JOINT ICES/IOC WORKING GROUP ON HARMFUL ALGAL BLOOM DYNAMICS (WGHABD; outputs from 2020 meeting)

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Contents

i Executive summary

The ICES/ IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD), co-sponsored by the International Oceanographic Commission (IOC) of UNESCO Intergovernmental Panel for Harmful Algal Blooms (IPHAB), looks at the dynamics of harmful algal blooms (HABs).

HABs continue to impact the ICES area and delegates presented national reports of HABs and their impacts, including widespread closures of shellfish harvesting areas across the ICES area due to levels of shellfish toxins exceeding regulatory thresholds, marine mammal and fish mortalities, brown tides, human illness due to ciguatera poisoning (CP) and beach closures due to cyanobacteria blooms. Closures of shellfish harvesting areas were also enforced due to levels of Tetrodotoxin exceeding regulatory thresholds in the Netherlands. A range of 'new findings' relating to HABs were presented including developments in satellite imagery of HABs, molecular methods, impacts of viruses on cyanobacteria, oomycete parasites of diatoms, records of *Ostreopsis* cf. *siamensis* in the Bay of Biscay and interpretation of shellfish toxin monitoring data.

The ecology of selected HAB groups were reviewed including CP producing species *Gambierdiscus* and *Fukuyoa*, Arctic HAB species and fish killing algae. CP continues to present a health risk in the Canary Islands and annual updates of developments in investigating CP and its causative organisms were presented. The role of HABs in the assessment of 'Good Environmental Status' for the EU Marine Strategy Framework Directive were reviewed. New methodologies and their utilisation were also discussed and outcomes of a CoClime qPCR workshop, presented.

WGHABD main focus was the updating of the IOC-ICES-PICES Harmful Algal Event Database, production of text for an ICES Harmful Algal Event Status Report and contributions towards the IOC Global HAB Status report (GHSR). HAEDAT data was updated and graphical products developed. HAEDAT data from the ICES area has contributed to an additional seven presentations at conferences and one book chapter. Five manuscripts have been submitted to the scientific journal Harmful Algae analysing HAEDAT data from the ICES area and delegates from WGHABD are co-authors on a global synthesis paper for the GHSR. HAEDAT maps were provided as example outputs developed by ICES and IOC at the UN Decade of Ocean Science North Atlantic Workshop. These maps were highlighted during the Workshop general summary as a template for compiling and integrating various HAB and other data to deliver products to a broader user community such as hazard maps and potential risk for early warning systems (EWS).

Throughout 2018–2020 WGHABD continued to report to the IOC Intergovernmental Panel for Harmful Algal Blooms and represent ICES on the IOC SCOR GlobalHAB Scientific Steering Committee.

ii Expert group information

Expert group name	ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD)
Expert group cycle	Multiannual
Year cycle started	2018
Reporting year in cycle	3/3
Chair	Eileen Bresnan, UK
Meeting venue(s) and dates	23–26 April 2018, Sant Carles, Spain (17 participants)
	2–4 April 2019, Oslo, Norway (20 participants)
	2–4 March 2020, Gdansk, Poland (19 participants)

1 ToR A: National Reports

National reports were presented annually at each WGHABD meeting. A three-year annual report for each country summarising events during 2017, 2018 and 2019 is presented in Annex 3. A range of impacts were experienced during the reporting period. In Europe, diarrhetic shellfish toxins (DSTs) caused the most problems. Portugal, Spain, France, UK, Ireland, Iceland, Norway, Sweden and Denmark all reported incidents of shellfish closures as did the USA and Canada, although the number of closures varied interannually. No reports of incidents associated with DSTs were reported from Belgium, the Netherlands or Germany during the reporting period. Incidents associated with paralytic shellfish toxins (PSTs) were more variable with the first records of closures of shellfish harvesting areas due to PST levels exceeding regulatory limits reported from the south west of Ireland and a rare record from Sweden. Amnesic shellfish toxins (ASTs) caused closures of shellfish harvesting activities in Portugal, Spain, France, Ireland, Iceland and Norway during the reporting period with closures varying in duration from a couple of weeks to many months in some instances. Closures of shellfish harvesting areas due to levels of azaspiracid (AZA) toxins above regulatory limits were enforced in Ireland during the reporting period and for the first time in Sweden in 2018. The only reports of impacts from aerosolised toxins in Europe came from Catalonia in Spain. Ciguatera poisoning (CP) continued to cause human illness in the Canary Islands with annual reports during the reporting period. In the Netherlands closures of shellfish harvesting areas due to levels of tetrodotoxin (TTX) in breach of the threshold of 44µg kg^{-1} where implemented in 2018 and 2019.

A number of animal mortality events were included in national reports from Europe during the reporting period associated with blooms of harmful algae. These included canine fatalities from the South East of England after consumption of PST contaminated fish and starfish washed ashore during a winter storm in Dec 2017/ Jan 2018. In Belgium in 2018 a mixed bloom of ciliates and cyanobacteria is thought to have caused the hypoxic conditions that killed wild fish (European eel, European seabass) and benthic organisms (shrimp, crabs, gobies). An unusual bloom of *Lepidodinium chloroforum* occured along the east coast of Denmark in 2018 which caused a number of beach closures but was not associated with any mortality events. A bloom of *Pseudochattonella* along the Norwegian Skagerrak coast in 2017 caused mortalities of farmed fish at one site. In 2019 a *Pseudochatonella* bloom in Denmark resulted in the mortality of 400 – 500 tons of fish, worth approximately one million euro.. In 2019 a bloom of *Chrysochromulina leadbeateri* caused significant mortalities of farmed fish in Northern Norway resulting in an estimated an economic loss between 2.3-2.9 billion NOK, (~ $0.27 – $0.34 billion US), direct and indirect gross.

Shellfish toxins did not cause problems in the Baltic Sea area. In 2018 a significant bloom of cyanobacteria was observed. This bloom was mainly comprised of *Aphanizomenon* and *Dolichospermum* in the Northern Baltic Sea while *Nodularia spumigena* caused extensive closures of beaches in Poland during the summer of 2018, the highest number of closures in a decade. Swedish satellite imagery during 2018 showed the cyanobacteria bloom had the largest extent and was of the longest duration in records collected between 2002 and 2019.

The USA experienced a wide range of impacts from HABs. PSTs caused problems for shellfisheries along the northeast coast, eastern and western Florida coasts and along the west coast including Alaska. One case of human illness was reported associated with PSP after consumption of recreationally harvested shellfish was reported from California in 2018. Closures of shellfish harvesting areas due to ASTs also caused problems for shellfisheries in Maine and Rhode Island during the reporting period. An additional AST event was recorded in the west coast of Florida in 2017. ASTs continued to cause significant problems on the west coast of the USA during the reporting period, both for marine life and shellfisheries. Marine mammal strandings were reported in California in 2018 with symptomology associated with ASP and impacts from ASTs continue to cause concern for shellfisheries and Dungeness Crab industry. There were two closures of shellfish harvesting areas on the east coast of the USA due to high concentrations of DSTs in Maine and NY state during the reporting period. The Maine event in 2018 was associated with the discovery of a new toxin – dihydro-dinophysistoxin. On the west coast, closures of shellfish harvesting areas associated with DST were restricted to Washington State where DSTs have become a persistent problem since they were first recorded in 2011. Significant and prolonged blooms of *Karenia brevis* in the Gulf of Mexico caused problems along the Gulf coast during the reporting period. In Florida, these impacts included shellfish closures, multiple fish kills, marine mammal, bird and turtle deaths, human respiratory irritation and significant economic losses related to the cleanup of beaches and waterways as well as decreased revenues to waterfront merchants due to reduced traffic and tourism flow. Brown tides also caused problems, impacting areas in New York State, Maryland and Florida. Two unusual incidents of mortalities were recorded. In Virginia an extensive bloom of *Levanderina fissa* caused fish and crab mortalities due to hypoxia in the Potomac River during July/August 2019. Mississippi coastal beaches experienced negative impacts from cyanobacterial blooms from June – Oct 2019. This was a result of high-volume discharges from the Mississippi River through the Bonnet Carre spillway that carried the blue-green and nutrient laden fresh waters into the coastal zone, sufficiently lowering the salinity and increasing nutrient levels to promote the blooms along 21 Mississippi beaches.

