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 Dr. Mark Wells (USA) and Dr. Pengbin Wang (China) on September 7 at 16:00 (Pacific Daylight Time), September 8 7:00 (Beijing), 8:00 (Tokyo/Seoul), and 9:00 (Vladivostok), 2020, via Zoom. Dr. Wang welcomed all participants. The meeting was attended by members from five PICES member countries (*S-HAB Endnote 1*). The proposed agenda for the meeting (*S-HAB Endnote 2*) was reviewed and some items were rearranged or taken off the agenda before being approved by the Section.

First row, from left: Seung Ho Baek, Pengbin Wang, Ruoyu Guo, Mark L. Wells, Natsuko Nakayama, Setsuko Sakamoto, Yoichi Miyake.
Second row, from left: Andrew Ross, Andrea Locke, Weol-Ae Lim, Sonia Batten, Chunjiang Guan.
Third row, from left: Douding Lu, Mitsunori Iwataki, Sha Mai, Charles Trick, Misty Peacock.
Fourth row, from left: Chunlei Gao, Takafumi Yoshida, Mengmeng Tong, Vera L. Trainer, Hao Guo.
Fifth row, from left: Dolly Manic, William P. Cochlan.

AGENDA ITEM 2
Country reports

__Canada (reported by Andrea Locke)__

1) Historical review

The available knowledge of the composition and distribution of harmful algae in Canada have recently been summarized in two publications. McKenzie *et al.* (2020) reported the first part of a national peer review meeting on the "Extent and Potential Consequences of Harmful Algal Blooms on Canadian Marine Ecosystems" held by Fisheries and Oceans Canada in March 2019 to identify the status of harmful algae in Canada, knowledge gaps and research needs. This publication is the Canadian contribution to a special issue by the journal *Harmful Algae* on 30 years of HAEDAT data. The second publication, Bates *et al.* (2020), is a major compilation of knowledge on harmful algae in Canadian marine waters and was used as one of the sources of information reviewed during the March 2019 peer review meeting.

Marine scientists first confirmed the presence of phycotoxins in British Columbia in 1942 and at present, eight classes of phycotoxins have been recorded (Table 1).

Table 1. List of phycotoxins and date of first report by scientists in marine waters of British Columbia (after Bates *et al*. 2020, see Bates *et al*. 2020 for references).

Phycotoxin / Syndrome	First report	Reference
Saxitoxin / Paralytic Shellfish Poisoning	1942[1]	Quayle 1966
Domoic acid / Amnesic Shellfish Poisoning	1992	Forbes and Chiang 1994
Pectenotoxins	2003	CFIA and NRC data
Gymnodimines	2003	CFIA and NRC data
Yessotoxins	2004	CFIA and NRC data
Okadaic acid group toxins / Diarrhetic Shellfish Poisoning	2011	McIntyre and Kosatsky 2013
Pinnatoxins	2011	CFIA and NRC data
Spirolide toxins	2011	CFIA and NRC data

[1] Symptoms consistent with PSP were documented by Europeans on the BC coast in 1793, and awareness existed even earlier among Indigenous Peoples of the Pacific Northwest.

To date, 33 species known to cause harmful algal events have been recorded in British Columbia waters (Table 2). The list includes seven pennate diatoms, four centric diatoms, 13 dinoflagellates, three dictyophytes, four prymnesiophytes, a rapidophyte and a ciliate. Fourteen of these species have caused Harmful Algal Events (HAE) in British Columbia.

Table 2. List of harmful algal species recorded in BC waters and occurrence of HAEs linked to the species (data from Bates *et al*. 2020). (Note, there may be some updates to this list from the CSAS meeting.)

Taxon	Caused HAE(s) in BC
DIATOMS	
Chaetoceros concavicornis Mangin	Yes
C. convolutus Castracane	Yes
C. debilis Cleve	
Corethron hystrix Hensen	
Pseudo-nitzschia australis Frenguelli	Yes
P. delicatissima (Cleve) Heiden	
P. fraudulenta (Cleve) Hasle	
P. multiseries (Hasle) Hasle	
P. pseudodelicatissima (Hasle) Hasle	
P. pungens (Grunow ex Cleve) Hasle	
P. seriata (Cleve) H. Peragallo	
DINOFLAGELLATES	
Akashiwo sanguinea (Hirasaka) Hansen & Moestrup	Yes
Alexandrium acatenella (Whedon & Kofold) Balech	Yes
A. catenella (Whedon & Kofold) Balech	Yes
A. ostenfeldii (Paulsen) Balech & Tangen	
Dinophysis acuminata Claparède & Lachmann	Yes
D. acuta Ehrenberg	

