# 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 Changkyu Lee from 9:00 to 18:00 h on October 16, 2011, in Khabarovsk, Russia. The meeting was attended by members from 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 1
**Discussion of the future of HAB work within PICES**

Suggestions for future work by S-HAB were discussed and the proposed new Terms of Reference can be found in *S-HAB Endnote 3*.

AGENDA ITEM 2
**Country reports and HAE-DAT database**

Presentations on the use of the Harmful Algal Event Database (HAE-DAT) from each country and country reports were provided, except for Canada.

*Canada*

No report was available.

*China*

No report was given at the meeting, however, a written summary is presented here.

In 2010, a total 69 marine red tide events with a total affected area of 10,892 $km^2$ was recorded in China's sea areas. There were 39 red tide events with an affected area of 6,374 $km^2$ in the East China Sea, 14 events with an affected area of 233 $km^2$ in the South China Sea, 9 events and an affected area of 735 $km^2$ in the Yellow Sea, and 7 events and an affected area of 3,560 $km^2$ in the Bohai Sea. The occurrence of the red tides and the affected areas were obviously less than the mean value of that in the past five years.

May was the month that witnessed the most frequent occurrences of marine red tides. There were 23 red tide events with total affected areas of 5 730 $km^2$ in May, 15 events with total affected areas of 4 292 $km^2$ in June, 8 events with total affected areas of 311 $km^2$ in July, 7 events with total affected areas of 52 $km^2$ in September, 6 events with total affected areas of 317 $km^2$ in August. During the periods of January to April and October to November, there were not more than two events with relatively small affected areas for each event. The occurrences the red tides and the affected areas in each month mentioned above were generally less than the mean value of the corresponding month in the recent five years.

In 2010, there were altogether 19 species which caused red tides. Among them, *Prorocentrum donghaiense* caused the outbreak of as many as 18 red tide events; *Noctiluca scintillans* 12 red tide events; *Skeletonema costatum* and *Scrippsiella trochoidea* 6 red tide events for each; *Mesodinium rubrum* and *Karenia mikimotoi* 4 red tides events for each; *Heterosigna akashiwo*, *Gonyanlax polygramma* and *Chaetoceros* sp. 2 red tide events for each; *Chattonella marina*, *Akashiwo sanguinea*, *Pseudo-nitzschia pungens*, *Prorocentrum lima*, *Gymnodinium catenatum*, *Gyrodinium spirale*, *Gymnodinium* sp. *Phaeocystis globosa*, *Chaetoceros cyrvisetus*, and *Cryptomonas*, 1 red tide event for each. The red tides caused by toxic dinoflagellates evidently increased compared with the last five years.

The largest area affected by red tides caused by *Prorocentrum donghaiense* was 4 539 $km^2$; next were those affected by *Cryptomenas*, *Skeletonema costatum* and *Noctilluca scintillans*, being 3 350, 855 $km^2$ and 254 $km^2$ respectively. Red tides caused by *Prorocentrum donghaiense* and *Skeletonema costatum* were mainly recorded in the coastal waters of Zhejiang and Fujian; and red tides caused by *Noctiluca scintillans* were mainly recorded in the coastal waters of Tianjin and Xiamen. Red tides caused by *Cryptomonas* were recorded in the coastal waters between Qingwangdao to Shuizhong, having the largest affected area by a single event in this year.

*Japan*

Dr. Shigeru Itakura presented Japanese HAB events of the past year (2010) and the recent status of research and development activities on HABs.

Red tides

In Japan, harmful algal blooms (HABs) still remain a severe threat to aquaculture industries in coastal waters. For instance, in the summer of 2009 and 2010, large-scale red tides of *Chattonella marina*/*antiqua* occurred around Yatsushiro Bay and Ariake Bay (Kyushu Island), and those blooms caused mass mortality of cultured finfish (yellowtail, *etc*.), which resulted in the loss of over $10 million of aquaculture products at Yatsushiro Bay and Ariake Bay. So, the management of HABs is still one of the important issues for the government and fisheries industry in Japan.

In 2010, red tide occurrences were reported from eastern Japan (82 cases), Seto Inland Sea (86 cases) and Kyushu area (74 cases). Within these red tides, fisheries damage cases were reported from eastern Japan (9 cases), Seto Inland Sea (8 cases) and Kyushu area (9 cases). The biggest fisheries damage (*ca*. $70 million) was reported from Ariake and Yatsushiro bays (Kyushu area), which was caused by *Chattonella* spp., as noted above.

Toxic phytoplankton blooms

PSP (Paralytic Shellfish Poisoning) and DSP (Diarrhetic Shellfish Poisoning) are the major marine biotoxins caused by toxic phytoplankton in Japan. However, incidents of food intoxication by ciguatera or palytoxin-like poisoning have been increasing around the coastal area of western Japan in recent years. This may be partly due to environmental changes, for the average sea surface temperatures around Japan have risen as much as three times the world average over the past century. So, a research program funded by MAFF was started to develop toxin detection/quantification methods for ciguatera and palytoxin-like poisoning and to investigate the distribution of causative phytoplanktons around Japanese coastal areas.

In 2010, there were 26 cases of PSP events (exceeding the quarantine limit of 4.0 MU/g) and 19 cases of DSP (exceeding the quarantine limit of 0.05 MU/g) events in Japan.