In Canada, interannual variability in the impacts from harmful algae was recorded during the reporting period. On the Atlantic coast closures of shellfish harvesting areas due to PST levels exceeding regulatory thresholds were enforced in Quebec in 2017 and New Brunswick/Nova Scotia in 2017 and 2018. No data are available from Quebec for 2018 and 2019 or from New Brunswick/Nova Scotia in 2018. There have been gaps in the records from some regions (2018, 2019) due to difficulties accessing phycotoxin data and levels which had led to the shellfish closures. This information will be added to HAEDAT as it becomes available. There were no PST events in Prince Edward Island or Newfoundland and Labrador during the three-year period. Several areas in Newfoundland and Labrador remain closed due to the presence of PST containing cysts in the sediment. Closures due to DSTs were enforced at several locations on the Eastern Shore of Nova Scotia, Richibucto Harbour and Shediac Bay in New Brunswick and PEI during the reporting period. Shellfish harvesting areas in Quebec were impacted by ASTs in 2018, in Nova Scotia in 2017, 2018, 2019 and New Brunswick in 2018. In Newfoundland and Labrador, some AST shellfish biotoxin closure orders from previous years are still in effect in the region. Along the Pacific Canadian coast closures of shellfish harvesting areas due to PSTs were enforced in 2017 and 2018. No data were available for 2019. Closures for DSTs were enforced in 2018. Yessotoxins, gymnodimines and pectenotoxins were also recorded as present but are not regulated in Canada so there were no closures due to these toxins. In 2017 mortalities of farmed fish were recorded along the Pacific coast due to *Heterosigma akashiwo, Alexandrium catenella, Chaetoceros convolutes* and *C. concavicornis.* In 2018, mortalities of farmed fish due to *H. akashiwo* were recorded in Vancouver Island and Clayquot Sound. In 2019, mortalities of farmed fish were recorded due to *Chaetoceros concavicornis* and *C. convolutes*.

2 ToR B: Fish Killing Algae

WGHABD have included sections on fish killing algae for the ICES WGHABD Status Report and sections on fish killing algae and mortalities have been included in the regional manuscripts submitted to Harmful Algae for the GHSR special issue (see section 3).

3 ToR C & D: IOC-ICES-PICES Harmful Algal Event Database and the Global HAB Status Report

Work on the IOC-ICES-PICES Harmful Algal Event database was a core part of WGHABD activity during this three-year reporting cycle both in terms of recording harmful algal events in the ICES area but also as a contribution to the Global HAB Status Report.

The HAEDAT Guidelines stress that only information about **harmful events** according to the following definition is to be entered in the database:

A harmful algal event is defined as a water discoloration, scum or foam causing a socio-economic impact due to the presence of toxic or harmful microalgae; a biotoxin accumulation in seafood above levels considered safe for human consumption, or any event where humans, animals or other organisms are negatively affected by algae. A bloom or a toxicity that did not cause a socio-economic impact, or cause biotoxin accumulation in seafood above levels considered safe for human consumption or negatively affected humans, animals or other organisms is not an event in HAEDAT sense and is not entered.

National editors from the ICES area updated HAEDAT annually during the reporting period. Outputs from HAEDAT are presented in Annex 4. These comprise of annual maps for 2017, 2018, 2019 and a composite maps showing years with events from 2017–2019 for aerosolised toxins, ASTs, AZAs, CP, cyanotoxins, DSTs, mass mortalities, NSTs and PSTs.

During the 2018 meeting one day was dedicated for national editors to review their historic HAEDAT data and begin to draft text for the ICES Status Report. Historic data was thoroughly quality checked. WGHABD have been presenting national reports since the 1980s and their HAEDAT data entries have evolved over the decades from being typed by hand in variable formats and paper copies submitted at WG meetings, to completed paper 'pro forma' templates that were filled in and submitted at each WG meeting, to national editors entering their own data in the HAEDAT database. These variable data entries led to some inconsistencies in records entered. For example, there are a number of records from the 1980s that are of high phytoplankton cell densities of potential causative organisms with no stated negative impact. In some instances these entries are the only records of these historic cell counts so a decision was made by WGHABD to leave these records in HAEDAT but to remove any syndrome associated with them. Missing data were also identified and entered. In addition, CP events from Macaronesia were entered into HAEDAT. This allows European CP events to be collated with data from across the globe.

A reporting format for the ICES status report was agreed to account for inconsistences in the older data. The introduction of HAEDAT areas in 2003 affected the manner in which events that spanned multiple areas were entered. As a result, maps showing the number of years with 'events per area code' were chosen as the preferred graphic to report (see example a). It was felt that owing to inconsistency with monitoring programmes in the early years, it was valid to present the maps showing the number of HAEDAT events in 5-year blocks with the last year being 2017. Bar charts of number of area codes with events per year were also used as an example of product output. The structure of the report was agreed and work is underway. An important consideration in interpreting results from is the metadata behind the monitoring that has generated the HAEDAT data. This has changed considerably over the duration of the time-series (e.g., closing on cell counts and not toxin values, changes from mouse bioassay to chemical methods); this all needs to be captured. Report structure was decided and preliminary text drafted. During 2019/2020, the focus of efforts was placed on production of manuscripts for the HA special manuscript for the GHSR.

Annual HAEDAT maps for the current reporting period for each syndrome are presented in Annex 4 as well as a map showing the incidents of events over the 2017–2019.

The Global HAB Status Report (GHSR)

The IOC is currently producing a Global HAB Status Report (GHSR) presenting the first global synthesis of HAB species and HAB events and how they have changed over time. The GHSR will consist of a summary 'glossy publication', a GHSR; and a special issue Harmful Algae.

WGHABD submitted five manuscripts to the special issue of Harmful Algae dedicated to the GHSR (details below) and are also co-authors on a synthesis paper submitted to Nature:

Anderson, D.M., Fensin, E., Gobler, C.J., Hoeglund, A.E., Hubbard, K.A., Kulis, D.M., Landsberg, J.H., Lefebvre, K.A., Provoost, P., Richlen, M.L., Smith, J.L., Solow A. R., and Trainer V. L. (*Submitted*) Marine harmful algal blooms (HABs) in the United States: History, current status and future trends. *Harmful Algae*, p.101975.

Belin, C., Soudant, D. and Amzil, Z., 2020. Three decades of data on phytoplankton and phycotoxins on the French coast: Lessons from REPHY and REPHYTOX. *Harmful Algae*, p.101733.

Bresnan, E., Arévalo, F., Belin, C., Branco, M.A., Cembella, A.D., Clarke, D., Correa, J., Davidson, K., Dhanji-Rapkova, M., Lozano, R.F. and Fernández-Tejedor, M., Guðfinnsson H., Jaén D., Laza-Martinez A., Lemoine M., Lewis A. M., Maskrey B., Mamán Menéndez L., McKinney A., Pazos Y., Revilla M., Siano R., Silva A., Swan S., Turner A. D., Schweibold L., Provoost P., and Enevoldsen H., (*Submitted*). Diversity and regional distribution of harmful algal events along the Atlantic margin of Europe. *Harmful Algae*, p.101976.

Karlson, B., Andersen, P., Arneborg, L., Cembella, A., Eikrem, W., John, U., West, J.J., Klemm, K., Kobos, J., Lehtinen, S., Lundholm, N., Mazur-Marzec, H., Naustvoll, L.-J., Poelman, M., Provoost, P., De Rijcke, M., and Suikkanen, S. (*Submitted*) Harmful algal blooms and their effects in coastal seas of Northern Europe. *Harmful Algae*, p.101989.

McKenzie, C.H., Bates, S.S., Martin, J.L., Haigh, N., Howland, K.L., Lewis, N.I., Locke, A., Peña, A., Poulin, M., Rochon, A., Rourke, W.A., Scarratt, M.G., Starr, M., and Wells, T. 2020, Three decades of Canadian marine harmful algal events: phytoplankton and phycotoxins of concern to human and ecosystem health. *Harmful Algae*, p.101852.

Hallegraeff G.M., Anderson D.M., Belin C., Bottein M-Y, Bresnan E., Chinain M., Enevoldsen H., Iwataki M., Karlson B., McKenzie C. H., Sunesen I., Pitcher G. C., Provoost P., Richardson A., Schweibold L., Tester P. A., Trainer V., Yñiguez A. T., Zingone A., (submitted) Are harmful marine microalgal blooms and their societal impacts increasing? A 30 year global data analysis. *Nature.*

The preparation of the GHSR has identified some challenges with HAEDAT/HABMAP/HAB data which points to the need for continued technical support, continued development of user interface and data products.

The first GHSR was built on the data available. These data-mining efforts can hopefully be an opportunity to get recognition at both institutional and global levels of the value of collecting, sharing and compiling accurate HAB information/data so there will be better funding for collection and synthesis of HAB data in the future. It was discussed if a next leap forward in compiling and integration various HAB data would be a possible UN Decade of Ocean Science project in order to deliver products to a broader user community such as, e.g., hazard maps. The Global HAB report and the HAEDAT mapping data were discussed at the UN Decade of Ocean Science North Atlantic Workshop in Halifax, NS Canada January 6–10, 2020. During the Working Group 4 on safe oceans and protection from ocean hazards, HAEDAT maps were provided as an example of what was being developed by ICES and IOC for distribution of HAB hazards. The maps were well received and highlighted during the Workshop general summary as a template for compiling and integrating various HAB and other data to deliver products to a broader user community such as, e.g. hazard maps and potential risk for early warning systems (EWS).