Taxon	Caused HAE(s) in BC
D. fortii Pavillard	
D. norvegica Claparède & Lachmann	
Gonyaulax spinifera (Claparède & Lachmann) Diesing	Yes
Karenia mikimotoi (Miyake & Kominami ex Oda) Hansen & Moestrup	
Karlodinium veneficum (Ballantine) Larsen	
Margalefidinium fulvescens (Iwataki, Kawami & Matsuoka) Gómez, Richlen & Anderson	
Phalacroma rotundatum (Claparède & Lachmann) Kofold & Michener	
DICTYOCHOPHYTES	
Dictyocha fibula Ehrenberg	Yes
Octactis speculum (Ehrenberg) Chang, Grieve & Sutherland	Yes
Pseudochattonella verruculosa (Hara & Chihara) Tanabe-Hosoi, Honda, Fukaya, Inagaki & Sako	Yes
PRYMNESIOPHYTES	
Haptolina ericina (Parke & Manton) Edvardsen & Eikrem	Yes
H. hirta (Manton) Edvardsen & Eikrem	Yes
Phaeocystis pouchetti (Hariot) Lagerheim	
Prymnesium polylepis (Manton & Parke) Edvardsen, Ekrem & Probert	
RAPIDOPHYTES	
Heterosigma akashiwo (Hada) Hada ex Hara & Chihara	Yes
CILIATES	
Mesodinium rubrum Leegaard	

Paralytic Shellfish Toxins (PST) and ‘other’ HAEs were reported every year from 2000 to 2017 (Fig. 1). The ‘other’ category includes marine mortalities, the majority of which occurred as fish kills at aquaculture sites although some are marine mammal or wild fish mortalities. It also includes discoloured water events. Amnesic Shellfish Toxin (AST) was reported in five of the 18 years, whereas Diarrhetic Shellfish Toxin (DST) was detected in six years starting in 2011.

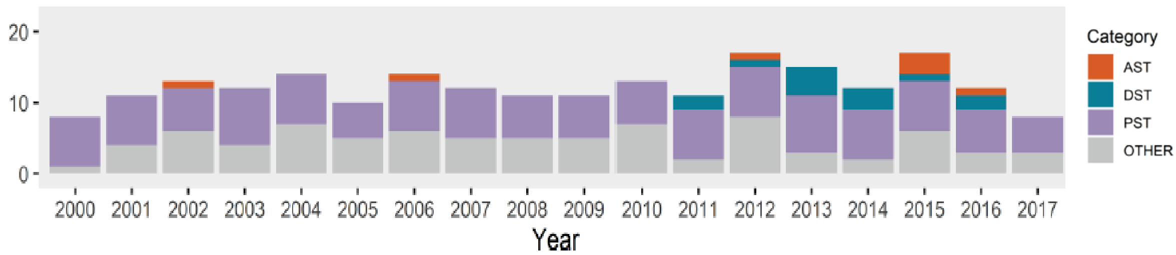

Fig. 1. Marine HAEs in British Columbia, reported in HAEDAT (from McKenzie *et al*. 2020).

PST was also the most geographically widespread cause of HAEs, although ‘other’ HAEs were almost as widespread (Fig. 2). DST and AST were detected in waters around Vancouver Island and the central coast, and AST was also present on the outer coast of Haida Gwaii.

