainer (USA) and Chang Hoon Kim (Korea). The ½-day Topic Session will deal with “*Emerging issues with diarrhetic shellfish poisoning*”; Co-convenors: Charles Trick (Canada), Ichiro Imai (Japan).

AGENDA ITEM 8

PICES/MAFF Seafood Safety Project - Final report

A “responsible sentinel approach” was used by S-HAB in the PICES Seafood Safety Project (5-year project from 2007–2012, funded by the Ministry of Agriculture, Forestry and Fisheries of Japan) entitled “*Development of the prevention systems for harmful organisms’ expansion in the Pacific Rim*” in which knowledgeable and trained scientists could train students and community members in selected non-PICES member countries to watch for the “symptoms of change” caused by harmful algal bloom (HAB) events in their regional fisheries and ecosystems.

A series of training classes that covered anthropogenic changes in coastal waters, sampling and measurement of toxins and cells, the critical needs for monitoring projects, and the importance of phytoplankton in healthy, coastal ecosystems were given to community workers and regional scientists in selected Pacific communities outside the PICES region.

S-HAB members established strong relationships through routine contact to develop strong socio-ecological connections, successfully avoiding “helicopter science” but embedding themselves into the decision making of three enthusiastic communities (Manila, Philippines, 2009; San José/Guatemala City, Guatemala, 2010; Jakarta/Lombok Island, Indonesia, 2012) to ensure sustainability in current and emerging fisheries while attempting to safeguard the health of their citizenry from HABs.

In the Philippines there is strong, high-level support at the Ministry level. S-HAB has effectively integrated its toxin screening tools and other ideas into the country’s monitoring plan. In Guatemala, the government is supportive of management. The project there is sustainable in that there is monitoring in place. This program is succeeding due to a very strong leader at the University of San Carlos, Guatemala City, with strong Ministry support and connections. S-HAB wishes to further the relationship in Guatemala by continuing its collaboration during the new PICES project on “*Marine ecosystem health and human well-being (sato-umi)*” that is also being funded by MAFF. In Indonesia, S-HAB has achieved strong support with the government institution (LIPI) directorate. Training has 2 focused areas: the central facility for monitoring in Jakarta and a

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regional laboratory on Lombok Island that is interested in aquaculture development. S-HAB efforts in the South Pacific Islands was logistically challenging and focused on benthic harmful algal blooms and ciguatera. Although they were very positive regarding our collaboration, a training class was not held in this 23-island nation. We hope that future collaborations might be possible.

AGENDA ITEM 9

Review of PICES-2012 Workshop

S-HAB reviewed the 1½-day Workshop on “*The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011*”. A complete description and summary of the Workshop can be found in the Session Summary section of the PICES-2012 Annual Report.

AGENDA ITEM 10

New PICES/MAFF project

Dr. Mark Wells and Trainer on are the steering committee of the new PICES/MAFF project on “*Marine ecosystem health and human well-being*”. A primary goal will be to conduct research on ecosystem health and human well-being. The target countries and focus areas are: Indonesia (aquaculture), Guatemala (aquaculture and wild), Palau (wild). The project strategy will involve a combination of workshops and social impacts studies. Workshops will be held 2–3 times at each site. The project output will be the development of a manual for each site.

AGENDA ITEM 11

Proposal from WG 21

Ms. Darlene Smith, Co-Chair of the Working Group on *Non-indigenous Aquatic Species* (WG 21) proposed that the WG perhaps could be combined with S-HAB due to the fact that the WG 21’s term has now come to an end. There was interest by some members of the WG to continue its work, but waning motivation by some of its membership. S-HAB felt that its primary mission is to study phytoplankton and that by joining with the WG 21 scientists, the Section’s goals would be diluted.

AGENDA ITEM 12

Proposals for the future

S-HAB’s quick exchange of new findings focused on the Section’s 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 consider 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).

S-HAB felt strongly that it 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. The HAB-S 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.
- HAEDAT (Global database on HAB events) will provide valuable trend datasets.

AGENDA ITEM 13

Requests to Science Board

Travel funds are requested for:

- 2 invited speakers for the PICES-2013 Workshop (tentatively Dan Leschine, USA; Grant Murray, Canada; Shigeru Itakura, Japan; and/or Ann Guerry);
- 1 expert speaker for the PICES-2013 Topic Session (tentatively Dr. Won Ho Lee, Korea, Dr. Suzuki, or Dr. Myungil Park);
- 1 local student rapporteur for S-HAB at PICES-2013;
- 1 PICES S-HAB member to attend both the ICES-IOC WGHABD meeting in Belfast, Northern Ireland, and IPHAB in Paris, France in April 2013 (1 trip);
- S-HAB requests new members to be considered either due to retirements or needed expertise. Proposed new members include: Chunjiang Guan (China), Douding Lu (HAE-DAT focal person in northern China), Stephanie Moore (USA), Chang Hoon Kim (Korea).