A number of presentations using ICES HAEDAT data were made during the reporting period. These include:

Bresnan *et al.*, 2018. Regional changes in harmful algal events in the North Atlantic area over the last two decades documented using the HAEDAT database, *4th International ICES/PICES/IOC/FAO Symposium - The effects of climate change on the world's oceans, 4–8 June 2018, Washington D.C., USA*

Bresnan *et al.*, 2018. Regional changes in harmful algal events in the North Atlantic area over the last two decades documented using the HAEDAT database. *18th International Conference on Harmful Algae, Nantes, France, 21-26 October 2018*

McKenzie *et al.*, 2018 Three Decades of Canadian Marine Harmful Algal Events- Reviewed and Evaluated Using Information from the HAEDAT Database. *18th International Conference on Harmful Algae, Nantes, France, 21-26 October 2018.*

Bresnan *et al.*, 2019. Regional changes in harmful algal events in the North Atlantic area over the last two decades documented using the HAEDAT database. *ICES ASM, Gothenburg, Sweden 9 – 12th Sept 2019.*

Bresnan *et al.*, 2019. Regional changes in harmful algal events in the North Atlantic area over the last two decades documented using the HAEDAT database. *11th Shellfish Safety Workshop, Athlone, Ireland 8th Oct 2019*

McKenzie *et al.* 2019. Harmful Algal Events in Canadian Marine Ecosystems: Introduction and Current Status. *National Canadian Science Advice Secretariat (CSAS) "Harmful Algal Events in Canadian Marine Ecosystems: Current status, impacts, consequences, and knowledge gaps" Victoria, B.C. Canada 12-14 March, 2019.*

McKenzie *et al.* 2020. Canadian Atlantic, Pacific and Arctic Harmful Algae Review. *ICES WGITMO/WGHABD/WGBOSV joint meeting. Gydnia, Poland. March 4, 2020.*

Information on HAEDAT has also been included in a book chapter for the IOC manual *"Best Practice Guidelines for the Study of HABs and Climate Change*" currently in production.

Chapter 3: Zingone A., Escalera L., Bresnan E., Enevoldsen H., Provoost P., Richardson A. J., and Hallegraaf G. (revised) Databases for the study of harmful algae, their global distribution and their trends. *IOC Manual "Best Practice Guidelines for the Study of HABs and Climate Change.*

4 ToR E: New Findings

Details of the diverse range of presentations on new findings that were presented at during the reporting period are given below.

Bioanalytical devices for the rapid, reliable and cost-effective detection of toxic microalgae

M. Campàs, A. Toldrà, K. B. Andree, M. Fernández-Tejedor, M. Rey, E. Dàmaso, V. Castan, J. L. Costa, J. Diogène, IRTA, Spain

Biotechnological tools for the detection, discrimination and quantification of toxic microalgae have been developed in the framework of the Spanish projects SEASENSING AND CIGUASENSING (BIO2014-56024-C2-2-R and BIO2017-87946-C2-2-R, MINECO). The targeted microalgae have been *Karlodinium veneficum* and *Karlodinium armiger*, *Ostreopsis ovata* and *Ostreopsis siamensis*, and *Gambierdiscus/Fukuyoa*.

Different formats have been designed: colorimetric assays on microtiter plates, electrochemical biosensors and visual strip tests. All biotechnological tools include an isothermal DNA amplification step using tailed primers, followed by a sandwich hybridisation assay. The isothermal DNA amplification uses recombinase polymerase enzymes and is able to operate at low constant temperature (37 °C). In this process, a duplex amplicon is formed, with a tail that hybridises with a capture probe immobilised on a plate or on a magnetic bead (used as a support for the immobilisation on electrodes), and another tail, at the other extreme, that hybridises with a reporter probe. After enzyme substrate incubation, colorimetric and electrochemical measurements are recorded. Seawater and macrophyte samples have been analysed using these approaches, and results have been compared with qPCR and light microscopy, showing appropriate correlations.

Novel widespread oomycetes parasitising diatoms, including the toxic genus *Pseudo-nitzschia*: genetic, morphological and ecological characterisation

Andrea Garvetto, Elisabeth Nézan, Yacine Badis, Gwenael Bilien, Paola Arce, Eileen Bresnan, Claire M.M. Gachon, Raffaele Siano, Ifremer, Spain

Parasites are key drivers of phytoplankton bloom dynamics and related marine ecosystem processes. Yet, the dearth of morphological and molecular information hinders the assessment of their diversity and ecological role. Using single-cell techniques, we characterise morphologically and molecularly intracellular parasitoids infecting four potentially toxin producing *Pseudo-nitzschia* and one *Melosira* species on the North Atlantic coast. These sequences define two novel, morphologically indistinguishable, clades within the phylum Oomycota, related to the genera of algal parasites *Anisolpidium* and *Olpidiopsis* and the diatom parasitoid species *Miracula helgolandica*. Our morphological data are insufficient to attribute either clade to the still unsequenced genus *Ectrogella*; hence it is proposed to name the clades OOM_1 and OOM_2. A screening of global databases of the barcode regions V4 and V9 of the 18S rDNA demonstrate the presence of these parasitoids beyond the North Atlantic coastal region. During a biweekly metabarcoding survey of the Concarneau Bay (France), barcodes associated with the sequenced parasitoids coincided with the decline of *Pseudo-nitzschia* spp. and *Cerataulina pelagica* blooms. Our data highlight a complex and still unexplored diversity of oomycete parasitoids of diatoms and calls for the investigation of their phenology, evolution, and potential contribution in controlling their host spatial-temporal dynamics.

Effect of viruses on *Nodularia spumigena*

Justyna Kobos, Agata Błaszczyk, Hanna Mazur-Marzec, IO, University of Gdańsk, Poland

The effect of viruses on the dynamics, morphology and toxin (nodularin, NOD) production by the bloom-forming cyanobacterium *Nodularia spumigena* was explored. For the purpose of the study, the cyanophage-cyanobacteria system was established. Within 96 h of experiment, viral infection led to a significant reduction of cyanobacteria cell density (to 93 % of the initial value). As a result of virus-induced cell lysis, the extracellular concentration of NOD increased over 57 times. The filaments size distribution has also changed toward shorter ones; which might promote *N. spumigena* ingestion by zooplankton grazers. The most important finding was a gradual increase in cellular NOD quota (× 10) in the cyanophage resistant *N. spumigena* subpopulation. The results of our preliminary study into the effect of cyanophage on *N. spum*igena were published Harmful Algae (Šulciuš S. *et al.* 2018 https://doi.org/10.1016/j.hal.2018.07.004).

Update on satellite techniques for monitoring for HABs

Peter Miller, Plymouth Marine Laboratory, UK

There have been a number of developments in Earth observation (EO) capabilities, and several ongoing UK and European projects developing EO techniques for detecting HABs. The key development is that a pair of Sentinel-3 satellites is now operational, together providing daily global coverage of 300 m resolution ocean colour data. Looking forward, the NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission is due for launch in 2022, providing hyperspectral colour data which would enable more sensitive HAB discrimination. There has also been a proliferation in the number of websites offering access to ocean colour data. A number of projects using EO.

The **PRIMROSE** project aims to provide local HAB forecast bulletins for the aquaculture industry, based on hydrodynamic models and EO data on algal blooms; progress was presented on linking these two approaches. (Funded by Interreg Atlantic Area, extending an earlier FP7 project ASIMUTH). **ShellEye** has launched a subscription service to provide early warning of water quality risks to aquaculture (mainly shellfish) farmers, via regional bulletins sent by e-mail, focused initially on the UK region. The bulletins comprise satellite monitoring and detection of certain dense HABs. It is also generating long-term satellite HAB risk maps for potential use by marine insurers. (Funded by UK research councils BBSRC and NERC). **S-3 EUROHAB** is developing a web-based alert system to track the growth of potential HABs, for marine managers, regulators, and the fishing industries within the French/English Channel region. The project is also creating a cross-border monitoring network and data portal for monitoring water quality, incorporating Sentinel-3 satellite data as well as *in situ* monitoring, and physical and ecosystem modelling. (Funded by Interreg France/England Channel.).