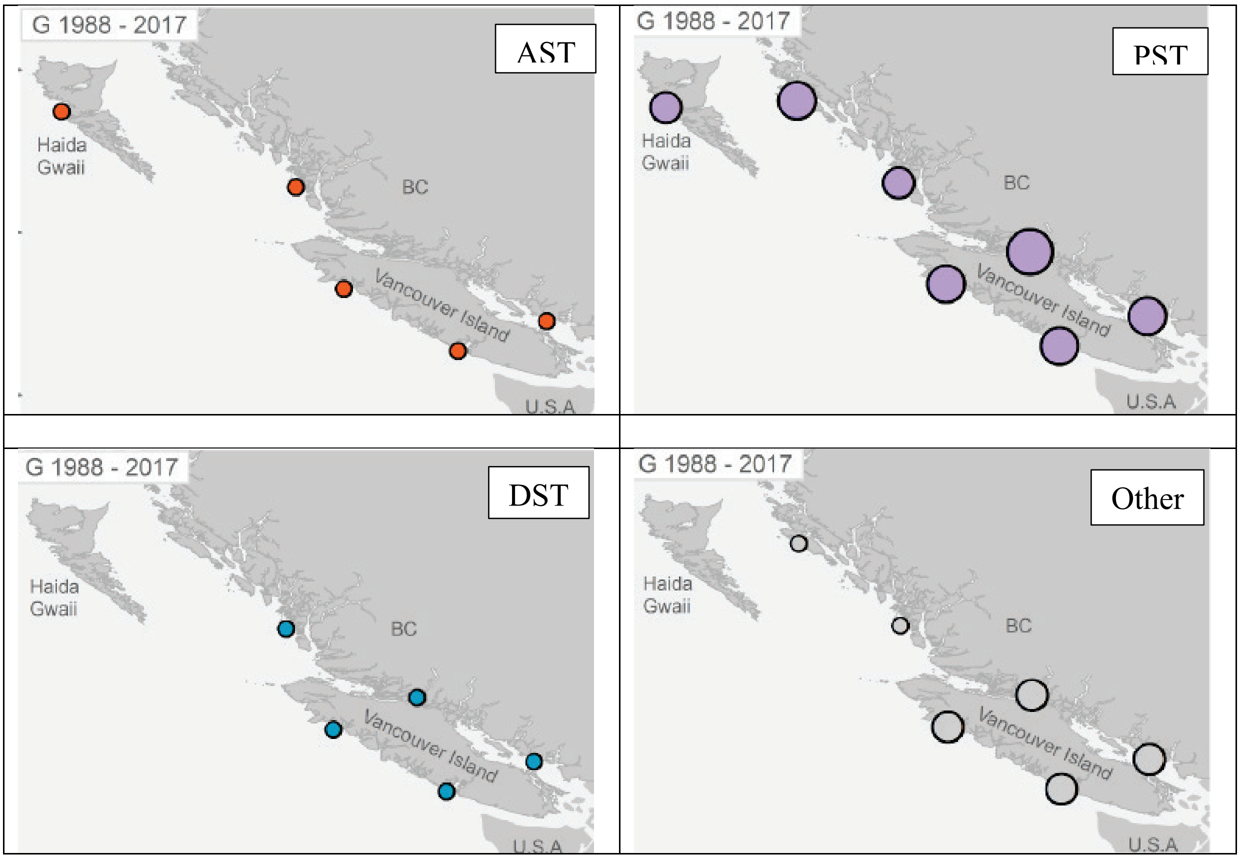

Fig. 2. Distribution of HAEs in BC in years 1988–2017. Dots at the mid-point of HAEDAT areas indicate one or more HAE occurred in the area. Areas without dots have no occurrences. Larger dots indicate more years with occurrences (smallest, 1–5 years; largest 21–25 years). From McKenzie *et al*. 2020.

2) HAEs in British Columbia waters: September 2019–August 2020

This report covers the period September 2019–August 2020 but the available records are incomplete because most Fisheries and Oceans Canada samples from this period are still being analysed. Reports presented here are from summaries in Boldt *et al*. (2020), events observed by DFO researchers, salmon aquaculture industry monitoring (Jay Pudota, Samudra Consulting), and HAEs reported in the news media.

To date, the most notable event reported in the past year is a *Pseudo-nitzschia* bloom on the west coast of Vancouver Island in June–July 2020. *Pseudo-nitzschia* was first noted at salmon aquaculture sites in inlets near Tofino (west coast Vancouver Island) in June. By late-June/early July, the La Perouse survey of Fisheries and Oceans was detecting very high cell counts and domoic acid concentration along much of the nearshore shelf of the west coast of Vancouver Island. See below for details.

September 2019 – Red water due to a bloom of *Ceratium divaricatum, C. fusus* and *C. furca* was reported near Tofino. *Heterosigma* was abundant on the west coast of Vancouver Island. *Rhizosolenia* was abundant in inlets of the Strait of Georgia and Johnstone Strait.

October 2019 – A large bloom of dinoflagellates, mainly *Ceratium divaricatum*, was observed on the Canadian side of the west entrance of Juan de Fuca Strait. Thousands of birds, schooling fish and a large number of whales were observed.

November 2019 – Four salmon aquaculture sites in Clayoquot Sound, west coast Vancouver Island, reported fish kills caused by *Chaetoceros concavicornis* and *C. convolutes*.

May 2020 – *Dictyocha* was abundant on the west coast of Vancouver Island north of Tofino. *Pseudo-nitzschia* was abundant in the northern part of the Strait of Georgia.

June 2020 – *Heterosigma* was abundant north of Tofino. *Pseudo-nitzschia* and *Rhizosolenia* were abundant in the Tofino area. *Dictyocha*, *Heterosigma* and *Pseudo-nitzschia* were abundant in the northern Strait of Georgia.

July 2020 – *Heterosigma* was abundant at multiple locations on the west coast of Vancouver Island, at Tofino and north of Tofino. High concentrations of *Pseudo-nitzschia* continued on the west coast of Vancouver Island at Tofino. *Pseudo-nitzschia* was abundant in Queen Charlotte Strait.

At an offshore station near Estevan Point on the west coast Vancouver Island north of Tofino, *Pseudo-nitzschia* (likely *P. australis)* was present on July 3 at ~525,000 cells/L and a domoic acid concentration of 2,104 pg/mL was measured. Much lower levels of domoic acid had been measured the previous week when the same station was sampled on June 28 and domoic acid was present at 133 pg/mL. A domoic acid concentration of 339 pg/mL was sampled off Ucluelet on June 28 and two samples in the 130–150 pg/mL range were sampled just south of Ucluelet off Barkeley Sound on June 25 and 28.

In early July, 'red tides' consistent with *Noctiluca* were observed on the east coast of Vancouver Island between Victoria and Nanaimo. Red water was also reported by members of the public at Sooke, in Juan de Fuca Strait.

August 2020 – *Rhizosolenia* was abundant in Queen Charlotte Strait and *Heterosigma* was abundant in the northern Strait of Georgia.

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China (reported by Prof. Douding Lu)

Roughly 38 HAB events affected an area of 1,991 km^2 along the Chinese coastline in 2019, causing a total direct economic loss of 31 million RMB (mainly caused by the two red tide events in Fujian Province). The events and the cumulative occurrence area of HABs increased by 6% and 42% compared with that in 2018, respectively. On the whole, from 2010 to 2019, the number of HABs and the affected area in China's seas have been greatly decreased. According to the monthly distribution, red tides were found in May most often and with the largest cumulative area, 11 times and 1,148 square kilometers, respectively. In terms of the regional distributions, HABs were found in the East China Sea most often and in the largest spatial accumulation, 31 times and 1,974 square kilometers, respectively. The greatest number and areal extent of HABs among the coastal provinces (autonomous regions and municipalities) occurred in Zhejiang Province, with 22 and 1,863 square kilometers, respectively. The largest and longest single HAB occurred in the sea east of Wenzhou Nanji Islands to Beiji Islands to Dongtou Islands, with a maximum area of 800 square kilometers and a duration of 34 days.