Research and development for HABs

The HABs research and development framework can be divided into three tiers. The first tier is “Monitoring” - Development of a rapid, precise and easy method to identify/enumerate HAB species with ambient environmental factors. Many molecular biological techniques (such as LAMP methods, *etc*.) have been applied to this field recently.

The second tier is “Elucidation of HABs occurrence mechanism/Development of HABs prediction method” - Investigation of ecophysiological characteristics of each HAB species and exploration of the relationship between environmental factors and HAB occurrence. Species-specific and area-specific HAB occurrence mechanisms have been gradually revealed by these investigations.

The last tier is “Mitigation” - Development of countermeasures to reduce the impact of HABs. Due to the recent huge damage to fisheries caused by the red tide *Chattonella* spp., many chemical, physical or biological controls of HABs are under consideration.

Prepared by Shigeru Itakura (National Research Institute of Fisheries and Environment of Inland Sea, FRA).

*Korea*

Dr. Changkyu Lee reported that a total of 5 HAB events occurred on Korean coasts in 2011. *Akashiwo sanguinea, Prorocentrum micans, Scrippsiella trochoidea, Heterosigma* sp. and *Mesodinium rubrum* were responsible for 2011 HABs. The number of HAB events in 2011 was much lower than in 2009 and 2010 when they showed 37 and 16 events, respectively. There was no ichthyotoxic *C. polykrikoides* bloom in 2011; likewise in 2009 and 2010. The vegetative cells of *C. polykrikoides* appeared in the offshore of the southern coasts from late June to early July; likewise ordinary years. However, low salinity from late July through August by heavy rainfall from typhoon and/or strong approach of low saline water mass from the East China Sea was estimated to be related to the suppression of the growth of the species, particularly, considering that *C. polykrikoides* is a stenohaline species showing low growth rate at lower than 30–31 ppt salinity. Instead, there were blooms in the coastal areas by other dinoflagellates which are more competitive than *C. polykrikoides* in low salinity during this period. Overall, HABs by both fish killing species and non-fish killing species have been decreasing year by year since 2007. However, shellfish toxin producing species such as *Alexandrium* spp., *Dinophysis* spp. and *Pseudo-nitzschia* spp. still frequently appear and/or sometimes intoxicate shellfish although they seldom show high density to form blooms.

The benthic dinoflagellate *Gambierdiscus* spp. is the primary causative agent of ciguateria fish poisoning in tropical and subtropical areas. However, the geographic distribution of benthic dinoflagellates is poorly understood on Korean coasts. Benthic dinoflagellates population densities were investigated on the southern coast including Jeju Island from June to August in 2011. *Gambierdiscu*s sp., *Ostreopsis* sp., *Coolia* sp., *Prorocentrum lima* and other unknown benthic dinoflagellates were found. *Gambierdiscus* sp. was detected from 32 out of 75 samples on the Jeju Island coast. *Ostreopsis* sp. was the most dominant benthic dinoflagellate. Vertical distributions were also surveyed from 0 to 15 m depth at 3 m intervals on the Jeju Island coast. Most benthic dinoflagellates were distributed within 6 m depth. This result suggests that *Gambierdiscus* sp. is widely distributed on the Jeju Island coast indicating potential ciguatera fish poisoning in Korean waters. Toxicity, morphological, molecular genetic characterization of these benthic dinoflagellates is currently in progress.

Prepared by: Changkyu Lee, Hyeong-Seop Kim, Taegyu Park and Youngtae Park (Southeast Sea Fisheries Research Institute, NFRDI)

*Russia*

Dr. Tatiana V. Morozova, reported that a total of 21 bloom-forming species were recorded in 2010–2011 in Amurskii Bay. Those species belong to 5 taxonomic groups of phytoplankton: diatoms (72%), dinoflagellates (7%), raphidophytes (7%), cryptophytes (7%) and euglenophytes (7%). Monitoring studies carried out from 2010 to 2011 revealed the presence of biotoxin producers in plankton, benthic and epiphytic assemblages. Potentially toxic species belong to 3 groups of phytoplankton: dinoflagellates, raphydophytes and diatoms. *Dinophysis* species are capable of producing ocadaic acid, which accumulates in the tissues of filter-feeding mollusks, causing the syndrome of diarrhetic shellfish poisoning (DSP). Five *Dinophysis* species were observed in 2010–2011 in the study area. The joint density of *Dinophysis* spp. reached a critical level throughout the observation period and was 5 times the critical level in July 2011. Data on toxin concentration of okadaic acid in the samples of mussels from Amurskii Bay were received by Enzyme Linked Immunosorbent Assay (ELISA) method. Maximum concentration of ocadaic acid was detected in July and exceeded the reportedly harmful level for DSP.