***Ostreopsis* cf. *siamensis*: A new HAB risk in the Gulf of Biscay?**

Raffaele Siano, Ifremer, France

The study of the distribution of *Ostreopsis* along the French Atlantic coasts was done within the European project CoCliME. A sampling campaign in the Bay of Biscay was carried out during the summer of 2018 in an attempt to identify the western and northern limits of distribution of this genus in this area. The campaign ran from 25 August to 20 September 2018, and covered a total of 40 sites (8 in Spain, 32 in France). To detect the presence of the genus *Ostreopsis*, we used optical methods (microscopic observations of conventional benthic samples) as well as molecular tools (PCR, qPCR) allowing us to analyze environmental DNA samples. The novelty of the approach used lay mainly in the use of artificial substrates (deposited 24 hours, during two tidal cycles at each sampling station) for the analysis of traces of DNA specific to *Ostreopsis* species. *O.* cf. ovata and *O.* cf. *siamensis*. The molecular biology techniques chosen, which are much more sensitive and practical than conventional optical microscopy approaches, have allowed us to identify rare traces of the presence of these species in the study area. After qPCR analyzes of the samples collected and sequencing of the PCR products, the presence of *Ostreopsis* cf. *siamensis* has been found over a large part of the Bay of Biscay (in Spain and France), in no less than 24 sites, while *O.* cf. *ovata* was absent in all stations. Higher abundances of *O.* cf. *siamensis* (currently estimated qualitatively in terms of the number of positive replicas to qPCR, sequencing of amplification products and sequencing analyses) were found at stations located in the southern Bay of Biscay. However, the species has also been detected in the Perthuis Bretons and in Brittanny and in the Brest Bay. Our data therefore demonstrate the presence of *O.* cf. *siamensis* at low latitudes of the Bay of Biscay, in colder waters than those where the species had been detected so far. From our study, it is therefore obvious that the limit of distribution of this species in the North Atlantic is located further north than the Bay of Brest. In order to understand the time and conditions (water temperature) of transporting a cell from south to north in the Bay of Biscay, our study will be completed by an analysis of the connectivity between the sampling stations carried out by modeling physical. Our series of samples has enabled us to collect a large number of cells at several sites, notably on the Spanish coast and close to the border in France, and thus to carry out isolations and the establishment of new monoclonal strains. No less than 68 strains have been isolated on a set of 8 different sites and will be used for future eco-physiological, eco-toxicological and toxin production experiments. First *Artemia* bioassays carried out showed the potential toxicity of strains, demonstrated a HAB risk connected to *O.* cf. *siamensis* in the Bay of Biscay. Toxin analyses are ongoing. This study demonstrates new emerging risk in the Bay of Biscay due to the development of *O.* cf. *siamensis* in the area.

Dynamics of toxic phytoplankton species along the Catalan coast (NW Mediterranean Sea)

Nagore Sampedro, Sílvia Anglès, Laura Arin, Magda Vila, Esther Garcés, Albert Reñé and Jordi Camp, Instituto de Ciencias del Mar. Spain

There is a general concern that HABs are increasing worldwide maybe as a consequence of some factors favouring the development of blooms or maybe due to an increase of sampling efforts and the improvement of detection methods. To solve this question, studies on the dynamics of these algal species are required in places with a similar frequency sampling over a long period of time. Using time-series of phytoplankton from several stations along the Catalan coast (NW Mediterranean), we analyze the trends of potentially toxic species. The objective was to determine if the proliferations of toxic species increased during the study period (2000–2012) along the Catalan coast.

While the blooms of potentially PST producing species, increased in many of the confined stations studied, due to the increase of *Alexandrium minutum*, *A. pacificum* were not more frequently detected in most of the stations during the last years of the study period. The blooms of DST producing species did not shown an increase but there was also a clear increase in the number of blooms of the genus *Pseudo-nitzschia* (genus with species that can potentially produce ASTs) as a consequence of the increasing abundances in most of the confined stations.

Monitoring potential toxin-producing phytoplankton in Scottish coastal waters: Interpreting the data for risk assessment and identifying trends – the caveats

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Food Standards Scotland supports regulatory monitoring programmes for both biotoxins and phytoplankton in classified shellfish harvesting areas. Individual harvesting sites are placed into groups known as ‘pods’, based on hydrographic similarity. Each pod has a Representative Monitoring Point (RMP) and may also have Associated Harvesting Areas (AHAs). Only the RMPs are monitored and a pod can be closed for harvesting, based on the toxin results from shellfish collected at the RMP. Harvesters operating an AHA may challenge this result if they can demonstrate that their product is safe for human consumption, for example, if the area has been closed based on a toxin result from mussels and they are harvesting oysters. Typically, between 75 and 90 RMPs from Scotland are tested every year for shellfish biotoxins at Cefas (Weymouth), and water samples from 40 RMPs are analysed for the presence of toxin-producing phytoplankton by SAMS (Oban). *Pseudo-nitzschia*, *Alexandrium* and *Dinophysis* are the main organisms likely to cause toxin contamination, but these are only identified to genus level by light microscope within the monitoring programme. The dinoflagellates *Protoceratium reticulatum* and *Lingulodinium polyedra*, associated with the production of yessotoxins, are also recorded. However, dinoflagellates belonging to the genera *Azadinium* and *Amphidoma* that are known to produce azaspiracids are not enumerated due to their small size and difficulty of identification.

Within the Scottish phytoplankton monitoring programme, the number of water samples analysed has varied over the last ten years (2010 to 2019), with sampling frequency in March increased to weekly since 2013, in response to the detection of toxins in shellfish. The number of RMPs monitored has been set at forty from 2014, with weekly sampling taking place between March and September, and reduced sampling over the winter months. A total of 11 759 water samples were analysed between 2010 and 2019.

Risk assessment is used to determine the frequency of toxin testing at RMPs, based on a review by Holtrop *et al.* (2016). At RMPs when no routine toxin testing is planned, if phytoplankton results indicate an increased risk, or when biotoxins exceed 0.5 Maximum Permitted Level (MPL), additional toxin testing is scheduled for the following week. The phytoplankton trigger levels used to schedule extra toxin testing are: *Pseudo-nitzschia* spp. 50 000 cells/L; *Alexandrium* spp. 40 cells/L; *Dinophysis* spp. 100 cells/L; *Prorocentrum lima* 100 cells/L. Scheduled testing of other biotoxin groups does not occur when a site is closed due to one toxin group above MPL, unless the area is closed due to the presence of more than one toxin group exceeding MPL in the same sample.

The number of shellfish samples tested per year varies. Between 2010 and 2019, 12 635 shellfish samples were tested for the presence of ASTs, associated with *Pseudo-nitzschia*, the majority of which were mussels (*Mytilus edulis*). For all shellfish species, a total of 3767 samples were tested in 2010 and 2011 combined, but between 2017 and 2019 and in response to the risk assessment by Holtrop *et al.* (2016), 2642 samples were analysed, the number varying between years depending on the frequency of *Pseudo-nitzschia* blooms exceeding trigger level. Closures occurred in 2012, 2013 and 2016 (four events). A maximum AST value of 49 mg/kg was recorded in mussels during May 2016, although a greater number of *Pseudo-nitzschia* blooms occurred between June and September. Although ASTs were most frequently reported in mussels, Pacific oysters and razor clams, this is a reflection of harvesting activity. Fewer samples of queen scallops, surf clams and carpet clams were analysed for ASTs, but toxins were detected in a greater proportion in these species. It was noted that the June maximum value for ASTs was 34.0 mg/kg and the August maximum value was 33.0 mg/kg, but the July maximum value was unexpectedly low at 19.0 mg/kg. This may have been due to the lack of AST testing in July as a result of site closures due to DSTs, particularly in 2013.

A total of 17 741 shellfish samples were analysed for the presence of PSTs, associated with *Alexandrium*, between 2010 and 2019, with routine testing reduced from 2017 as a result of risk assessment. *Alexandrium* exceeded the trigger level in 15.5% (2019) to 39.7% (2013) of samples, with the densest bloom of 24 660 cells/L recorded in the Highland: Lochaber area in July 2014. Not all *Alexandrium* blooms produce PSTs and although 2015 and 2016 had a similar number of samples exceeding trigger level, 21.7 % and 21.5 %, respectively, PSTs above MPL in shellfish occurred in 42 samples in 2015, but only six samples in 2016. Most samples with PSTs above MPL were recorded in mussels, but again this reflects harvesting activity and the highest proportion of PSTs present occurred in surf clams.

Shellfish samples were tested for the presence of DSTs, associated with *Dinophysis*, using a mouse bioassay (positive/negative result) up to July 2011, and then by an analytical method (quantification). The presence of other lipophilic toxin groups (YTXs and AZAs) produced by other dinoflagellates may have contributed to DST positive results for samples tested prior to July 2011. *Dinophysis* exceeded the trigger level in 6.4% (2008) to 27.5% (2013) of samples, with the densest bloom of 180 289 cells/L recorded in Argyll in August 2017. Between 2010 and 2019 a total of 25 267 samples were analysed and DST values were found to exceed the MPL of 160 µg OA eq./kg (or were positive by bioassay) in all years, with most occurrences between July and September. A maximum DST value of 6950 µg OA eq./kg was recorded in mussels during July 2013, associated with an outbreak of diarrhetic shellfish poisoning (Whyte *et al.*, 2014). DSTs were most frequently reported in mussels, but also occurred in a high proportion of surf clams and queen scallops. Between 2010 and 2015/2017, two sites in the Clyde Sea region of southwest Scotland were observed to have frequent and extended episodes of DST contamination, often preceded by a period of PST contamination. These particularly problematic sites are no longer classified for shellfish harvesting, and the number of PST and DST events recorded in recent years is probably lower than it would have been, had these sites still been included in the monitoring programme.

Both azaspiracids (AZAs) and yessotoxins have been quantified in shellfish since July 2011, with MPLs set at 160 µg AZA1 eq./kg for azaspiracids and 3.75 mg YTX eq./kg for yessotoxins. The presence of AZAs has varied considerably between 2011 and 2019, with site closures between 2011 and 2013, but relatively little issue with this toxin group since then. Surf clams, Pacific oysters, common cockles and mussels were particularly prone to AZA contamination. A maximum AZA value of 626 µg AZA1 eq./kg was recorded in mussels during October 2011. Yessotoxins were detected in every month of the year over the period 2011 to 2019, but were absent in 2017. They were detected in queen scallops and mussels, but did not exceed the MPL.

