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 chairmanship of Drs. Vera Trainer and Shigeru Itakura on October 17, 2015, in Qingdao, China. The meeting was attended by members from Canada, China, Japan, 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 and approved by the Section.

AGENDA ITEM 1
Goals of FUTURE

Dr. Sinjae Yoo, member of the FUTURE Scientific Steering Committee (SSC) presented a talk on the new structure and status of FUTURE whose goals are to ensure a collective and integrative delivery of FUTURE. Drs. Guangshui Na, Sinjae Yoo and Toyomitsu Horii are the FUTURE SSC liaisons to S-HAB.

AGENDA ITEM 2
Country reports and HAE-DAT usage

Canada

Dr. Nicky Haigh reported that 2015 was an unusual year. The harmful algal monitoring program (HAMP) observed more harmful diatoms in 2015 than usual. "The Blob" – a large warm water mass off the U.S. west coast may have influenced an extensive diatom bloom offshore, including *Pseudo-nitzschia*, that can cause amnesic shellfish poisoning (ASP). More harmful *Chaetoceros* and lower dissolved oxygen (DO) events than usual were observed in the summer. These are usually seen in spring, not summer. Mid-western Vancouver Island temperature was anomalously high starting in week 18 of 2015 (early May). Some sites had very low DO throughout May until the summer (especially mid-western and northwestern sites). *Heterosigma akashiwo* average, maximum and 2015 levels were noted for each of the 5 HAMP monitoring regions. Low abundances of *H. akashiwo* were seen early in the season on the west coast of Vancouver Island, possibly due to the warm water blob.

China

Dr. Douding Lu reported that in 2013, there were 13 causative HAB species reported including *Prorocentrum donghaiense*, *Noctiluca scintillans*, *Aureococcus anophagefferens*, *Heterosigma akashiwo*, *Phaeocystis globosa*, *Cochlodinium geminatum*, and *Prorocentrum miniimum*. In 2014, there was a high HAB occurrence with most blooms occurring in the Bohai Sea and East China Sea. Approximately 80% of the HABs were caused by flagellates. They are the main component of HAB species in China and may be increasing in occurrence. *P. donghaiense* blooms begin offshore and are brought onshore in conjunction with the monsoon. The ecosystem effects of these blooms are changes in motility of zooplankton and changes in their egg laying behavior. *Karenia mikimotoi* blooms cause severe economic losses in China. *Alexandrium tamarense* (group IV) can co-occur with *Prorocentrum* blooms in May. *Alexandrium fundyense* (group I of the tarmarense complex) is located in highest concentrations in the Bohai Sea. *Cochlodinium polykrikoides* is found in small blooms. *H. akashiwo* was found for the first time in the Dalian area. There was no record of it in 2002 and 2014. *P. globosa* clogged the water cooling system for power plants in the South China Sea. In June 2013, large green tides reached some beaches – a recurrent phenomenon.

Japan

Dr. Shigeru Itakura reported that Dr. Setsuko Sakamoto would be the new HAE-DAT contact for Japan. In 2013–2015, *Karenia mikimotoi* became a more dominant species in coastal Japan and caused about 13 million USD in damage to fisheries in the southern part of Japan – Hiroshima Bay, Seto Inland Sea region, and Sasebo

Bay. The bloom developed over a month in the Bungo Channel in 2012. *K. mikimotoi* grows well at lower salinity, *e.g*., 25 psu, but the optimal growth rate is at 25°C Fish farmers at 82 stations did sampling to complement sampling by boat. A 4 cm diameter hose was used to take a vertical plankton sample. *K. mikimotoi* was detected using the LAMP (loop-mediated isothermal amplification) method. Uwajima was the only location where cells were found.

In 2013–2014, the major HAB species included *Chattonella*, *H. akashiwo*, *C. polykrikoides*, *Heterocapsa circularisquama*, and *K. mikimotoi*. Of 23 reported cases of *H. akashiwo* blooms, only 2 resulted in fish kills in 2013; of 23 cases in 2015, only 3 resulted in fish kills. Of 35 cases of *K. mikimotoi*, 15 were fish kill cases. This year's fishery damage (2015) is $3 million USD.