Studies of epiphytic dinoflagellates on macrophytes growing in a bight of Peter the Great Bay revealed the presence of two potentially toxic species *Ostreopsis ovata* and *O. siamensis*. Those species are known to produce palytoxin-like compounds. The occurrence of *Ostreopsis* spp. was recorded in the middle of August 2010 at minimum concentration. Density of *Ostreopsis* spp. fast increased and reached maximum concentration in the middle of September 2010. The maximum abundance of *Ostreopsis* was observed on macrophytes *Neordomella larix* – more than $70 \times 10^3$ cells per gram of dry weight in 2008 and *Briopsis* sp. – $334 \times 10^3$ cells per gram of dry weight. The abundances of *Ostreopsis* spp. increased when surface water

temperature was decreasing and a maximum peak occurred in the middle of September, when the temperature was 20°C. *Ostreopsis* density decreased at the end of October and no cells were recorded in November, when temperature was 7°C. The spatial distribution of *Ostreopsis* spp. in relation to hydrodynamics was studied in Peter the Great Bay in 2010. Three hydrodynamic regimens were defined: shaken, slightly shaken and calm. In sites with low hydrodynamics (calm regimen), *Ostreopsis* was present, as other benthic dinoflagellates were absent. In sites were macroalgae were directly hit by waves (shaken regimen), density of *Ostreopsis* spp. was low. On overage, the abundance of *Ostreopsis* spp. was significantly higher in sites with a slightly shaken regimen (500–306 000 cells $g^{-1}$ DW) than in shaken regimen sites (0–2400 cells $g^{-1}$ DW). Cells of *Ostreopsis* spp. were not found in the water column. The maximum density of *Ostreopsis* spp. (more than $306*10^3$ cells $g^{-1}$ DW) was recorded on the macrophyte *Neordomella larix*. Toxic events and reports of poisoning are not registered; however, concern centers on both the high diverse representation and abundance of potentially toxic algae in Russian waters.

Diatoms are the most common bloom-forming algae in the study area. The seasonal dynamic and toxicity of the diatom genus *Pseudo-nitzschia* (potential producers of the neurotoxin domoic acid and causative organisms of Amnesic Shellfish Poisoning) were studied in 2010–2011. The role of environmental factors in population dynamics of *Pseudo-nitzschia* species in Amurskii Bay was analyzed. A bloom of *Pseudo-nitzschia* was registered in October–November at a salinity of 31–33.5‰ and water temperature of 6–12°C. The most intensive peak of the *Pseudo-nitzschia* spp. density (the mean value of 1428.9 thousand cells/l) was recorded in the last two weeks of October after heavy rains. The outburst was determined presumably by mass development of *P. multistriata* (67% of the total density) and *P. calliantha* (9%). The methods of correlational and regressive analyses were used to find that water salinity, $NH_4$ concentrations in the environmental waters and water temperature had an influence on the "bloom" of *Pseudo-nitzschia* spp. A negative correlation was revealed between the density of *Pseudo-nitzschia* spp. and water salinity, $NH_4$ concentrations in the waters, and a positive correlation was found between the population density of diatom algae and water temperature.

Concentrations of domoic acid in clones of *Pseudo-nitzschia* isolated from Peter the Great Bay as well as in tissues of bivalves (*Mytilus trossulus*, *Crenomytilus grayanus*) from the same location were measured by Enzyme Linked Immunosorbent Assay using "ASP direct cELISA" kit (Biosence laboratories AS, Norway, AOAC official method 2006.02). For DA analysis, unialgal cultures were established for *P. pungens* (three isolates), *P. calliantha* (two isolates), and *P. delicatissima/arenysensis* (three isolates). Cultures of *Pseudo-nitzschia* species were isolated from Peter the Great Bay between December 2007 and December 2010. Samples of bivalve tissues were collected between May 2009 and April 2010 from two stations situated in Amurskii (43°12' N, 131°54' E) and Vostok (42°54' N, 132°46' E) bays. Domoic acid was found in stationary-phase cultures of *P. pungens* and *P. calliantha* isolated from Peter the Great Bay at concentrations varying between 42.9 and 115.4 pg $ml^{-1}$. No domoic acid has been detected in cultures of *P. delicatissima/arenysensis* from the same locality. Total concentrations of domoic acid in the bodies of the bivalves ranged from 0.01 to 0.5 $mg \cdot kg^{-1}$ with a maximum in July samples; they were markedly lower than the maximum permissible content (20 $mg \cdot kg^{-1}$) according to the European Community Regulation 2002/226/EC and to the Sanitary Regulations and Standards 2.3.2.2401-08 approved by the RF State Committee for Health and Epidemiological Inspection. The potential toxicity of *Pseudo-nitzschia* clones from Peter the Great Bay suggests that phytoplankton and shellfish toxicity monitoring is warranted in these waters, where bivalves are commercially harvested for human consumption.

Long-term observations indicated that the occurrence of HABs on the Russian East coast had an increasing trend and significant seasonality. To date we have identified 35 potentially toxic algal species. The appearance of new causative species, especially toxin-producing species, was observed in this period. Toxic algae represent several of the most dominant taxa in both abundance and biomass within the study area (*e.g.*, *Dinophysis, Ostreopsis, Pseudo-nitzschia*). Other taxa, although low density was noted, still remain a potential threat as toxic producers. Continued studies of phytoplankton and microbenthic communities in Far Eastern Seas of Russia will no doubt reveal other potentially toxic species. For beneficial management practices, it becomes necessary to maintain programs that will identity and monitor potentially dangerous flora.

Prepared by: Tatiana Yu. Orlova, Inna V. Stonik, Marina S. Selina, Tatiana V. Morozova, Olga G. Shevchenko and Nellya G. Litvinova (A.V. Zhirmunsky Institute of Marine Biology of the Russian Academy of Sciences, Vladivostok)

*USA*

Dr. Vera Trainer related that in SE Alaska, Ketchikan and Metlakatla during May and June 2011, several people were sickened by paralytic shellfish poisoning after their consumption of butter clams, little neck clams, cockles and blue mussels. Four of the 21 people were hospitalized, none died. Toxin concentrations in the meal eaten by 1 person who was in the intensive care unit were ~5000 μg/100g (blue mussels) and concentrations of toxin in urine were 118 μg/100g. The time from consumption of shellfish to the onset of symptoms in this person was <1 minute. Symptoms included ataxia, dysphagia, floating sensation, paresthesia, shortness of breath, and weakness. Toxin analysis by LC/MS and ELISA in baby mussels from Ketchikan showed PSTs up to 28,000 μg/100g shellfish.