HABs in the Chinese seas comprised 16 dominant species. Among them, *Prorocentrum donghaiense*, as a dominant species, caused the most numbers of HABs with the largest cumulative area, which was 12 times and 1,251 square kilometers respectively. On May 23 and 25, two HABs events in the waters near the northern Huangqi Peninsula of Lianjiang in Fujian Province and near Pingtan Suao affected the cultivation of local red sea bream and grunt, leading to direct economic losses of 4,00,000 RMB and 27,000,000 RMB respectively. The dominant species were *P. donghaiense* and *Karenia mikimotoi*. HAB events extending over 100 square kilometers (including) all occurred in the waters of Zhejiang Province, mainly dominated by *P. donghaiense*, *Noctiluca scintillans*, *Skeletonema costatum* and *Chaetoceros brevis*, *etc*.

Japan (reported by Dr. Natsuko Nakayama)

1) Long-term and recent trends of HAB events

The inter-annual variation in the blooms and the damage to the fisheries from the HAB events have been reported over the past few decades in southwestern Japan, such as in the Seto Inland Sea and Kyushu area. In the Seto Inland Sea, the number of blooms decreased during the 1970s to 1980s and subsequently has been slowly declining. On the other hand, in the Kyushu area, the number had been on the rise overall, yet has been on the decline in the last five years.

2) HAB events and damages to the fisheries in 2018 and 2019

The total number of HAB events in 2018 and 2019 was 67 and 65 cases in the Seto Inland Sea and Kyushu area, respectively. Major HAB species in Japan are *Chattonella* spp. (*Cha*), *Heterosigma akashiwo* (*Ha*), *Karenia mikimotoi* (*Km*), *Cochlodinium polykrikoides* (*Cp*), *Heterocapsa circularisquama* (*Hc*). In recent years, *Km* has been the main species causing the blooms which have taken place in western Japan, as it scored the highest in both the cell number and extent of the damage caused by the blooms in 2018 and 2019. A great number of cultured fish were harmed or injured during the blooming period from May to September. Additionally, in 2019, the large scale of blooms were caused by *Cp* and *Cha.* The *Cp* blooms in the Bungo Channel caused in March seriously damaged cultured fish such as bluefin tuna and red seabream, with damage to the fisheries exceeding 380 million JPY. In *Cha*, the maximum cell density reached 18,600 cells/mL in the Yatsushiro Sea, which damaged cultured yellowtail and red seabream, with the value of the damages reaching 120 million JPY.

3) Damages from other HAB species

The blooms by *Gonyaulax polygramma* occurred in the Uwa Sea and the Bungo Channel in August 2019, with the losses to the fisheries stemming from damaged, cultured fish representing 9 million JPY. This blooming of *G. polygramma* was the first to have occurred in this area in 25 years.

4) Shellfish ban by PSP and DSP

In Japan, most of the outbreaks caused by paralytic shellfish poisoning (PSP) and diarrhetic shellfish poisoning (DSP) occur in the southwest (Seto Inland Sea and Kyushu area) and North Pacific coast (Tohoku area and Hokkaido) of Japan. There were 80 and 49 cases of shellfish ban by PSP in 2018 and 2019, respectively. The causative species for PSP were *Alexandrium tamarense* and *Alexandrium catenella* (the statistical data were collected under the old name) and *Gymnodinium catenatum* in 2018 and 2019. Although *Alexandrium tamiyavanichii* and *Alexandrium ostenfeldii* were present as causative species for PSP in some limited area in western Japan, these species rarely occurred and did not cause the shellfish ban in 2018 and 2019. The number of shellfish bans due to PSP has been increasing as well as the distribution of the species with PSP toxicity has expanded in recent years. In Osaka Bay, where *A. tamarense* has been appearing on a large scale for the last a couple of years, the maximum cell density was

166,375 cells/mL in mid-March, which ended up representing the highest score in 2019. It was lower than the previous year, but more than usual. The initial timing for the PSP accumulation in shellfish was in February 2019, which is the same as last year. The PSP toxic level and period became higher and longer in 2019. There were 3 and 26 cases of shellfish ban due to DSP in 2018 and 2019, respectively. The causative species for DSP were *Dinophysis fortii* and *Dinophysis acuminata*. The number of shellfish bans due to DSP has remained flat recently but there were more in 2019 than in 2018.

5) Name of '*Alexandrium tamarense* species complex' in statistical data

A new scientifically approved classification of *Alexandrium* spp. has been contributed to the national statistical data since January 2020. However, many local governments that have been conducting monitoring remain unable to incorporate genetic identification due to lack of funds and manpower. Therefore, for the time being, data have been collected under the name of '*Alexandrium tamarense* species complex' with morphological information.