Korea

No Korean member was present to give a report.

Russia

Dr. Tatiana Orlova reported that there were three main issues in Russia – toxic species seasonal dynamics, early warning, and mechanisms of occurrence. There is high biodiversity of harmful algae in Russia – over 40 species have been identified as toxin producers. Most monitoring is in Amurskii Bay and Peter the Great Bay near Vladivostok. The Center for Monitoring of Harmful Algal Blooms and Biotoxicity in Coastal Waters, IMB FEB RAS, has a program in culturing toxin-producing species and performing molecular genetics. In 2013–2015, the Center found 13 bloom-forming species with diatoms as the predominant type. *Pseudo-nitzschia calliantha* formed blooms and *Thalassiosira* species have formed blooms under ice. An intense bloom of the prymnesiophyte *Pseudohaptolina birgeri* (a newly observed species) was observed at 270 million cells/L. Monitoring showed that 17 strains of *Pseudo-nitzschia* have been found in 2013–2015 in Peter the Great Bay. *P. callianta*, *P. multistriata*, *P. delicatissima*, and *P. pungens* have been found to produce domoic acid. No *P. australis* has been found. The highest cellular domoic acid (DA) concentrations were found in cultures of *P. multistriata* and *P. calliantha*. Very low quantities of DA were found in shellfish (a maximum of 0.5 mg/kg in viscera). However, cultures produce DA. In 2008, *Ostreopsis* was found for the first time in Russian waters. *Ostreopsis* has been found each subsequent year at high abundances (up to 100,000 cell/g dry weight) with a peak in spring. Genetically these *Ostreopsis* are similar to those observed near Jeju Island, Korea. These similar species are toxin producers. *Prorocentrum foraminosum* is a new benthic species in eastern Russia waters. This species was found to produce dinophysistoxin-1 (Kamaneva *et al*., *Toxins* 2015, 7: 3947–3959). *Noctiluca scintillans* and *Dinophysis acuminata* were reported in the harmful algal event database (HAE-DAT). *D. acuminata* concentrations reached 0.5 million cells/L. *Mytilu edilus*, *Mytilus grayanus*, clams, and oysters contained okadaic acid in the summer.

USA

Dr. Vera Trainer reported on the large-scale, long-lasting *Pseudo-nitzschia* bloom off the U.S. west coast, beginning in spring 2015. It resulted in closures of the razor clam and Dungeness crab fisheries, resulted in some of the highest toxin levels ever measured in anchovies and seawater, and caused marine mammal mortalities. The bloom impacted many sites along the west coast, including the U.S. and western Vancouver Island, Canada, in early May 2015. Cruises of opportunity made it possible to sample along the continental shelf from California to Alaska during summer of 2015. These samples will be analyzed for particulate and dissolved domoic acid to determine the spatial distribution of the large HAB event. NOAA declared an Unusual Mortality Event (UME) in Alaska due to the deaths of fin whales, humpback whales and a gray whale that may be associated with this HAB.

AGENDA ITEM 3
Scientific papers

"*Emergency monitoring of green tides in the Yellow Sea*" authored by Peng Zhao, Jingtian Guo, Juan Huang, Ruifu Wang and Liang Zhao – Dr. Zhao reported that the North China Sea Marine Forecasting Center (NMFC)

is responsible for observation and forecasting. Green tides are associated with eutrophication of marine environments and have occurred annually in the Yellow Sea since 2007. *Ulva prolifera* is the major organism. Green tides have seriously influenced sports events (*e.g.*, 2008 Olympics). Economic losses reached 1.32 billion Chinese yuan. The North China Sea Branch is a government agency that forecasts and mitigates these events. Satellite remote sensing has been used for tracking since 2008. Green tides develop in late May–July. If a green tide crosses north of 35°N latitude, ships are sent for monitoring. Aircraft are used to monitor in Shandong Province. Vehicles are also sent to monitor impacts on beaches and tourist areas. Modelling is used to predict movement.