In late May 2011, a minor fish kill of yearling coho salmon occurred at the Squaxin Island Tribal net pens in Southern Puget Sound commencing on the 17th, possibly associated with a bloom of *Phaeocystic* sp., a harmful or noxious species not usually associated with fish kills and not previously reported from Puget Sound fish kills in the past. Fish are reared for a short term in these pens before release to enhance fisheries in the South Puget Sound and elsewhere in cooperation with the Washington State Department of Fish and Wildlife.

On June 25, 2011, 3 people became ill with diarrhetic shellfish poisoning (DSP) after eating mussels from Sequim Bay in northern Puget Sound near the Canadian border. Off Vancouver Island, Canada, there were an estimated 60 illnesses from DSP. This illness is caused through ingestion of shellfish that has accumulated toxins from the harmful algal bloom organism, *Dinophysis*, which produces a suite of neurotoxins including dinophysistoxins and okadaic acid. Approximately 2000 lbs of shellfish have been recalled due to this poisoning event. These toxins currently are not regulated in the U.S. *Dinophysis* abundance reached 53,000 cells/L and the primary species was *D. acuminata*. Toxin concentrations in blue mussels from Sequim Bay reached 1600 μg OA equivalents/g shellfish by LC/MS. The primary isomer was DTX-1.

In June–August 2011, *Heterosigma akashiwo* caused some fish kills in central Puget Sound and the Strait of Georgia, Canada. On June 21, 2011, a thick bloom of *H. akashiwo* was observed in Nanaimo, British Columbia (8,000–20,000 cells/mL). On June 25, 2011 the *H. akashiwo* bloom was observed to continue north – salmon mortalities occurred at Quadra Island. Samples from the east side of Quadra Island, Jervis Inlet and Sechelt Inlet all showed very high (2000–20,000 cells/mL) concentrations. In Puget Sound, on June 26, 27 and 28, counts in the millions of cells per liter were being found at the surface (1.5 m), peaking at 1.8 million cells/ L. on June 26 as red streaks swept through some of the fish pens in with the tide Deepwater Bay. America Gold fish farm personnel report seeing a dark brown streak of water (1.8 million/L) move through two of the 12 cages at the site on the evening of June 26. The next morning divers pulled 850 and 500 dead fish out of those two pens. The other 10 cages of fish at the same site had mortalities in the 50 to 90 fish per cage range. Fortunately the bloom stayed near the surface and cell counts at 10 m stayed an order of magnitude less. Subsequent dives over the next few days had <10 fish mortalities in each of the pens. Counts dropped to the 500,000 to 800,000 cells/L range at the surface and stayed at 180,000 cells/L at 10 m over the next couple of days. Large flood tides brought cleaner, green water into the area from the south up Rosario Strait. Increasing tides and tidal mixing during the week coupled with the cloudy weather may have helped to break up the dense *Heterosigma* bloom. Neap tides the week prior, and several weeks of large flow rates from the Fraser River, created a perfect "several hundred square mile large Petri dish."

In Oregon, *Pseudo-nitzschia* were present in September 2011 on the north coast in numbers ~ 500,000 cells/L. However, long chains of up to 15 cells and cells in division remain common. Early indications of toxin production were reported by the Oregon Department of Agriculture in the week of July 12 indicating DA levels in mussels to be 7.6 ppm, which is the highest recorded level of DA in mussels since the coast-wide closure in 2005. Along the central coast cell counts of the smaller *P.* cf. *pseudodelicatissima* cell type increased to as high as 719,000 cells/L with no significant DA.

In California, a HAB was documented in Sonoma County, north of San Francisco coincident with a large die-off of marine invertebrates starting the week of August 24, 2011. It is still uncertain whether the HAB caused the die-off, but this potential connection is being investigated by marine scientists. If a link is found, this would be the first scientifically confirmed report of a HAB associated with marine life mortalities in this region of northern California. Previously, only small-scale die-offs in coves have been observed, and these have been attributed to low dissolved oxygen conditions following the accumulation of macroalgae. Reports of the phytoplankton bloom were confirmed in the nearshore from Bodega Bay north to Anchor Bay and probably extended beyond 50 miles of these confirmed reports. In the week prior to the bloom, ocean conditions were calm and there was an extraordinary display of bioluminescence in the water at night that continued throughout the period of the bloom.

The invertebrates potentially affected by the bloom were reported from many taxa including mollusks, echinoderms and crustaceans. However, fish deaths were not observed. Invertebrates within the University of California Davis, Bodega Marine Laboratory also died during this event starting on August 29 including abalone, sea urchins, and sea stars but again, fish were not affected.