In this report, the *Alexandrium* spp. names were shown in the former classifications. Their names will be replaced by a new name through a new classification in Japan within several years.

Korea (reported by Weo-Ae Lim)

1) Variation in HABs in Korean coastal waters since 1970

Since the beginning of HABs monitoring in 1972, the number of HABs continued to increase from the 1980s to the 1990s. After the largest number of HAB incidents (109) in 1998, the trend declined until the 2010s. Most HABs in the 1970s were caused by diatoms, whereas coastal dinofloagellates caused HABs in the 1980s, and *Cochlodinium polykrikoides* blooms have occurred continuously since 1993. The concentration of nutrients in coastal waters was the highest in the 1980s and has declined since the mid-1990s. This reduction in nutrient concentration is a possible explanation for the decreasing number of HABs. Summer high water temperatures reached 30°C or more since 2016, and the range and scale of *C. polykrikoides* blooms have been greatly reduced. In 2016, *K. mikimotoi* blooms occurred around Wando, Jangheung and Goheung and small-scale blooms of *C. polykrikoides* occurred around Yeosu. There were no *C. polykrikoides* blooms in 2017; however, *Alexandrium affine* blooms occurred from Yeosu to Tongyeong. There was a small-scale bloom of *C. polykrikoides* in 2018 compared to those in the previous years. Our results show that reduction in nutrients and the high water temperature owing to climate change are possible explanations for the observed variations in HABs in Korean coastal waters.

2) Occurrence of HABs in 2020

There were 22 cases of HABs between January and August 2020. A bloom of *Akashiwo sanguniea* occurred in January on the south coast, along with *Heterosigma akashiwo* in April, and *H. akashiwo*, *Prorocentrum dentatum*, *P. minimum* in May. A *Ceratium furca* bloom began near Busan on June 30, and then spread to the south and east coasts, lasting for two months. The rainy season in Korea usually occurs from mid-June to mid-July, but it was unusually long in 2020 (June 24–August 16, 50 days). This exceptional phenomenon was the longest period and the highest amount of rainfall recorded since weather observations began in Korea. The extended rainy season in 2020 led to lower water temperatures and salinity than normal averages in coastal waters, and the phytoplankton community was dominated by diatoms and dinoflagellate *Ceratium furca*. *C. polykrikoides* blooms had not yet occurred at the time of this report. Since the end of the long rain season, frequent typhoons have been striking the Korean Peninsula. Signs of climate change (high water temperature, rainy seasons, typhoons, *etc*.) have appeared more frequently since 2016, it appears that the typical pattern of *C. polykrikoides* blooms is changing. We will continue to study the effects of climate change-induced rainy seasons and typhoons on HABs.

3) Appearance of *Alexandrium* species related to PSP

PSP in 2020 led to closures of shellfish harvesting along only the southeastern coast, including Jinhae Bay. PSP was first detected on March 2, 2020 and toxin levels increased to exceed the regulatory level (>80μg/100g) on March 9. PSP was again detected on July 8, but not in all coastal areas. The major causal species of PSP in Korea is *Alexandrium catenella*. However, in contrast to previous years, there were no large outbreaks of *A. catenella* blooms in 2020. Nonetheless, PSP was detected at very low levels of *A. catenella* abundance; less than 1cell/mL. *A. catenella* appeared in Jinhae Bay at 0.26 cells/mL (average of all survey stations) on March 2, when PSP was first detected, and 7.1 cells/mL (average of all survey stations) on March 9, when PSP in shellfish began exceeding the regulatory limits.

Russia (reported by Tatiana Yu. Orlova)

1) Long-term and recent trends of HAB events in Russian coastal waters

The results of the HAB monitoring program on the east coast of Russia during the period 1999–2019 are summarized. A total of 43 potentially toxic and bloom-forming microalgae have been identified. The changes and overall trends in the composition, abundances and distribution of toxic microalgae were: a) a decrease in the diatom component of the phytoplankton assemblage, b) new bloom-forming flagellate species were detected, and c) new toxin producing species were revealed. For the last two decades some species of harmful algae have become common. For example, toxic dinophyceae, prymnesiophyceae and pelagophyceae have benefited from increased water column stratification, along with warm water benthic dinoflagellates and cyanobacteria responding to increased water temperatures. A monitoring program was launched in 2007 with the aim to analyze the presence of toxic species and screen for phycotoxins in shellfish. Data from this monitoring program revealed a real threat of diarrhetic shellfish poisoning in Primorye (the East/Japan Sea). There are no practical methods for analyzing phycotoxins and as a consequence it is impossible to register poisons by any of these toxins in medical or sanitary organization. All of these are the reasons of not having data on real economic impacts and harm for people's health for Primorye and for the whole Far Eastern region of Russia.

2) HAEs in the past year

This report covers the period of January 2019–August 2020. The results of HAB monitoring in Russian waters during this period is presented in Table 1.