"*Prey cells and extraction trigger DSP toxin production by Dinophysis acuminate*" authored by Han Gao, Xinlong An and Mengmeng Tong – Dr. Gao reported on *D. acuminata* prey cells and triggering cellular toxin production. A publication by Li *et al*. (2012) documented diarrhetic shellfish poisoning illness in the East China Sea in 2011. Changes in N, P had no effect on the growth of *Dinophysis* or cellular toxin. Organic nutrients or cell fragments of prey will stimulate growth and toxicity. *Dinophysis* cells were provided with ciliates or ciliate fragments. Higher growth was observed with 3000 per ml ciliates. The 50% crushed treatment showed the highest growth rates. *Mesodinium rubrum* debris impacted growth and toxin production. Cryptophyte debris did not impact growth but did influence toxin production.

"*Modelling Prorocentrum donghaiense blooms in the coastal waters of the East China Sea*" authored by Ke Sun, Zhongfeng Qiu, Wei Fan, Yijun He and Zexun Wei – Dr. Sun reported on the modelling of a *P. donghaiense* bloom in the East China Sea (ECS). The Changjiang River estuary is eutrophic and a prime area for HABs every spring. *Karenia mikimotoi* and *P. donghaiense* followed a *Skeletonema costatum* bloom. Sun *et al*. tested the theory that P limitation drives the initiation of the *P. donghaiense* bloom in the subsurface waters. They used a multi-nested ROMS model.

"*HAB monitoring in Paris Bay (the north-western part of the East/Japan Sea) where marine mammals are kept in captivity*" authored by Anna Ponomareva and Olga G. Schevchenko – presentation cancelled.

"*Karenia mikimotoi bloom, massive fish-killing and shellfish-killing in the East China Sea*" authored by Tian Yan and Mingjiang Zhou. – Dr. Yan spoke about *K. mikimotoi* blooms killing fish and shellfish in the ECS. Various pathways of toxicity have been proposed for *K. mikimotoi*, including hemolytic compounds, reactive oxygen species, mucus, *etc*. In spring 1998, fish kills caused 350 million RMB in economic losses in Hong Kong's Guangdong Province. In spring 2005, fish kills causing 40 million RMB losses in Zhejiang Province. Pathology shows damage of fish gills. In spring 2012, Fujian Province experienced 200 million RMB in economic loss to the abalone industry. With sufficient DO, ideal pH, *etc*., *K. mikimotoi* still kills fish, so it was determined that there must be a direct toxic effect of this organism to the abalone. The immune status of abalone was affected by *K. mikimotoi*. Rabbit blood cells were used to test hemolytic activity. Crude methanolic extract showed non-lethal effects on abalone. Hemolytic compounds did not appear to be involved, therefore, there is a need to further explore the toxic mechanisms.

AGENDA ITEM 4
Collaboration with NOWPAP

Dr. Takafumi Yoshida reported on the joint PICES/NOWPAP Study Group on *Scientific Cooperation in the North Pacific Ocean* (SG-SCOOP). NOWPAP is interested in providing regular information updates through regional reports every 5 years. NOWPAP plans to actively participate in S-HAB meetings, develop mechanisms for sharing information on HABs from the regions of overlap, and continue the organization of joint sessions, workshops and reports. PICES interests are in regular information updates through regional reports and understanding dynamic mechanisms for future forecasting potential. SG-SCOOP was established to explore new areas of collaboration between PICES and NOWPAP, and a framework between the two organizations is now in place. HAB research is a high priority activity for the two organizations., Past focus was on HABs and remote sensing. Now the focus is eutrophication but with an interest in HABs. Screening is

being used to find potential eutrophic areas in the NOWPAP region. Screening includes: COD/TOC, red tide events, hypoxia events and chlorophyll *a* (through remote sensing). Maps will be available on the NOWPAP website showing potential eutrophic zones. The relationship between red tide occurrence and eutrophication will be useful for investigation so NOWPAP can provide its member states with advice on how to manage river inputs and how to manage their coastal resources. NOWPAP is an environmental program whereas PICES is more focused on fisheries, but with broader interests in coastal water quality issues (through some of its working groups and the FUTURE science program).