In water samples collected from Bodega Head, Fort Ross and Salt Point during the bloom, the dominant phytoplankters were dinoflagellates belonging to the *Gonyaulax spinifera* species complex. The algae were identified by Adele Paquin (Sonoma State University) and Gregg Langlois (California Department of Public Health), and the identifications were subsequently confirmed by Rita Horner (University of Washington) and Charles O'Kelly (Friday Harbor Laboratory). In the week prior to the bloom, ocean conditions were calm and there was an extraordinary display of bioluminescence in the water at night that continued throughout the period of the *Gonyaulax spinifera* bloom. The invertebrate taxa affected during the bloom included mollusks, echinoderms and crustaceans. Fish deaths, however, were not observed. Invertebrates within the Bodega Marine Laboratory also died during this event starting on August 29, including abalone, sea urchins, mussels and sea stars. As elsewhere, though, fish were not affected.

Mussels, which were among the animals that died during the bloom, feed on phytoplankton and bioconcentrate toxins produced by phytoplankton. Mussel samples collected during the bloom were tested for both Paralytic Shellfish Poisoning (PSP) and Amnesic Shellfish Poisoning (ASP) toxins. Both of these toxins were below minimum detection limits (Gregg Langlois, California Department of Public Health). Tests at the University of California, Santa Cruz (Raphael Kudela) and the Fish and Game Laboratory at OSPR (David Crane) detected trace levels of yessotoxins (YTX) in mussels. Members of the *Gonyaulax spinifera* species complex are known to produce YTX. To our knowledge, this is only the second time YTX has been detected in California waters. Further toxicity tests are now being conducted on tissues of abalone, sea stars, snails and kelp that were dying during the bloom.

Following anecdotal mortality reports, quantitative subtidal field surveys in the kelp beds in Sonoma County were conducted. At Fort Ross, 30% of red abalone *Haliotis rufescens* were dead. Other sites had 12–25% abalone mortality (Rogers-Bennett CDFG, BML). Red sea urchins, *Strongylocentrotus franciscanus*, that are fished commercially in the area, suffered 40–45% mortality. The patterns of mortality were not restricted to coves with the potential for low dissolved oxygen but were also encountered at exposed headland sites. Some species appeared to be unaffected by the toxin such as the Bat Star, *Asterina miniata*, which was observed actively feeding on dead abalone and sea urchins. Both abalone and sea urchins are herbivores, feeding primarily on drift kelp. The vector responsible for a potential trophic transfer from phytoplankton to herbivore is as yet unknown, and non-trophic vectors (*e.g.*, water born toxins) may also be involved.

The Southern California Bight experienced significant marine mammal and bird strandings and deaths during Spring (primarily March–May) 2011, particularly in the Newport Beach to Huntington Beach region. Stranded animals testing positive for domoic acid were brought into a number of centers and organizations including: Pacific Marine Mammal Center (Laguna Beach), Marine Mammal Care Center at Fort MacArthur (San Pedro), California Wildlife Center (Malibu), International Bird Rescue (San Pedro), Los Angeles County Natural

History Museum (Los Angeles). Samples collected from animals, and testing positive for domoic acid, included approximately 60 sea lions, 10 dolphins, 20 birds (several species).

Monitoring for domoic acid during much of this period indicated low but consistently measurable concentrations. Sampling offshore was limited, but water samples collected at a few stations in the central San Pedro channel in early March detected extremely high values of domoic acid in the plankton (>50 µg/l).

Contributions by: Laura Rogers-Bennett (CDFG, UC Bodega Marine Lab); Gregg Langlois (Cal. Dept. Public Health); Raphael Kudela (UC Santa Cruz); Karina Nielsen (Sonoma State Univ.); Adele Paquin (Sonoma State Univ.); James Moore (CDFG UC BML), Dave Caron (USC), Nicky Haigh (HAMP), Jack Rensel (Rensel Assoc.), Kevin Bright (America Gold Seafood), Zachary Forster and Matt Hunter (Oregon Dept. Fish and Wildlife)

AGENDA ITEM 3
**Planning for PICES-2012**

It was recommended that the following be proposed to Science Board:
1. ½-day Topic Session on "*Range extension, toxicity and phylogeny of epiphytic dinoflagellates*" (*S-HAB Endnote 4*).
2. 1½-day Workshop on "*The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011*" (*S-HAB Endnote 5*).
3. 1-day S-HAB meeting, including country reports for HAB events in 2006–2007 and discussion of HAE-DAT use. Countries are requested to input HAB event data to HAE-DAT for 2000–2007 directly to the online database.

AGENDA ITEM 4
**Items with financial implications and recommendations**

1. Request full funding for 2 invited speakers to attend a ½-day Topic Session on "*Range extension, toxicity and phylogeny of epiphytic dinoflagellates*" at PICES-2012;
2. Request full support for 1 local (Japanese) student rapporteur to attend a 2-day Workshop on "*The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011*";
3. Request funding for a 4 PICES members to attend a joint ICES/PICES/GEOHAB/NSF/NOAA sponsored workshop on Climate Change and HABs in Spring 2012 or 2013;
4. Request full travel support for 1 person for a joint ICES/PICES/GEOHAB/NSF/NOAA workshop planning meeting in late 2011 or early 2012;
5. New S-HAB member requests: Korea – Myeong Soo Han (Hanyang University), Tae Gyu Park (NFRDI); China – Chunjiang Guan (cjguan@nmemc.gov.cn), and HAE-DAT contributor Douding Lu (SOA). HAE-DAT focal point for China is changed to Hao Guo;
6. Request IOC representative to attend next PICES meeting to discuss HAE-DAT, country maps and decadal reports (Henrik Enevoldsen, Monica Lion);
7. Travel support for 1 Canadian S-HAB member and 1 Russian S-HAB member to attend PICES-2012;
8. PICES China delegate to contact the International Cooperation Department to request HAB data (from Liqi Chen) for HAE-DAT entry.