Non-routine toxin testing is not carried out in the same week as a bloom exceeding trigger level is reported, mainly due to the logistical difficulties and cost of obtaining further shellfish samples, so it is possible that the sudden onset of a toxic event could be missed. Testing is also not carried out in the presence of a bloom if an area is already closed due to other toxins, so bloom toxicity is not always determined. The number of tests carried out has decreased over the last ten years, with testing reduced between 2017 and 2019 as a result of risk assessment. It might be expected that the proportion of toxic events would remain similar between years, and an apparent decline may indicate a trend or could be the result of events being missed due to reduced sampling (although human illness might indicate that this was the case). Monitoring no longer occurs at some "historically problematic" sites, and this could give the appearance of a reduction in the number of toxic events. Also, in the years when DSP toxins dominate for extended periods, ASP and PSP toxins may go unrecorded. In contrast, an apparent proportional increase in the number of toxic events over time could indicate a genuine trend, or could be the result of an improved testing regime with greater emphasis on targeting high risk sites.

Users of the data generated by the phytoplankton and biotoxin monitoring should be aware that the main purpose of these programmes is to ensure that unsafe shellfish product does not enter the market, thereby protecting human health. Testing is targeted at sites with a history of toxic events and there is a requirement to be cost-effective. Testing for a particular toxin group does not occur at sites closed as a result of the presence of other toxin groups above regulatory limits. This could make risk assessment more difficult, as the correlation between bloom events and toxin contamination of shellfish is often reduced. The Scottish monitoring programme also reports the toxin-producing phytoplankton of most concern to genus level only, and not all species within a genus are toxin producers. The identification of trends using these data may be problematic, as monitoring effort may change in response to the activity of the aquaculture industry. Long-term data from a limited number of 'sentinel' sites might be more appropriate for identify trends. The importance of metadata is highlighted, as a means of informing the end user of the potential limitations of data collected specifically for the purposes of food safety.

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5 ToR F: HABs and the EU Marine Strategy Framework Directive

The EU Marine Strategy Directive (MSFD) was adopted in 2008. Its aim is to protect European marine waters which should achieve 'Good Environmental Status' (GES) using eleven different descriptors.; 1: Biodiversity, 2: Non-indigenous species, 3: Commercial fish and shellfish, 4: Food webs, 5: Eutrophication, 6: Sea-floor integrity, 7: Hydrographical conditions, 8: Contaminants, 9: Contaminants in seafood, 10: Marine litter, 11: Energy (including underwater noise).

To date HABs or HAB species have not been used in the direct assessment of Descriptor 1: Diversity for the MSFD. The Intermediate Assessment 2017 (https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/changes-phytoplankton-and-zooplankton-communities/) performed by the OSPAR used a plankton lifeform approach to assess diversity in the marine environment with diatoms and dinoflagellates, large and small phytoplankton (</> 20μm diameter), and pelagic and tychopelagic diatoms as lifeforms (McQuatters-Gollop *et al.*, 2019). A subsequent assessment of the pelagic habitat community using this approach showed significant changes to both phytoplankton and zooplankton communities within the northwest European shelf suggesting that the phytoplankton community is not in GES (Bedford *et al.*, 2020). Trends in the abundance of *Phaeocystis* is used as an indicator for MSFD Descriptor 5: Eutrophication in Belgian, Dutch and German waters. During the 2017 Intermediate Assessment no observed temporal trends in the annual blooms of *Phaeocystis* was observed (https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/eutrophication/trends-phaeocystis-blooms/).

In the Helcom area a cyanobacterial bloom index is used as an indicator of eutrophication. It is based on two parameters; cyanobacterial surface accumulations and cyanobacterial biomass. Currently there is no fixed threshold for this index. The different areas of the Baltic Sea are characterized by different magnitudes of biomass of the nitrogen-fixing (diazotrophic) cyanobacteria genera *Aphanizomenon*, *Nodularia* and *Dolichospermum*. During the study period 1990–2019 (June-August), the highest biomass occurred in the Gulf of Finland, whereas no or low biomass of nitrogen-fixing cyanobacteria appeared in the Bothnian Bay and the Kiel Bay/Kattegat area (Kownacka *et al.*, 2020).

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6 ToR G: Review how physical, chemical and biological interactions control the dynamics of selected harmful micro-algae

Three different species groups were examined during this ToR. In 2018 the ciguatera toxin producing dinoflagellates genera *Gambierdiscus* and *Fukuyoa* were selected as ciguatera poisoning in now established risk to human health in Europe as a result of consumption of endemic fish. The ToR overlapped with ToR H and is included in the summary presented there.

In 2019 the focus was on Arctic species. The potential impacts from HABs in the Artic is the current focus of a number of studies. Preliminary results from surveys around Svalbard during 2017–2018 were presented. Samples were collected during three cruises to the Barents Sea in 2018. The winter (4–18 January) and spring cruises (23 April – 5 May) were realised on board RV Helmer Hanssen, the summer cruise on board RRS James Clark Ross (16 June – 2 July). The transects focussed on the 30° East line of longitude, with the southern-most station each located in the year-round ice-free central Barents Sea. Preliminary results from these surveys identified blooms of HAB genera *Chaetoceros, Dinophysis, Pseudo-nitzschia* at various locations suggesting the potential for HAB risk in the area.

Results from surveys around Iceland and Greenland were also presented. Results from this cruises are presented in:

Richlen, M.L., Zielinski, O., Holinde, L., Tillmann, U., Cembella, A., Lyu, Y. and Anderson, D.M., 2016. Distribution of *Alexandrium fundyense* (Dinophyceae) cysts in Greenland and Iceland, with an emphasis on viability and growth in the Arctic. *Marine ecology progress series*, *547*, pp.33-46.

The work plan of the TaxMArc project in Norway which had just commenced was also presented. Through discussions of during this ToR the importance of Arctic HABs was recognised and became the focus for the shared day between ICES-IOC WG Ballast and Other Ship Vectors (WGBOSV), ICES WG Introduction and Transfer of Marine Organisms (WGITMO) and ICES-IOC WGHABD during their 2020 meeting (see section 9.3).

Fish killing species were the focus of the 2020 meeting. This presentation focused on the 2019 bloom of *Chrysochromulina leadbeateri* which caused significant mortalities of farmed fish in northern Norway. In May 2019 *Chrysochromulina leadbeateri* formed a large bloom in the Northern part of Norway (Figure 1). A large area was affected from 10 May to 10 June 2019. The main areas, with observed mortality were in Ofotfjorden, Astadfjorden, Tysfjord, and at one location outside Tromsø. The bloom started in Astadfjord and Ofotfjord around 10 May, reaching maximum abundance and geographic distribution at the end of May (Figure 1). By the end of May fish mortality were reported from Atsadfjorden and Ofotfjorden. In the beginning of June there were also reports of mortality from Tysfjorden. At the end of May *Chrysochromulina leadbeateri* were observed around Tromsø and in the beginning of June there were reports of mortalities in one smaller area outside Tromsø. During the bloom approximately 14 000 tons of caged salmon died. However, there were no reports of mortalities of wild fish during the bloom. Economic losses due to the *C. leadbeateri* bloom during the period are estimated to be between 2.3–2.9 billion NOK (~ $0.27 – 0.34 billion US), direct and indirect gross (Marthinussen *et al.* 2019).

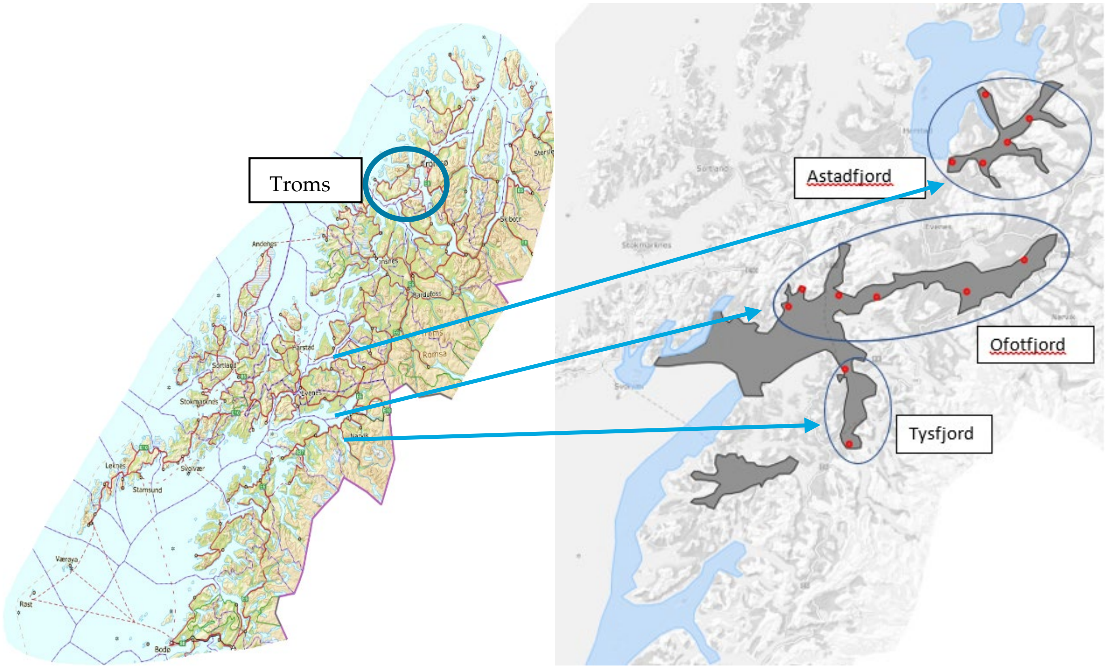

Figure 1. ***Chrysochromulina leadbeateri*** **bloom in 2019. Mapping showing moderate concentration (blue) and high abundance (black) of** ***Chrysochromulina leadbeateri*** **duirng the period from 10 May to 10 June 2019. Red dots indicate areas with fish mortality. Redrawn from Cembella** ***et al.*** **(in press).**

7 ToR H: Ciguatera Poisoning (CP) is an emerging issue in the ICES area

This ToR will provide an update of CP incidence in the ICES area, new developments in methodology to research the issue, modelling efforts, risk assessments to protect human health, initiatives in other bodies such as IP-HAB, PICES etc.