AGENDA ITEM 5
Update on Marine Ecosystem Health and Human Well-Being (MarWeB) projects

Drs. Charles Trick and Vera Trainer reported on the status of the 5-year PICES project on "*Marine ecosystem health and human well-being*" (MarWeB) funded by MAFF (Ministry of Agriculture, Forestry and Fisheries) through the Fisheries Agency of Japan, in which S-HAB is providing training and support to developing countries. MarWeB deals with the relationship between marine resources and the wellness of communities. Dr. Trick discussed the Guatemalan study which is looking for ways to explore an alternative to wild fishing by helping to establish an aquaculture possibility with the mangrove oyster. The other part of the study is dealing with performing a community needs assessment and social science survey. A questionnaire devoted to understanding the needs of the community was delivered to two coastal communities (Las Lisas and Monterrico, Guatemala) in February 2015: (1) What do they want, what are they missing? (2) How could we measure success if change were to occur? The intention is for the S-HAB members of the MarWeB Project Science Team to assemble a local team that is community driven, not science driven.

AGENDA ITEM 6
Joint ICES/PICES/GEOHAB symposium on "*HABs and climate change*"

Dr. Mark Wells reported on the joint ICES/PICES/IOC/SCOR symposium on "*Harmful algal blooms and climate change*" held from May 19–22, 2015, in Göteborg, Sweden. The purpose of this symposium was to bring together algal physiologists, ecologists, oceanographers, modelers and climate change specialists to present the most recent scientific results and to ascertain the most pressing future research needs. The 4-day symposium included 67 participants from 24 countries who provided 28 oral presentations and 28 poster presentations. Breakout group discussions were expected lead to a report and publication on HABs and climate change. The goals of the breakout groups were to:

- Identify critical research topics;
- Prioritize these research areas over the next 5–10 years;
- List new tools, experimental strategies, observation infrastructures and linkages to other programs;
- Identify key species/strains for focused HABs/climate change research.

A high priority resulting from the discussions highlighted the need for a "best practices" manual. The major conclusions of the workshop were:

- There is concern about HABs and climate change but scientific basis and data to prove this link is lacking;
- Toxic HABs are the result of competitive interactions, so HAB and climate change interactions need to be considered in the context of the plankton systems;
- An increased focus on multifactorial experiments with priority HAB species is critical to obtaining a foundation for model forecasting;
- A subset of key sentinel sites associated with Ocean Observing System networks need to be identified (a task for IPHAB and GOOS).

AGENDA ITEM 7
Report on publication on "*HABs and climate*" from PICES/ICES/IOC workshop

Dr. Wells reported that the results of a PICES/ICES/IOC workshop on "*Harmful algal blooms in a changing world*" held March 18–22, 2013, in Friday Harbor, USA, are now summarized in a publication in the journal *Harmful Algae* (2015; 49: 68 DOI: 10.1016/j.hal.2015.07.009). The structure of the paper discusses the parameters: temperature, stratification, light, ocean acidification, nutrients, and grazing, HABs and climate as well as linkages to other programs, put into context of FUTURE, is also provided in PICES Press, Vol. 23, No. 2, pp. 25–27.

AGENDA ITEM 8
IOC/IPHAB Global HAB Status Report

Dr. Trainer reported little progress on the Global HAB Status Report, but reviewed the background and goals of IOC Decision IPHAB-XI.2. Decision IPHAB-XI.2 on the "Development of the Harmful Algal Information System" in the Report describes the resolution to invite PICES' S-HAB to participate in a Task Team project on the development of a periodic Global Harmful Algal Bloom Status Report that shall:

1. Provide a global status and overview of HAB events and their societal impacts;
2. Provide a global overview of the occurrence of toxin producing microalgae;
3. Assess the status and probability of change in HAB frequencies, intensities, and range expansions resulting from global change.