AGENDA ITEM 5
**S-HAB Topic Session and Workshop at PICES-2011**

A summary of the MEQ Topic Session (S5) on "*Harmful algal blooms in a changing world*" and the MEQ Workshop (W2) on "*Remote sensing techniques for HAB detection and monitoring*" can be found in the "Session Summaries" section of PICES Annual Report for 2011.

AGENDA ITEM 3
**Report on the Satellite Remote Sensing workshop in Vladivostok**

Dr. Rafael Kudela, representing PICES at the NOWPAP/PICES/WESTPAC sponsored workshop on "*Remote sensing data anlaysis*" (October 8–12, 2011) in Vladivostok, Russia, provided a summary to S-HAB.

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**

Drs. Henrik Enevoldsen and Monica Lion, representing the IOC-IEO Science and Communication Centre on Harmful Algae, were unable to attend the meeting but sent a slide presentation which S-HAB members reviewed. The focal points for each country were listed and changes were made from Dr. Yasunori Watanabe to Dr. Shigeru Itakura (Japan) and from Jinhui Wang to Dr. Hao Guo (China). Only one user name and password is assigned for each country, however, focal points can ask for help with data submission. How to submit data to the online HAEDAT submission form was reviewed. All countries except China submitted their data to the HAEDAT database. No maps were available to review, as an IOC representative was not at the meeting. However, example maps from European countries were shown.

AGENDA ITEM 5
**Report on ICES Meeting and areas of ICES/PICES collaboration**
Dr. Wells represented PICES at the meeting of ICES-IOC Working Group on Harmful Algal Bloom Dynamics (April 24–27, 2012, Oban, UK). See *S-HAB Endnote 6* for the report.

AGENDA ITEM 6
**ICES/PICES joint workshop on "Range Extension of HAB Species"**

A proposal for a joint PICES/ICES workshop was discussed during the ICES/IOC WGHABD meeting in Oban, UK (April 24–27, 2012

AGENDA ITEM 7
**PICES Seafood Safety Project**

Travel to the Philippines in early 2011 allowed a visit to labs in the provinces (Tacloban and Sorsogon), sites where screening tests for toxins are being implemented. The effectiveness of these tests in unique species of shellfish were assessed. A planning trip to Indonesia occurred in September 2011. This trip allowed S-HAB members to critically assess the level of capacity at present and the immediate training needs. It also allowed us to assess the higher level government support for sustaining the capacity over the coming years. The training class in Indonesia, planned for February 2012 was discussed.

AGENDA ITEM 8
**Position statement on Rensel *et al*. paper**

This item was not discussed.

AGENDA ITEM 9
**S-HAB-S new Terms of Reference**

New terms of reference were discussed briefly, but it was decided that the final revision would be done by e-mail with Dr. Trainer providing the first draft.

AGENDA ITEM 10
**New findings, significant publications from each country**

This item was not discussed due to lack of time.

AGENDA ITEM 11
**Discussion of Proposals for the future and review of assignments**

A ½-day MEQ Topic Session on "*Range extension, toxicity and phylogeny of epiphytic dinoflagellates*" and a 1½-day MEQ/FUTURE workshop on "*The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011*" were proposed for PICES-2012 in Hiroshima, Japan. Section members agreed to provide written country reports and entries into HAEDAT for the coming meeting.

***S-HAB Endnote 1***

**S-HAB participant list**

| Members | Observers |
|---|---|
| Hao Guo (China) | Stewart Johnson (Canada) |
| Ichiro Imai (Japan) | Chunjiang Guan (China) |
| Akira Ishikawa (Japan) | Kunio Kohata (Japan) |
| Shigeru Itakura (Japan) | Raphael Kudela (USA) |
| Changkyu Lee (Korea) | Sangjin Lee (Korea) |
| Tatiana Morozova (Russia) | Chen Siging (China) |
| Satoshi Nagai (Japan) | Xiaomeng Wang (China) |
| Vera Trainer (USA) | Yasunori Watanabe (Japan) |
| Mark Wells (USA) | |
| Takafumi Yoshida (*ex-officio* member representing NOWPAP) | |

***S-HAB Endnote 2***

**S-HAB meeting agenda**

1. Welcome, goals of HAB Section meeting (Vera Trainer and Changkyu Lee)
2. Country Reports (2010-11) and HAE-DAT (year 2006) reports
   USA (Vera L. Trainer)
   Korea (Changkyu Lee)
   Japan (Shigeru Itakura)
   China (Mingyuan Zhu)
   Canada (Robin Brown)
   Russia (Tatiana Morozova)
3. Report on Vladivostok Satellite Remote Sensing workshop (Raphael Kudela)
4. The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information

Exchange Harmful Algae Information System: An update and country maps (Vera Trainer)
5. Report on ICES Meeting and areas of ICES/PICES collaboration (Mark Wells)
6. Discussion of ICES/PICES joint workshop on "Range Extension of HAB Species"
7. PICES Seafood Safety Project (Mark Wells)
8. Position statement on Rensel *et al*. paper
9. Discussion of S-HAB new Terms of Reference
10. Quick exchange of new findings, significant publications from each country
11. Discussion of Proposals for the Future and Review of assignments