To date, the most notable event reported in the past year was an *Alexandrium pseudogonyaulax* bloom in Amurskii Bay off Vladivostok City in July 2020. For the first time, *A. pseudogonyaulax* bloom was recorded in the Russian waters of the East/Japan Sea (before this species occured in local phytoplankton as single cells). During this extraordinary event, the surface waters off Vladivostok City (all shallow northern shallow parts of the Amurskii Bay) were covered with sticky foam of a brown-whitish color. This is was due to the presence of external polysaccharides produced by *Alexandrium pseudogonyaulax* during a bloom with exceptionally high cell concentrations (4.5×10^6 cells/L). In this bloom, *A. pseudogonyaulax* was monodominant, with diatoms being absent. As the bloom dominance shifted to *Prorocentrum* spp., diatoms of the *Skeletonema* complex appeared and reached significant abundance (up to 742,000 cells/L). Concentrations of *A. pseudogonyaulax* temporary cysts in surface sediments exceeded 10,080 cysts cells L^{-1} ml of sediments. Clonal cultures were established for morphological, molecular, toxicological and ecophysiological investigations to characterize the Russian population and compare them to other global *A. pseudogonyaulax* isolates.

Red-colored water due to a bloom of *Noctiluca scintillans* was observed under sea ice in Amurskii Bay off Vladivostok in February 2019 (temperature of sea water was –1.8°C). Red tides caused by *Noctiluca scintillans* were recorded at different locations in Peter the Great Bay in May 2019 and June 2020.

A monitoring survey focusing on potentially toxic species belonging to the diatom genus *Pseudo-nitzschia* was conducted in Amurskii Bay off Vladivostok City (January 2019–September 2020) and Ussuriiskii Bay (from September till November 2019). Six species of *Pseudo-nitzschia* were identified: *P. calliantha*; *P. delicatissima*; *P. fraudulenta*; *P. multistriata*; *P. pungens*, and *Pseudo-nitzschia* spp. (*Pseudo-nitzschia pseudodelicatissima/cuspidata* complex). The highest concentrations of *Pseudo-nitzschia* species were registered at the HABs monitoring station in Amurskii Bay on three occasions ($7.2{\cdot}10^5$ cells L^{-1} in October 2019, dominated by *P. fraudulenta*; $6.5{\cdot}10^5$ cells L^{-1} in November 2019, dominated by *P. pungens*; and

$6.1 \cdot 10^5$ cells L^{-1} in August 2020, dominated by *Pseudo-nitzschia* sp.). No cases of ASP (animal mortality) were found.

Table 1. List of harmful algal species recorded in Russian waters, January 2019–August 2020.

Taxon	Period of occurrences	Abundance, cells/L	Max. concentration, cells/L
DIATOMS			
Chaetoceros concavicornis Mangin	May, 2019; April–May, 2020	480–90 000	130 000 (May, 2019)
Pseudo-nitzschia calliantha (Cleve) Heiden	May–June, October–November 2019; August 2020.	1 904–200 000	614 900 (August, 2020)
P. delicatissima (Cleve) Heiden	October–November 2019	2 000–10 000	
P. fraudulenta (Cleve) Hasle	August, October–November 2019	6 820– 500 000	722 000 (October, 2019)
P. multistriata (Takano) Takano	October–November 2019	1 000–12 000	
P. pungens (Grunow ex Cleve) Hasle	August–November 2019; May–August 2020	1 653– 300 000	653 300 (November, 2019)
Pseudo-nitzschia pseudodelicatissima/cuspidata complex	October–November 2019	1 000–25 000	
DINOFLAGELLATES			
Alexandrium pseudogonyaulax (Biecheler) Horiguchi ex K.Yuki & Y.Fukuyo, 1992.	July 2020	1 00–2 500 000	2 600 000 (July, 9, 2020)
Dinophysis acuminata Claparède & Lachmann	February, May–November, 2019 ; January–February, May-August 2020	65–4 000	5 124 (May,2020)
D. fortii Pavillard	April, 2019	100	
Phalacroma rotundatum (Claparède & Lachmann) Kofold & Michener		100	
Margalefidinium fulvescens (Iwataki, Kawami & Matsuoka) Gómez, Richlen & Anderson	June–July 2019	500	
Prorocentrum cordatum (Ostenfeld) J.D.Dodge 1976	June, August–September, 2019; July–August 2020	728–1 200 000	5 280 000 (August, 2019)
Prorocentrum triestinum J. Schiller 1918	June–August, 2019; July–August 2020	1000–250 000	2 725 000 (July, 2020).
Noctiluca scintillans (Macartney) Kofoid & Swezy, 1921	February, May, August, 2019; May–June 2020	96–784	Red tide events: February (under sea-ice), May 2019; June 2020.
RAPIDOPHYTES			
Heterosigma akashiwo (Hada) Hada ex Hara & Chihara	June, October, 2019	66 100–1 2 00 000	1 320 000 (October, 2019)

USA (reported by Dr. Misty Peacock)

1) Overview

West Coast incidences of HAE produced mostly domoic acid, PSTs, DSTs, and there was some evidence of freshwater cyanotoxins transferred to marine habitats (including Alaska). There were continued incidences of marine mammal strandings in 2019–2020, though fewer reported than the toxic 2015–2017 events. Commercial fisheries were less impacted than those of the 2015–2017 closures, but there were still incidences of fisheries closures due to high levels of domoic acid, PSTs, and DSTs (south = domoic acid, north = PST and DST). The new "blob" developing in the North Pacific (off the coast of Alaska) that was similar to the 2014 marine heatwave did not materialize onshore, but marine heatwaves remain a cause for concern. Continued efforts for more offshore HAB sampling, modelling/forecasting of domoic acid, satellite/remote sensing for HABs, identification of new/emerging HABs, and freshwater toxin transfer to the marine environment continue to be areas of interest for academic, governmental, and tribal harmful algae researchers.