The goal will be to provide access to high quality data on current taxonomic names of harmful algae, the biogeography of harmful species and occurrence of harmful algal events, and to provide details of monitoring and management systems to scientists, managers of regulatory monitoring programs, and policy administrators. Data will be shared with WoRMS (taxonomy reference list), HAE-DAT (harmful algal events), and OBIS (biogeography data). The PICES HAE-DAT focal points are:
Canada – Dr. Jennifer Martin, Nicky Haigh,
China – Dr. Chunjiang Guan,
Japan – Dr. Setsuko Sakumoto,
Korea – Drs. Changkyu Lee, Taegyu Park,
Russia – Drs. Tatiana Morozova, Tatiana Orlova,
USA – Dr. Don Anderson (Vera Trainer to replace Rita Horner).

The PICES OBIS and WoRMS focal points are:
Canada – Drs. Nicky Haigh, Charles Trick,
China – Dr. Chungjiang Guan,
Japan – Dr. Setsuko Sakumoto,
Korea – Drs. Chang Hoon Kim, Taegyu Park,
Russia – Drs. Tatiana Orlova, Tatiana Morozova,
USA – Dr. Vera Trainer.

AGENDA ITEM 9
Workshop proposals for PICES-2016 and other requests

S-HAB agreed to focus a workshop on *Pseudo-nitzschia* for PICES-2016 to follow the successful workshop on harmful raphidophytes held during PICES-2015. The S-HAB workshop on "*Conditions promoting Pseudo-nitzschia events in the eastern but not the western Pacific*" (*S-HAB Endnote 3*) will be led by Drs. Vera Trainer (USA) and Polina Kameneva (Russia) who will provide "homework" for each country to prepare prior to the workshop. This homework will include describing the biological, physical and chemical characteristics associated with *Pseudo-nitzschia* blooms in each of the member countries.

S-HAB requests:

1. Travel support for 1 PICES representative to attend the Global HAB Scientific Steering Committee meeting. The meeting is anticipated to be held in Europe in 2016. Estimated total: ~$4,000 USD.
2. Funding for 2 invited speakers (expert(s) to talk about *Pseudo-nitzschia* in the eastern and western Pacific) for a workshop at PICES-2016. NOWPAP may fund 1 speaker. Estimated total: ~$2,500 USD.
3. Funds for publication of a "best practices" manual recommended as a priority need at the 2014 PICES/ICES/GEOHAB workshop on "*Harmful algal blooms in a changing world*". Travel support is requested for two S-HAB members to travel to a mini-workshop to discuss manual design. Estimated total: ~$5000 USD.
4. Funds for publication of a *Heterosigma* paper (W1 on "*Contrasting conditions for success of fish-killing flagellates in the western and eastern Pacific – A comparative ecosystem approach*" from PICES-2015) in peer-reviewed journal (Spring 2016; see paper outline discussed during the workshop in *S-HAB Endnote 4*).

AGENDA ITEM 10
Other business

Dr. Shigeru Itakura (Japan) stepped down as S-HAB Co-Chair. The membership unanimously nominated Dr. Douding Lu (China) as the new S-HAB Co-Chair. Dr. Satoshi Nagai stepped down as member representing Japan. Drs. Setsuko Sakamoto and Ryuji Kuhara were introduced as new members from Japan.

Dr. Trainer reviewed member assignments before adjourning the meeting.

S-HAB Endnote 1

S-HAB participant list

Members

William P. Cochlan (USA)
Chunjiang Guan (China)
Hao Guo (China)
Ichiro Imai (Japan)
Shigeru Itakura (Japan, Co-Chairman)
Ryuji Kuwahara (Japan)
Douding Lu (China)
Tatiana Yu. Orlova (Russia)
Setsuko Sakumoto (Japan)
Vera L. Trainer (USA, Co-Chairman)
Charles Trick (Canada)
Mark L. Wells (USA)
Takufumi Yoshida (Japan)