***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 (e.g. ICES) 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. Participants will 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, responsive to FUTURE goals.
3. Produce position papers that are posted on the PICES website that document the unanimous HAB Section opinion on timely subject 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 ½-day MEQ Topic Session on**
**"*Range extension, toxicity and phylogeny of epiphytic dinoflagellates*" at PICES-2012**

Co-conveners: Willam Cochlan (USA), Satoshi Nagai (Japan)

Ciguatera fish poisoning is a growing food-borne illness that is common in tropical waters, where poisoning numbers are poorly known but estimated to range from 50,000 to 500,000 cases per year. The incidence of ciguatera is on the rise, and appears to correspond to disturbances in the environment such as nutrients released into coastal waters, land-use changes, or warmer coastal waters. Indeed, the flagellates, *Gambierdiscus* and *Ostreopsis*, that can produce ciguatoxin or palytoxin-like compounds, appear to be spreading to more temperature latitudes, including the waters of PICES member countries. To gain better insight to this new issue, we invite papers addressing benthic dinoflagellate taxonomy, evidence for range extension, descriptions of standardized sampling programs; assays for assessing toxicity, and sentinel products to alert public health officials to ciguatera risk. The goal of the session is to formulate a better understanding of environmental conditions fostering the prevalence of ciguatoxin-producing organisms in new geographical regions.

Proposed invited speakers**:** Chinain (French Polynesia), Bob Bidigare, Takuro Omura (Japan)

*S-HAB Endnote 5*

**Proposal for a 1½-day MEQ/FUTURE Workshop on**
***"The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011"***
**at PICES-2012**

Co-conveners: Changkyu Lee (Korea) and Mark Wells (U.S.A.)

Harmful algal blooms reached historic levels along coastlines of the eastern Pacific in 2011 but similar blooms were minimal to non-existent in Japan, Korea, and Russia. The situation was largely reversed in 2007, and this disparity between these years offers a unique opportunity to compare and contrast the basic environmental parameters and HAB dynamics during these regimes. Combining these observations with a broader overview of the basin-scale physical dynamics during this time frame would provide new insights to the factors enhancing these blooms. The workshop foundation will be the pre-submission of available data from member countries, including but not limited to: HAB species presence and abundance, time of year, temperature range, salinity range, water clarity, wind, river flow (flooding), and upwelling indices. Workshop participants will review and discuss the trends and patterns in these data over the first day, and integrate them with information on the basin-scale physical dynamics. Participants will develop a detailed outline for manuscript preparation during the second day, with agreed writing assignments and draft submission deadlines. The manuscript will be targeted for the appropriate international journal decided upon by participants.

Proposed invited speakers: PICES experts in basin-scale physical dynamics such as William Peterson, Tsuyoshi Onizuka, Rho Youngjae to provide overview of basin-scale physical dynamics in the 2 contrasting years.

*S-HAB Endnote 6*

**PICES Report on**
**ICES - IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) 2012**
**Oban, United Kingdom, April 24-27, 2012**

PICES participation in the ICES WGHABD meeting focused primarily on two resolutions passed at the Intergovernmental Panel on Harmful Algal Blooms (IPHAB) meeting in April, 2011. These resolutions, and actions taken or discussed during the 2012 WGHABD meeting are:

**Resolution IPHAB-X.6 - HARMFUL ALGAE AND GLOBAL CHANGE**

1) Identify central unresolved issues that limit advances in understanding how projected climate change may influence HAB events by convening an ICES/IOC/PICES workshop of HAB experts. (The second of two resolutions.)

The original plan to address the HAB/Climate change issue was to organize and hold a 5 day workshop with ~30-35 invited participants whose expertise spans both the ecological and geographical issues surrounding the HAB problem. The workshop would be co-organized by Mark Wells (PICES) and Bengt Karlson (ICES). The central outcome would be a seminal publication in a high profile journal that identifies the keystone parameters and research infrastructure needed to test the purported HAB-Climate Change linkage. This publication would be accompanied shortly thereafter by a special publication of participant authored papers in the international journal Harmful Algae. A second aspect of the workshop would be to develop recommendations for LTER-type sites well suited for HAB evaluation (augmenting existing or planned infrastructures).

The funding required to support this workshop plan is ~ 130K USD. NSF, NOAA and GEOHAB are unable to provide this level of funding at this time. There is a small possibility that funding sources in Sweden may be able to support this scale of workshop, but it remains unclear at this time. An alternate, scaled down workshop

was discussed, comprising a small group (≤ 10) of key individuals with different expertise that bears strongly on climate change/HAB linkages or investigating them. The goal of this more modest workshop, to be held in 2013, remains the same; to outline and write a condensed review (position) paper on the central issues. This 3-4 day mini-workshop also would provide the organizational structure and steering committee for a broader, open workshop on HABs and Climate Change (Stage II) to be held in 2014. The cost of the mini-workshop is estimated to be ~25K USD, and preliminary discussion with NSF indicates that there may be sufficient funding available to support this mini-workshop with assistance from PICES. Effort now is on-going to finalize the funding sources.

After consultation with Bengt Karlson (co-organizer) and the WGHABD participants, the following draft list of key topic areas for discussion were decided upon:

1. Increased temperature (physiological, chemical)
2. Ocean acidification (cell growth, toxin production, trace metal speciation)
3. Stratification (nutrient and light dynamics)
4. Winds (nutrient re-supply to surface waters via mixing, upwelling)
5. Increasing/decreasing precipitation (changes in runoff, CDOM, light fields, salinity, nutrients)
6. Eutrophication (in combination with 5 plus increasing land use at higher latitudes)
7. Trophic effects from changes in essential fatty acids (in combination with 1, 2, and 5)
8. Broader ecosystem changes (annual windows for bloom development, timing of blooms relative to key trophic/human interactions)

A list of potential mini-workshop participants was drafted and is under consideration. The WGHABD strongly endorsed the above plan.