2) California State

Seafood safety is monitored by HABMAP, Coastal Ocean Observing System, and multiple state, federal, academic, private, and tribal partners for harmful algae and toxins. In 2019 there are multiple incidences of harmful algae, including *Pseudo-nitzschia, Alexandrium, Dinophysis, Linglodinium,* and *Prorocentrum* spp. Southern California included more incidences of *Pseudo-nitzschia* and particulate domoic acid (pDA) than the rest of California, though central and northern California had higher concentrations. *Alexandrium* incidences were infrequent in southern California, but were common in central and northern California as were *Dinophysis* and DSP events. There were multiple ASP and PSP commercial and recreational harvest closures throughout California, including the delay of the economically important Dungeness Crab fishery in December 2019. California continues to produce a state-wide HAB newsletter (CA HAB Bulletin), weekly updates by email, and use of the C-HARM model for domoic acid forecasting. Central and Southern California have also began including freshwater toxins found in the marine environment in weekly/monthly updates to the harmful algae community, and are in the process of setting up a statewide Imaging FlowCytobot System for harmful algae.

3) Oregon State

Monitoring for HABs in Oregon is done by the ORHAB and SoundToxins monitoring programs. In 2019 from north to south, there are higher cell counts for *Pseudo-nitzschia* (both large and small) and greater concentrations of pDA, with toxic events happening in April, July, and September–November. Throughout 2019, both *Alexandrium* and *Dinophysis* spp. were present at the five routinely sampled sites. October 2019 indicates an increase in both cells and toxins. In 2020 (so far) there are more incidences of pDA and greater concertation compared to 2019, at all five sampling sites. Cell counts for *Pseudo-nitzschia* large type also indicate higher concentrations, in April, and again in late May–August than in 2019. Recent offshore HAB sampling will be increased, with the awarding of new funds for an AUV to specifically sample offshore during spring and summer.

4) Washington State

In Washington State, monitoring for harmful algae is done by the ORHAB, SoundToxins, Washington Department of Health programs, and tribal nations. There were PSP events in multiple counties of Washington, along the entire coast of Washington State. The State analyzed ~2500 shellfish samples for PSP, and had a high of 6007 μg/100 g in blue mussels. There were 10 commercial closures for geoduck clam, as well as 21 recreational harvest closures. There were 1900 shellfish sampled for ASP, and one commercial closure in November. There were also ~1900 shellfish sampled for DSP, which had seven recreational and one commercial closures in 2019. In Northwest Washington there were 57 subsistence harvest closures for PSP and/or DSP events in 2019, and so far there have been 27 days in 2020. In 2019 beaches were closed well beyond the "regular" PSP season for harvesting, including through parts of December. The outer coast of Washington was mostly impacted by ASP events, and the 2019 December Dungeness crab fishery was delayed because of a multi-state closures (the entire West Coast). Other toxins that have been found in coastal Washington waters include the marine toxin Yessotoxin, and freshwater toxins: microcystin, anatoxin, and cylindrospermopsin.

5) Alaska

There are fewer HAB data for Alaska, but it is being monitored by SoundToxins, Southeast Alaska Tribal Ocean Research (SEATOR), Kachemak Bay National Estuarine Research Reserve (KBNERR), Alaska Sea Grant, Aleutian Pribolof Island Association, NOAA, and other tribal, governmental, and academic groups. In summer of 2019 there was one case of human PSP reported, and in July 2020, one death from PSP from Dutch Harbor (Unalaska) on July 4, 2020. Samples collected that same day were > 100× the regulatory limit. In Southeast Alaska, in 2019 there were elevated levels of PSP, first recorded in April (earlier than the previous year). By May 1, there was a recorded blue mussel sample 25× (2161 µg/100g) above the regulatory limit, and the maximum was 4412 µg/100g. Areas of SE Alaska had advisories all year round for PSP above regulatory limits even during winter months (December and January). In 2019 and 2020 the Bering Sea had clams with elevated PSP levels, and both ASP and PSP were found in stranded or harvested marine mammals' stomachs. Water temperatures in Alaskan and Bering Sea waters are increasing and extended PSP events are linked to the warming waters, particularly worrisome, where 100% of coastal Alaskans subsistence harvest.

AGENDA ITEM 3

HAEDAT, HABMAP

Dr. Vera Trainer gave a brief report on the updates of the Harmful Algal Event Database (HAEDAT) and discussed how these data were used as part of a new quantitative global assessment based on 30 years of data on the present status and trends of harmful marine microalgae (Hallegraeff *et al*., submitted). The report, based on the global database of HAEDAT and OBIS (Ocean Biodiversity Information System from 1985 to 2018, found regional trends of increases and decreases in different HABs, but no overall or regionally statistical trends. The report highlights some of the limitations to these datasets, and the need to link these data closer to environmental trends associated with climate drivers.