Observers

Lorrie Backer (USA)
Svetlana Esenkulova (Canada)
Chunlei Gao (China)
Jingtian Guo (China)
Nicky Haigh (Canada)
Gao Han (China)
Daisuko Hasegawa (Japan)
Chuanlin Huo (China, MEQ Chairman)
Polina Kamaneva (Russia)
Takashi Kamiyama (Japan)
Yeseul Kim (Korea)
Song Heon Lee (Korea)
Soonmi Lee (Korea)
Renyan Liu (China)
Xiaoxu Liu (China)
Pang Min (China)
Ke Sun (China)
Youngbaek Sun (Korea)
Yongliang Wei (China)
Tian Yan (China)
Sinjae Yoo (Korea)
Hao Zhang (China)
Peng Zhao (China)
Yuping Zhou (China)

S-HAB Endnote 2

S-HAB meeting agenda

1. Welcome, goals of HAB Section meeting (Itakura, Trainer)
2. Country reports (2013–15) and HAE-DAT (year 2008)
   - China (Douding Lu)
   - USA (Vera L. Trainer)
   - Japan (Shigeru Itakura)
   - Korea (Changkyu Lee)
   - Canada (Charles Trick)
   - Russia (Tatiana Morozova)
3. Review of scientific papers presented at the S-HAB meeting
4. Collaboration with NOWPAP
5. Update on Marine Ecosystem Health and Human Well-Being (MarWeB) projects (Trick, Trainer)
6. Joint ICES/PICES/GEOHAB symposium on HABs and Climate Change in Sweden, May 2015 (Wells)
7. Report on publication on "*HABs and climate*" (Wells)
8. IOC/IPHAB Global HAB Status Report – contribution by PICES member countries (Itakura, Trainer)
9. Discussion of workshop proposals, part III, Contrasting conditions for success of selected harmful algal species in the western and eastern Pacific – a comparative ecosystem approach
10. Other business

S-HAB Endnote 3

Proposal for a 1½-day Workshop on
"Conditions promoting Pseudo-nitzschia events in the eastern Pacific but not the western Pacific"
at PICES-2016

Conenors: Vera L. Trainer (USA) and Polina Kameneva (Russia)

Invited speakers: Ryan McCabe (University of Washington), TBD

Potential Co-sponsor: NOWPAP

There is clear evidence of contrasting occurrence and impacts of the toxin-producing diatom, *Pseudo-nitzschia*, between the western and eastern Pacific. In 2015, a massive bloom spanning from California to Alaska, had major impacts on the economic viability shellfish industry and on wildlife health. In contrast, *Pseudo-nitzschia* are not highly toxic and do not cause economic losses in the western Pacific. These data provide a unique opportunity for east-west Pacific comparisons to identify and rank those environmental factors that promote harmful algal bloom (HAB) success at different times. The recent PICES-funded workshop on HABs and Climate Change emphasized the importance of studying such extreme events to further our understanding of climate impacts. This workshop will focus on *Pseudo-nitzschia*,a diatom that historically had massive economic impacts in the eastern PICES member countries, with low or no impacts in the western Pacific. The workshop foundation will be an extension of the current dataset to the 1990s and earlier where available, with PICES participants pre-submitting available data on: HAB species presence, maximum abundance, toxicity, optimal conditions for growth, time of year, temperature range, salinity range, water clarity, nutrients, wind, river flow (flooding), and upwelling indices. Workshop participants will evaluate the trends and patterns in these data to develop hypotheses for development into outlook products on day 1, and develop a detailed outline for manuscript preparation on day 2, including writing assignments and submission deadlines. The manuscript will be targeted for an appropriate peer-reviewed journal.

S-HAB Endnote 4

Workshop 1 plan for preparing a paper for submission to a journal

Plan for a publication to be submitted to a peer-reviewed journal, *e.g*., *Harmful Algae*

1. A publication resulting from this workshop will focus on *Heterosigma akashiwo*, a species for which there are data from each PICES member country;
2. Background material, maps and data for inclusion will be included in the publication.