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

William Cochlan (USA)
 Chunjiang Guan (China)
 Ichiro Imai (Japan)
 Shigeru Itakura (Japan)
 Akira Ishikawa (Japan)
 Sangjin Lee (Korea)
 Changkyu Lee (Korea, Co-Chairman)
 Tatiana Morozova (Russia)
 Satoshi Nagai (Japan)
 Tatanya Orlova (Russia)
 Vera Trainer (USA, Co-Chairman)
 Charles Trick (Canada)
 Mark Wells (USA)
 Mingyuan Zhu (China)

Observers

Svetlana Esenkulova (Canada)
 Jingfeng Fan (China)
 Nicky Haigh (Canada)
 Nobuharu Inaba (Japan)
 Takeo Kurihara (Japan)
 Ruixiang Li (China)
 Masa Ohyama (Japan)
 Inna Stonik (Russia)

S-HAB Endnote 2

S-HAB meeting agenda

Saturday, October 13, 2012

1. Welcome, goals of S-HAB meeting (Lee)
2. Country Reports (2011-12) and HAE-DAT usage
 - Canada (Trick)
 - China (Zhu)
 - Japan (Itakura)
 - Korea (Lee)
 - Russia (Morozova)
 - USA (Trainer)
3. Discussion of proposed new Terms of Reference (Lee)
4. Joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and country maps (Henrik Enevoldsen and Vera Trainer)
5. Report on ICES Meeting and Joint Workshop on HABs and Climate (Wells)
6. Assignments for the evening (All)

Sunday, October 14, 2012

Welcome and review of previous day (Trainer)

7. Discussion of Topic Session and Workshop for PICES-2013
8. PICES/MAFF Seafood Safety Project - Final Report (Trick)
9. Review of results of PICES-2012 Workshop (Wells)
10. New MAFF project, Marine Ecosystem Health and Human Well Being (Trainer)
11. Proposal from WG 21
12. Exchange of information on collaborative studies, new findings, significant publications from each country
13. Request to Science Board

S-HAB Endnote 3

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

1. 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;
2. 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;
3. 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;
4. 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 1½-day MEQ Workshop on
 “Economic impacts of harmful algal blooms on fisheries and aquaculture” at PICES-2013**

Harmful algal blooms (HABs) have adverse economic and social impacts on the aquaculture industry, human health, coastal economies, and wild fisheries. HABs have prompted routine closures of both commercial and recreational shellfish harvesting as well as the death of aquaculture finfish resulting in financial losses in coastal communities. But the economic impacts generated by these events extend far beyond the industry itself. Obtaining more realistic estimates of HAB economic impacts, and the costs of preventing and managing them, calls for an integrated assessment approach that comprises the following; the economic impact of HABs on the aquaculture industry, the secondary integrated industries, and consumers, on both local and regional scales; some valuation of the costs and benefits of taking any recognized steps to lessen the HAB problem (e.g., reducing coastal pollution and other human-related activities); and weighing the costs and benefits of enhanced monitoring and surveillance that potentially reduces the magnitude of the impacts (e.g., by limiting shellfish harvesting closure windows or alteration in the timing of finfish harvesting). This workshop comprises 2 parts, with the first being presentation of what is known about the economic and social impacts of HABs in the eastern and western Pacific, by both HAB researchers and invited speakers who can inform on cutting edge approaches and methodologies for assessment of HAB and other marine economic impacts (e.g., oil spills). In Part 2 participants will identify specific steps for developing improved and more comprehensive economic impact assessments of HABs on fisheries and aquaculture in the north Pacific.

The thrust of the workshop, and the direct findings and insights that will be derived, directly addresses two FUTURE Research Themes, namely, (1) what determines an ecosystem’s intrinsic resilience and vulnerability to natural and anthropogenic forcing, and (2) how do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future?

Co-convenors: Vera Trainer (USA) and Chang Hoon Kim (Korea)

Invited speaker: Daniel Huppert (USA)

**Proposal for a ½-day MEQ Topic Session on
 “Emerging issues with Diarrhetic Shellfish Poisoning” at PICES-2013**

While primarily associated with blooms in Europe and some Asian coasts, Diarrhetic Shellfish Poisoning (DSP)-producing blooms are increasingly shaping the phytoplankton communities in PICES nations. Some western Pacific nations have a long history of DSP problems. Now the Salish Sea (US and Canada) has recent reports of illnesses due to DSP toxins. Nations are initiating DSP analysis as a more standard seafood safety assay. Even with a rich history of research, the induction of growth of DSP-producing cells is unevenly understood. We propose to consider research details that broaden our knowledge on the three primary ecological questions: how did the DSP-producing species enter into PICES waters and what regulates their toxin production? What factors have allowed these species to out compete natural phytoplankton populations? And will these DSP-producing species remain in our coastal waters?

Co-convenors: Charles Trick (Canada) and Ichiro Imai (Japan)