Also reported was the near completion of a report stemming from the 2019 PICES Scientific Report on "MEQ Workshop on GlobalHAB: Evaluating, Reducing and Mitigating the Cost of Harmful Algal Blooms", October 17–19 2019, during PICES-2019, Victoria, British Columbia, Canada. A brief summary of the chapters and overall findings was presented. The Scientific Report now is available on the PICES website (PICES Sci. Rep. No. 59).

AGENDA ITEM 4

Global HAB Best Practices Manual

Dr. Mark Wells reported on the GlobalHAB "Guidelines for the study of climate change effects on HABs" currently under development. Five chapters have been written, peer reviewed and revised: Observing changes in harmful algal blooms over time: Long-term observations for studying impacts from climate change; HABs under global change: Experimental conditions and approaches; Studying the acclimation and adaptation of HAB species to changing environmental conditions; Databases for the study of harmful algae, their global distribution and their trends; and Future perspectives in modeling harmful algal bloom (HAB) responses to climate change: Guidelines for HABs modelling. The guidelines are to be released for public comment early in 2021.

AGENDA ITEM 5
MAFF project

Dr. Wells reported on the completion of the PICES project "Building capacity for coastal monitoring by local small-scale fishers in Indonesia" funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. Indonesian coastal communities have suffered environmental degradation over the past decades which has had substantial negative effects on the wellbeing of the coastal people. PICES started working with Indonesian local communities and government using the Transdisciplinary Research Concept of the Future Earth to help begin mitigation efforts. Through community workshops, the Project Science Team integrated their opinions and ideas to identify five issues as important keystones for their wellbeing: 1) water quality, 2) fish catch, 3) Illegal Unregulated and Unreported fishing: IUU, 4) floating garbage (plastics), and 5) toxic phytoplankton (red-tides, or Harmful Algal Blooms). With the scientific support of PICES researchers, a smartphone-based GIS application was developed that enabled local fishers and community members to collect and electronically share fisheries and water quality data with relevant government authorities and researchers (*i.e.*, the co-production of data). Local students and teachers were included in the training workshops to help foster the sustainability of these data collection programs. The positive outcomes of these project activities include: 1) the Indonesian national government is moving to include these citizen-science collected data in the Indonesian National Ocean Data Center, 2) the local communities have formed a sense of ownership and pride for their monitoring activities, and 3) these data streams provide the foundation for the co-creation of new knowledge and scientifically envisioning the future of coastal ecosystems and livelihood in Indonesia.

AGENDA ITEM 6
Session and Workshop proposals for 2021

Dr. Setsuko Sakamoto reported that the 1-day Workshop on "*The expansion of Harmful Algal Blooms (HABs) from lower to higher latitudes*" (Convenors: Mark Wells, Setsuko Sakamoto and Natsuko Nakayama), proposed for PICES-2020, but not held virtually, has been postponed to PICES-2021.

Dr. William Cochlan reported that a ½-day Topic Session on "The effect of ocean acidification on harmful algal species growth and toxicity" (Convenors: William Coclan, Pengbin Wang and Mark Wells), proposed for PICES-2020, but not held virtually, has been postponed to PICES-2021.

AGENDA ITEM 7
Nomination of potential new members

Dr. Yoichi Miyake (Japan) was recommended to be a new member of S-HAB.

AGENDA ITEM 8
Requests to MEQ

- Half-day S-HAB meeting at PICES-2021;
- Travel support for 1 PICES representative to attend the IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB) in 2021 ($3,000).

S-HAB Endnote 1

S-HAB participation list

Members

Pengbin Wang (China, Co-Chair)
Mark L. Wells (USA, Co-Chair)
Andrea Locke (Canada)
Andrew RS Ross (Canada)
Charles Trick (Canada)
Chunlei Gao (China)
Hao Guo (China)
Chunjiang Guan (China)
Douding Lu (China)
Mengmeng Tong (China)
Mitsunori Iwataki (Japan)
Natsuko Nakayama (Japan)
Setsuko Sakamoto (Japan)
Seung Ho Baek (Korea)
Weol-Ae Lim (Korea)
William Cochlan (USA)
Misty Peacock (USA)
Vera L. Trainer (USA)
Takafumi Yoshida (*ex officio*, representing NOWPAP)

Members unable to attend

Canada: Nicola Haigh
China: Qiufen Li
Korea: Hae Jin Jeong, Kwang Young Kim, Tae Gyu Park
Russia: Tatiana Morozova, Tatiana Orlova, Mikhail Simokon

Observers

Ruoyu Guo (China)
Sha Mai (Philippines)
Yoichi Miyake (Japan)

PICES

Sonia Batten (Executive Secretary)

S-HAB Endnote 2

S-HAB meeting agenda

1. Introduction by Section Co-Chairs (Pengbin Wang and Mark Wells) and Greetings (All)
2. Country Reports (All)
3. HAEDAT, HABMAP (Vera Trainer)
4. Global HAB Best Practices Manual (Mark Wells)
5. MAFF project (Mark Wells)
6. Session and Workshop proposal for 2021 (Setsuko Sakamoto, William Cochlan)
7. New member of S-HAB
8. Requests to MEQ and other issues (Mark Wells, Pengbin Wang and all)