Throughout the reporting period annual updates were presented on Ciguatera Poisoning (CP) in Europe. As a result of the increase of reported cases of CP since 2008, the government of the Canary Islands has established a monitoring program for the official control of ciguatoxins in captured fish that are sold at the authorized fish markets. In the Canary Islands, fish from an established list of fish species and over a determined weight cannot be sold without having been first tested for the presence of CPs. This list will be updated after the analysis of the results obtained during the time that this monitoring has been active. The list is public and can be found on the website of the government of the Canary Islands (http://www.gobiernodecanarias.org/agricultura/pesca/temas/primera_venta/ciguatera). The report from the Fisheries Directorate states that on average, 8.4% of the fish tested in the Canary Islands contained ciguatoxins.

The research project MIMAR (http://mimarproyecto.com) is trying to implement the same protocol in other regions close to the Canary Islands such as Cape Verde, Madeira, Mauritania and Senegal (Perez-Gonzalez *et al.*, 2018). In addition, and since sport fishing is not included in the official control program, the MIMAR project offers a free ciguatera test on request from the sport fishermen.

A summary of the results of the EC safeSEAFOOD project (FP7, 2013–2017) were presented. The identification of CTXs and gambieric acid in shark was described, highlighting the importance of the selection of extraction and purification methods during analysis. Two new CTXs were identified, the first identification of gambieric acid in fish.

Updates from the EuroCigua project "Risk Characterisation of Ciguatera Poisoning (CP) in Europe" were reported. EuroCigua ran from 2012–2020 and had a number of successful deliverables which has improved management and increased awareness of CP issues in Europe. Epidemiological surveillance protocols were developed and 23 ciguatera outbreaks from Spain, Portugal, Germany and France between 2012 and 2018 identified. These involved both endemic and imported fish. *Gambierdiscus* and/or *Fukuyoa* species were identified from the Canary Islands, Madeira and Selvagens archipelagos, Crete and Cyprus. *Gambierdiscus* was also identified in the Balearic Islands for the first time. The majority of strains from the Canary and Balearic Islands were found to produce CTX like toxins. The N2a Assay to identify CTX toxins was standardized and validated by LC-MS-MS and successfully used to test fish in the Canary and Madeira Islands. Currently methods are being optimised to produce reference materials from fish contaminated with CTX. More information can be found at ECsafeSEAFOOD: http://www.ecsafeseafood.eu/ and EUROCIGUA: https://www.foodsafetynews.com/tag/eurocigua/.

8 ToR I: Species specific HAB detection methods and other cutting edge technologies are now moving from research towards operational use

WGHABD will aim towards developing collaborations with other WGs working in this area to optimise practical applications in operational situations

Molecular methods are increasingly utilised in ecological studies. Quantitative PCR is one of the readily used methods in HAB monitoring and research programmes. During this reporting period delegates from WGHABD attended the CoCLIMe qPCR workshop held in Bremerhaven, October 2019. The potential of applying of qPCR in routine monitoring was recognised and need for agreement on common protocols and assays flagged as an important issue to be addressed. As a result WGHABD extended this ToR to include the next two reporting cycles.

9 Other activities

9.1 WGHABD and IOC UNESCO

WGHABD is co-sponsored by the IOC UNESCO. A number of activities underway in the IOC were of relevance to the development of the terms of reference for the next WGHABD reporting cycles. These were discussed in-depth during development of the ToRs for the 2021–2023 reporting cycle.

Significant global initiatives are Agenda 2030 and the UN Decade of Ocean Science.

9.1.1 UN Agenda 2030

The United Nations has adopted a resolution for transforming our world; Agenda 2030. This is plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. All countries and all stakeholders, acting in collaborative partnership, will implement this plan. We are determined to take the bold and transformative steps which are urgently needed to shift the world onto a sustainable and resilient path. As we embark on this collective journey, we pledge that no one will be left behind. The 17 Sustainable Development Goals and 169 targets which are part of the Agenda 2030 demonstrate its scale and ambition. They build on the Millennium Development Goals and complete what these did not achieve. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental. For marine and ocean science the most relevant is the Sustainable Development Goal 14 on life below water "Conserve and sustainably use the oceans, seas and marine resources for sustainable development". The aims of this goal are:

14.1 by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution

14.2 by 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration, to achieve healthy and productive oceans

14.3 minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

14.4 by 2020, effectively regulate harvesting, and end overfishing, illegal, unreported and unregulated (IUU) fishing and destructive fishing practices and implement science-based management plans, to restore fish stocks in the shortest time feasible at least to levels that can produce maximum sustainable yield as determined by their biological characteristics

14.5 by 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on best available scientific information

14.6 by 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, and eliminate subsidies that contribute to IUU fishing, and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the WTO fisheries subsidies negotiation*

14.7 by 2030 increase the economic benefits to SIDS and LDCs from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

14.a increase scientific knowledge, develop research capacities and transfer marine technology taking into account the IOC-UNESCO Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular SIDS and LDCs

14.b provide access of small-scale artisan fishers to marine resources and markets

14.c ensure the full implementation of international law, as reflected in UNCLOS for states parties to it, including, where applicable, existing regional and international regimes for the conservation and sustainable use of oceans and their resources by their parties

For each goal, indicators have been agreed and most of these need to be fully developed to become operational. The stage of development is defined in three indicators tiers

Tier 1: Indicator conceptually clear, established methodology and standards available and data regularly produced by countries.

Tier 2: Indicator conceptually clear, established methodology and standards available but data are not regularly produced by countries.

Tier 3: Indicator for which there are no established methodology and standards or methodology/standards are being developed/tested.

Target	Indicator	Tier	Lead agencies
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from landbased activities, including marine debris and nutrient pollution	**14.1.1 Index of coastal eutrophication** and floating plastic debris density	III	UNEP (Custodian agency) **(with support of IOC/UNESCO)**

What does Custodianship Mean?

The Custodian agency is the agency responsible to develop internationally agreed standards, coordinate the indicator development, and support increased adoption and compliance with the internationally agreed standards at the national level.

The Custodian agency shall also collect data in relevant domain from countries (or regional organizations as appropriate through existing mandates and reporting mechanism to provide internationally comparable data are and calculate global and regional aggregates, as well as strengthen national statistical capacity and improve reporting mechanisms-

9.1.2 UN Decade of Ocean Science

On 5 December 2017, the United Nations proclaimed a Decade of Ocean Science for Sustainable Development, to be held from 2021 to 2030. This Decade will provide a common framework to ensure that ocean science can fully support countries' actions to sustainably manage the Oceans and more particularly to achieve the 2030 Agenda for Sustainable Development. The Decade will provide a 'once in a lifetime' opportunity to create a new foundation, across the science-policy interface, to strengthen the management of our oceans and coasts for the benefit of humanity.

The Decade should turn the scientific knowledge and understanding into effective actions supporting improved ocean management, stewardship and sustainable development. If the societal benefits of the sustainable use of the ocean are to be accrued through achievement of the SDG targets as well as other frameworks, it is important to define a number of outcomes that the Decade will address over the course of its implementation. These outcomes are considered to be highly transformative because they are expected to trigger environmental, societal and policy changes. There are six societal outcomes (i) a clean ocean, (ii) healthy and resilient ocean, (iii) predicted ocean, (iv) a safe ocean, (v) a sustainable and productive ocean and (vi) a transparent and accessible ocean.

The science action plan for the decade comprises six objectives (i) to increase transformative science capacity and capability, (ii) to expand, innovate and integrate ocean knowledge systems, (iii) to understand and predict fundamental aspects of the ocean system and (iv) to develop integrated assessment and decision support systems, transformational tools and processes. These objectives follow four guiding principles, GP1 inclusive nature, GP2 partnerships between disciplines/sectors, GP3 transformative nature, GP4 contribute to global and equitable sustainable future.