Paper components

1. Background material (2–3 pages for each member country), including:
   - Historical *H. akashiwo* blooms, including summary information on maximum cell abundance needed for fishery impact, types of fisheries that are impacted and whether wild or aquacultured fish that are impacted. Also include seasonality, whether all blooms are toxic or not;
   - Culture data showing growth rates under different environmental conditions including T, S, macronutrients, and trace metals;
   - Any other relevant background information.
2. Map showing regions in each member country, including regions that experience no *H. akashiwo* blooms. However, there should be a maximum of 4 regions in each member country that have data for *H. akashiwo*. These may or may not correspond to HAE-DAT area codes, but should consider local coastal oceanography. Maps should show where historical blooms of *H. akashiwo* have occurred, distinguishing toxic from non-toxic blooms.
3. Table from each member country documenting *H. akashiwo* maximum cell abundance, average temperature (0–1 m) and average salinity (0–1 m) for each month from 2000–2015 (these will be made into a circle plot and temperature/salinity diagrams (see below).

Paper outline

Working title: Contrasting cases of Heterosigma akashiwo in the eastern and western Pacific
Co-editors: Douding Lu and Vera L. Trainer
Introduction: Will describe that this publication is the result of a workshop at PICES in Qingdao.
Background:
Will contain the following elements:

- The way forward for a better understanding of the behavioral, physiological and pathological factors controlling *H. akashiwo* blooms and their toxicity.
- Whether we believe that *H. akashiwo* on different sides of the Pacific Ocean is indeed the same organism. It may be several strains. What differentiates toxic *vs*. nontoxic blooms? Is there any definable difference between nontoxic and toxic *H. akashiwo*? Currently, there is no evidence that there are different organisms in W and E Pacific. However, would more detailed genetic analysis point to differences?
- Whether toxicity is genetic or physiological. Or are the affected fish species across the Pacific merely more sensitive in one region versus another?
- Why there are nontoxic blooms? Strains from the U.S. East Coast do not appear to be toxic
- Why biomass is a poor predictor of toxicity. For example, we need a lot more cells in Japan than B.C. to cause toxicity (0.5 million/ml in Japan required for fish kill; B.C 300–500 cells/ml as a minimum for fish kills).

Country contributions:
Point people in each member country to provide 1–3 (above) including background material, map and completed tables.

- China: Hao Guo,
- Korea: Changkyu Lee (changed to Tae-Gyu Park because Dr. Lee is on sabbatical),
- Japan: Ichiro Imai,
- Russia: Tatiana Orlova,

- USA: Vera Trainer, Kevin Bright,
- Canada: Nicky Haigh.

Figures:
1. Country maps including sites of historical blooms,
2. Temperature/salinity maps to be created from data provided by each member country,
3. Circle plots showing bloom intensity and toxicity,
4. Conceptual model of *H. akashiwo* blooms.

Discussion:
To include:
- Factors that induce cell growth or toxicity;
- Text about excystment from the sediment clarifying that temperature is important (not light, nuts, S) – and that 15°C is the optimal temperature for excystment;
- Some information about *H. akashiwo* vegetative cells, including that they do well in high light, have a great ability to use N and P from a multitude of different sources;
- That *H. akashiwo* behaves in some ways better than a dinoflagellate (it does better than other flagellates), competes well with diatoms, has a low Ks, likes quiescent waters;
- Toxicity is driven by light, salinity and temperature. Lower salinity means more toxic cells (in the lab); stationary cells are more toxic (slower growth), and there is no toxicity during exponential growth.

More Questions/Discussion:
- The role of trace metals. What is iron quota per Ha cell compared to others? The western Pacific has enough Fe in the water, while the eastern Pacific has high nutrient/low chlorophyll zones. Iron availability may play a key role;
- Important to differentiate what makes *H. akashiwo* toxic *vs*. what makes it bloom;
- pH effect;
- Dissolved organic carbon and vitamins;
- Runoff.

Timeline

Goal: Spring 2016 publication in PICES Press/*Harmful Algae*
- Spreadsheets filled out and returned to Dr. Trainer and Dr. Trick by January 29, 2016,
- First draft (background from each member country) and maps: to be sent to Dr. Trainer and Dr. Lu on February 15, 2016 (3 mo.),
- Review of drafts: February 29, 2016,
- Final version to *Harmful Algae*: March–April 2016.