**Resolution IPHAB-X.7 - FISH KILLING MARINE ALGAE**

**IPHAB Decides**, with reference to the HAB Programme Plan, objective 6.3.1, ii, to establish a Task Team on Harmful Algae and Fish Kills with the following terms of reference:

i) develop a Term of Reference on fish killing algae for 2012 for the ICES-IOC Working Group on Harmful Algal Bloom Dynamics before 1 August 2011;

ii) prepare an overview of scale of issue and priorities and report to IPHAB-XI with view to develop a community scale project

iii) support the organization of a joint ICES/IOC/PICES meeting to better define global understanding of the broad issues listed in item i);

**Decides** also that the Task Team will be composed by A. Cembella (Germany) (Co-chair), R. Gowen (United Kingdom) (Co-chair), P. Hess (France), and M. Wells (PICES). The Task Team may be expanded as required to fulfil the Terms of Reference.

The Terms of Reference for the Fish Killing Algae were reviewed. The ICES WGHABD will prepare a draft report in time for the PICES Annual meeting in fall, 2012, so that PICES HAB section may add their findings and perspective. The joint ICES/PICES final report on Fish Killing Marine Algae will be available after the ICES WGHABD meeting in spring, 2013, where it will be presented at the next IPHAB meeting.

The general discussion points during the WGHABD meeting were:

1. Fish killing algae occurred in Danish waters during 2011. In an unusual case, *Pseudochatonella* blooms happened in winter, with the cell isolates having an optimal growth between 1–6°C, with growth cessation above 6-10°C. This observation is extraordinary, and indicates that the traditional view that fish killing blooms are restricted to seasonal warm periods is wrong.
2. The Danish government is working to increase aquaculture fish production by 100,000 tons per year over the next few years. This is a major increase, with potential negative impacts on coastal waters. This drive to substantially increase marine fish aquaculture parallels ongoing efforts in Indonesia.

3. The first occurrence of *Pseudofiesteria Shumwayae* in European waters was observed in Dec., 2011, where it was involved a in penned aquaculture fish kill. This event attracted considerable discussion in terms of whether it resulted from a new species introduction, or a selective bloom of a rare endemic origin.
4. Wells presented a PICES perspective on blooms of the fish killing phytoplankton *Heterosigma akashiwo*. This species has been observed in coastal waters across the U.S. but Puget Sound is the only region where this organism is harmful and economically devastating to fish aquaculture operations. *H. akashiwo* is a major killer of fin-fish including cultivated Atlantic (*Salmo salar*) and Pacific (*Oncorhynchus* spp.) salmon (Taylor and Haigh, 1993) and there are reports of wild salmon and marine fish mortality in Washington coastal waters (Horner *et al*., 1997; Hershberger *et al*. 1997). "Farmed" fish are particularly vulnerable because they cannot escape when winds or currents move the blooms into penned areas. Large blooms have covered the entire central and north basins or Puget Sound, North Hood Canal, portions of the Juan de Fuca Strait and much of Strait of Georgia (Taylor and Haigh 1993). *H. akashiwo* has caused the death of net pen salmonids in Puget Sound since at least 1976 (Rensel *et al.*, 1989; Rensel, 2007) with major losses occurring in 1989, 1990, 1997, 2006, 2007, and 2009. *H. akashiwo* blooms also have occurred during intervening time periods, some small in spatial extent, but these are poorly documented. These HABs are considered a serious risk to site development for new, net-pen facilities, particularly given that as few as 500 cells/L can cause fish deaths when cells are expressing toxicity (Horner, 1998). The salmon aquaculture industry in Washington State suffers economic losses of ~ $2 to 6 million per episode due to *H. akashiwo* blooms. Losses to free-ranging (wild) fish are known to occur but are poorly quantified because these fish sink upon death in the cool, temperate waters of the Sound. Recent findings suggest that Fraser River sockeye salmon returns, historically the most valuable west coast Canadian and United States salmon fishery, can be detrimentally affected by blooms of *H. akashiwo* (Rensel *et al.*, 2010).

The 2013 ICES-IOC WGHABD meeting will be hosted by Beatriz Reguera in Vigo, Spain, planned for April 9-12, 2013. PICES travel support will be requested for a HAB Section member to participate in this meeting and IPHAB for follow up on the HAB workshop report, the Fish-Killing Algae report and for planning of the open science meeting on HABs and Climate Change.

ICES-IOC Working Group on Harmful Algal Bloom Dynamics

Scottish Marine Institute Oban, United Kingdom 2012


Left to right: Mark Wells, Jean-Pierre Lacaze, Joe Silke, Keith Davidson, Don Anderson, Jennifer Martin, Eileen Bresnan, Samia K. Mikhail, Ainhoa Blanco, Richard Gowen, Steve Milligan, Beatriz Reguera, Neils Daugbjerg, Hak-Gyoon Kim, Bengt Karlson, Ken Jones and Seong-An Choi. Missing from the photograph: Hanna Mazur-Marzec, Ailsa Hall,Peter Petrov an Layla al-Musawi.