The Decade is an opportunity to make HAB science even more relevant to society. Ongoing activities can be identified as contributing to the Decade and new initiatives can be developed under the themes of the Decade.

9.1.3 IOC Intergovernmental Panel for Harmful Algal Blooms (IPHAB)

The next meetings of IPHAB are in April 2021 and April 2023. This allows WGHABD to report to IPHAB 2021 and input from IPHAB 2021 can feed into the 2021–2023 WGHABD reporting cycle. It also allows IPHAB input for ToRs for the next cycle (2024–2026) in 2023. Note that WGHABD can also recommend actions to IPHAB.

The IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB) has 16 different groups: seven IPHAB Task Teams; five Regional HAB networks and groups; two Expert Working Groups; one Steering Committee; one Project group and an IOC Science and Communication Centre on HABs, University of Copenhagen Denmark.

IPHAB XIV was held in Paris, 24–26 April 2019 and took eight Decisions and made two Recommendations concerning one new and six continuing Task Teams with revised Terms of Reference. The IPHAB elected as its Chair (2019–2021) Joe Silke (Ireland) and as its Vice-chair (2019–2021): Alexandra Silva (Portugal).

Decision IPHAB-XIV.1 Task Team on early detection, warning and forecasting of harmful algal events. The Task Team will review the current state of early warning systems for HABs; address UN Ocean Decade objectives at conferences and HAB symposia on early warning systems; and promote HAB observations in the Global Ocean Observing System and at regional level.

Decision IPHAB-XIV.2 Regional HAB Programme Development: Regional HAB Groups under an IOC regional subsidiary body (RSB) thrive. Groups not anchored in a RSB struggle; (IOC/FANSA and IOC/HANA).

Decision IPHAB-XIV.3 Task Team on Development of a Periodic Global HAB Status Report GHSR): The GHSR will be a periodic global synthesis of datasets on the distribution of toxin-producing marine microalgae and harmful events. The work is ongoing to finalize and publish the first edition of a Global Harmful Algal Bloom Status Report (GHSR) including compilation and integration of data sets derived from global and local data systems stored in IODE/HAEDAT and OBIS. The 1st edition of the GHSR and a Special Issue of Elsevier journal Harmful Algae is in an advanced stage of preparation. GHSR is developed with IAEA, ICES and PICES.

Decision IPHAB-XIV.4 Task Team on a Global Inter-Agency Ciguatera Strategy for Improved Research and Management: The Task Team interacts with FAO, IAEA and WHO for the implementation of the MoU on the inter-agency Global Ciguatera Strategy. Specific elements of Ciguatera Strategy includes the enhanced capabilities for Ciguatera toxin detection; and improved epidemiological data collection, reporting and assessments.

Decision IPHAB-XIV.5 Task Team on Harmful Algae and Desalination of Seawater: The Task Team will follow up by exploring special HAB sessions and workshops at *International Desalination Association* conferences; and seeking support for developing and applying the HAB detection and forecasting system previously developed with USAID funding. IOC Manuals and Guides No. 78 is a +500 pages as a practical resource for the desalination industry to deal with HAB issues. There have been over 2600 downloads, 400 printed copies, so more than 3000 copies are in use

Decision IPHAB-XIV.8 Task Team on Harmful Algae and Fish Kills. The Task Team organised an international scientific colloquium and advanced technical workshop in 2019 in Chile and will continue to work on a-knowledge review and future strategy publication as well as an annotated event analysis of fish-kills and other marine faunal mortalities associated with HABs as a component of the Global HAB Status Report

IPHAB longer term (continuing) Task Teams providing services linked with IODE/HAEDAT and OBIS includes the IPHAB Task Teams on Biotoxin Monitoring, Management and Regulations and the one on Algal Taxonomy.

9.1.4 Index of Coastal Eutrophication Potential (ICEP)

The Index of Coastal Eutrophication Potential (ICEP) allows the expression of the risk of enhanced phytoplankton growth, decay and oxygen depletion and nutrient distortion. ICEP represents the production by non-diatom phytoplankton due to N or P exported by rivers in excess of the demand from diatoms based on the available Si (Billen and Garnier, 2007). The work to be done to have ICEP fully developed as a tool includes to compile existing N, P, Si data to calculate ICEP over time to demonstrate inter- and intra-annual scale variability and compare ICEP with HAB occurrences. Specific tasks are to document the global river silica export model; to compute ICEP for year-2000 conditions, aggregated at COSCAT (coastal segmentation and related catchments) scale; to document the validation of the computed ICEP against observed nutrient loads; to prioritize coastal systems for additional focused study based on computed ICEP and susceptibility to land-based nutrient loads; to document a comparison between measured and predicted ICEP and HAB occurrence in susceptible coastal systems; and to document the future projections of ICEP for the SSPs (shared socioeconomic pathways) scenarios. The key challenge to do so is the funding. The IOC has invested in a broader understanding of what ICEP is by having an explanatory video produced for YouTube https://youtu.be/qW2nV2bsyCs.

IOC SCOR GlobalHAB Scientific Steering Committee

WGHABD continue to represent ICES on the IOC SCOR GlobalHAB Scientific Steering Committee. GlobalHAB s an international scientific programme on harmful algal blooms (HABs). It is aimed at fostering and promoting co-operative research directed toward improving the understanding and prediction of HAB events, and providing scientific knowledge to manage and mitigate their impacts against the background of global changes in climate, and increased anthropogenic pressures on aquatic ecosystems.

9.2 ICES Annual Science Conference 2019

ICES-IOC WGHABD, ICES WG on Zooplankton Ecology and the ICES Aquaculture Steering Group convened a special theme session at the ICES Annual Science Meeting (ASM) 2019 "*Harmful Algal Blooms and Jellyfish: Impacts on Ecosystems and Ecosystem Services*". This theme session was designed to open dialogue between the three different work streams within ICES. HAB presentations focussed on reviews of HAB monitoring and impact data collected over the last two decades with presentations from the North Atlantic Area, Irish coastal waters, and the Kattegat-Skagerrak and the Baltic Sea. In contrast to HABs, routine monitoring for jellyfish is not established in many areas. A new method to use fish surveys to collect jellyfish data was presented and molecular methods have shown them to be a component of the diet of forage fish in the Celtic Seas and Western Channel. Modelling methods were used by both HAB and jellyfish scientists to look at bloom advection and development with a view to providing a service for the aquaculture industry. Challenges for offshore aquaculture, the distribution of benthic dinoflagellates in Sweden, impacts from filamentous algae on herring larvae in the Baltic were the focus of poster presentations. Conveners encouraged maintaining lines of communications between the different work strands into the future.

9.3 Cooperation with ICES WGs: WGBOSV, WGITMO

In 2020, ICES-IOC WG Ballast and Other Ships Vectors (WGBOSV), ICES WG Introduction and Transfer of Marine Organisms (WGITMO) and ICES-IOC WGHABD held a shared day where the three WGs presented their work in the Arctic and shared experiences using molecular methods. Common methodological difficulties were highlighted between the three WGs. The three groups produced an ICES Science Highlight from the outcomes of the meeting.

The Arctic is a region of interest for both ICES and the scientific community. Climate change is envisaged to alter this region in terms of biological impacts as well as increasing potential for shipping. Members from the different WGs exchanged experiences using molecular methods as well as results from studies in Arctic areas. These studies presented data on HAB and invasive non-native species present in Arctic waters.-

A study in USA focused on the distribution, community structure, and dynamics of *Alexandrium catenella* and *Pseudo-nitzschia* in the Northern Bering, Chukchi and Beaufort Seas. A massive *A. catenella* cyst seedbed has been documented in multiple years, centered in the nearshore waters of the Chukchi Sea, representing a major threat to the region now that surface and bottom and surface waters have warmed sufficiently to support localized cyst germination and vegetative cell growth. Multiple toxic species of *Pseudo-nitzschia* have also been observed throughout the region. As there is little or no societal recognition of the dangers of HAB toxins in the animals used in traditional subsistence harvesting (sea birds, seals, walruses, whales), this new threat needs to fully characterized and risks evaluated and communicated.

A review of Canadian data revealed the widespread presence of potential toxin producing species throughout Canadian Arctic waters; Beaufort Sea, Baffin Bay, North West Passages as well as Hudson Bay and the Labrador Sea. Records include species from the genus *Pseudo-nitzschia* (*P. pseudodelicatissima, P. seriata, P. calliantha, P. granii, P. delicatissima, P. obtusa), Alexandrium* (*A. catenella, A. ostenfeldii*), *Dinophysis* (*D. norvegica, D. acuminata, D. acuta*), *Phalachroma rotundatum* and *Prorocentrum lima*. Reports from cruises to the west coast of Iceland and Greenland recorded *Phaeocystis* and *Pseudo-nitzschia* species. Measurement of algal toxins from the water was also a useful tool to identify the presence of HAB species.

Presentations by all three WGs highlighted similar issues with the use of molecular methods. These included the standardisation of methods between laboratories and over time to allow data to be compared, primer bias and the requirement for bioinformatics expertise, and computing and data power.

A summary of this shared day formed an ICES ‘highlight’ on science in the Arctic. This highlight can be found in Annex 5.

Annex 1: List of participants

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Annex 2: Resolutions

The ICES/ IOC **Working Group on Harmful Algal Bloom Dynamics** (WGHABD), chaired by Eileen Bresnan, UK, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2018	23–26 April	Tarragona, Spain	Interim report by 15 June	
Year 2019	2–4 April	Oslo, Norway	Interim report by 15 May	
Year 2020	2–4 March	Gdynia, Poland	Final report by 1 May	Joint meeting with WGBOSV and WGITMO

ToR descriptors

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
A	Deliver National Reports on harmful algal events and bloom dynamics for the years 2017, 2018 and 2019.	HAB events may affect human activities and marine ecosystems at different levels. Understanding can best be achieved by integrating multiyear data sets.	5.5; 5.6; 5.7	Year 1,2,	Summary of national reports in Annex in WGHABD report. Contribute with reports to HAE-DAT.
B	There are a number of fish killing algae activities underway during the reporting period from 2017–2020 e.g. IP-HAB task team on fish killing algae, fish killing algae colloquium in 2018. Participants involved with these activities will update the WG with progress and a summary will be provided to ICES and the IOC and other relevant WGs	The WG identified a need for a detailed assessment of the scale of the problem and the identification of key knowledge gaps.	2.7; 5.5	Year 1	Work with chair of IP-HAB task team on fish killing algae to produce peer review paper.
C	ICES-PICES-IOC Harmful Algal Event Database (HAE-DAT) – the harmful algal event database will be updated by participants on an annual basis. This database will be used to produce 'products' such as spatial descriptions of harmful algal events in the ICES area . Examples include maps of incidence of toxicity and/or mortalities, updates to ICES Ecosystem reviews that can be updated annually or as required.	Data from the ICES area in HAE-DAT has been updated and quality controlled for the 2014–2016 period and historic data entry and QC is almost complete. Outputs from this database will allow the regional and spatial distribution of harmful algal events to be examined.	3.4; 4.2; 6.3	Year 1,2,3	Outputs on request and as described in ToR D

D	ICES WGHABD will produce a HAB Status Report. This will represent the ICES contribution to the Global HAB Status Report for the North Atlantic area. This will use data and products generated from HAE-DAT and supplementary time-series data as appropriate.	Data from the ICES area in HAE-DAT has been updated and quality controlled for the 2014–2016 period and historic data entry and QC is almost complete. Outputs from this database will allow an examination of the harmful algal events in the ICES area over the last 25 years.	1.3; 5.6; 6.1	Year 1, 2 ,3	Year 1: Data QC complete and plots produced. HAB Status report finalised at 2018 meeting. Year 2: Global HAB Status Report launched. Presentation at ISSHA HAB conference, other associated activities as they arise. Year 3. Special issues of Harmful Algae on Global HAB Status report containing papers from the ICES area.
E	Report on new findings in the area of harmful algal bloom dynamics	WG members report new findings on the topic of algal bloom dynamics in the ICES area. This is a particularly valuable ToR for providing the most up-to-date status of HAB dynamics in the ICES area.	1.3; 1.6; 5.6	Year 1,2,3	A report on new findings in the area of harmful algal bloom dynamics.
F	HABs and the EU Marine Strategy Framework Directive (MSFD). Currently there is no consistent approach in Europe to including HABs in the assessment of GES for the MSFD. A commission decision on the MSFD is pending. .	WGHABD will review the pending EU commission decision and how HABs are included in the MSFD.	1.5; 6.3	Years 1,2,3	Year 1: A section in the WGHABD 2018 report reviewing the the EU commission decision in relation to HABs Year 2-3: Further work driven by outputs from year 1.
G	Review how physical, chemical and biological interactions control the dynamics of selected harmful micro-algae	Harmful algal genera respond to environmental forcing in different ways. During each meeting a different genus will be evaluated to provide a comparative evaluation of known and potential responses to physical / environmental forcing.	1.3; 1.7; 2.2	Years 1,2,3	Produce summary for ICES report. During Yr 1 – genera will be Gambierdiscus and Fukuyoa. Species for review during years 2 and 3 will be selected at the preceding meeting.
H	Ciguatera Fish Poisoning (CFP) is an emerging issue in the ICES area. This ToR will provide an update of CFP incidence in the ICES area, new developments in methodology to research the issue, modelling efforts, risk assessments to protect human health, initiatives in other bodies such as IP-HAB, PICES etc.	There are currently a number of initiatives underway examining different aspects of CFP in the ICES area.	5.6; 6.1; 6.3	Years 1,2,3	Year 1: update to WGHABD on work underway to address this issue in affected areas in Europe. Year 2 and 3; deliverables pending developments in this area of work.

I	Species specific HAB detection methods and other cutting edge technologies are now moving from research towards operational use. WGHABD will aim towards developing collaborations with other WGs working in this area to optimise practical applications in operational situations.	Optical and molecular methods have been used routinely in HAB context for the 15 years. New state of the art methods have been trialled in the ICES area. Potential for collaboration with other WGs.	1.6; 3.3; 4.1	Year 2, 3	Year 3: Output to be decided based on collaboration with other WGs and discussions during Year 2.

Summary of the Work Plan

Year 1	Finalise QC of HAE-DAT data, production of outputs and ICES Status report. Review EU commission decision and role of HABs in the MSFD. Update on activities in relation to CFP and implications for the ICES area. Present national reports, new findings, complete HAE-DAT entries for 2017 data. Work with IP-HAB to finalise production of manuscript on fish killing algae, review HAB genera Gambierdiscus and Fukuyoa.
Year 2	Contribution of ICES input to the Global HAB Status Report and input into activities around its launch. Agree associated peer review publications to be produced for year 3. Activities on HABs and MSFD, and CFP as decided in Year 1. Present national reports, new findings, complete HAE-DAT entries for 2018 data. Review of Hab genera to be decided. Communicate with other WGs with regard to ToR I. Respond to advisory requests as appropriate.
Year 3	Production of peer review publications for Global HAB Status Report special issue. Input to associated activities as appropriate. Activities on Habs and MSFD and CFP as decided in Year 2. Present national reports, new findings, complete HAE-DAT entries for 2019 data. Review of Hab genera to be decided. Pariticipate in activity associated with ToR I.

Supporting information

Priority	The current activities of this WG address the strategic goals 1,2 and 3 in the ICES strategic plan. Output from this WG also represents the contribution from ICES at a number of forums (e.g. UNESCO-IOC) which consider problems associated with HABs at a global scale. The WG is also producing the contribution from the ICES area to the Global HAB Status report currently being produced by the IOC.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities	Standard EG support.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	Output from HAE-DAT and ICES HAB status report will provide material for ACOM should requests for advice require consideration of impacts from HABs. .
Linkages to other committees or groups	There is a working relationship with WGPME, WGZE, WGITMO. The cooperation with Aquaculture EGs could be further developed.
Linkages to other organizations	UNESCO-IOC Intergovernmental Panel on Harmful Algal Blooms, IOC/SCOR Global HAB (previously GEOHAB - Global Ecology and Oceanography of Harmful Algal Blooms).

Annex 3: National Reports

Belgium: National Report 2017–2019

Maarten De Rijcke Vlaams Instituut voor de Zee

Between 2017 and 2019, no toxic blooms were reported within the Belgian part of the North Sea. During the first two years of this reporting period, neither the Belgian part of the North Sea nor the inshore shellfish water "Spuikom" were monitored due to the absence of shellfish production at the time. Shellfish culture has now resumed in the area. As a result, both plankton and toxin monitoring has resumed in 2019.

A single event was entered into HAEDAT; in 2018, environmental agencies were alerted to a mass mortality event in the Spuikom. A mixed bloom of ciliates and cyanobacteria is thought to have caused the hypoxic conditions that killed wild fish (European eel, European seabass) and benthic organisms (shrimp, crabs, gobies). Surfers displayed skin rash which may indicate unresolved toxicity. The area was temporarily closed for recreation.

Canada: National Report 2017–2019

Cynthia McKenzie, Research Scientist, Fisheries and Oceans Canada Chair, Canadian Harmful Algal Working Group (CAN HAB)

Canadian Scientists from Fisheries and Oceans Canada, Canadian Food Inspection Agency and the National Research Council of Canada have conducted a formal CSAS (Canadian Science Advisory Secretariat) process to assess the status of harmful algae in Canada, identify knowledge gaps and research needs for current and future impacts of HABs on ecosystems and resources. The Science Advice Workshop on the impact of marine HABs on the Canadian ecosystem was held in March 2019 in Vancouver, British Columbia. A conceptual bow tie model was developed as a framework to investigate ecosystem risk and gaps, the CSAS document addressed the following objectives:

1) Review the national scope of HAEs and their impacts in Canada's Atlantic, Arctic and Pacific marine waters, with a focus on trends over the past 30 years;

2) Determine areas or issues of particular or emerging concern with respect to impacts and consequences to Canadian marine ecosystems and how they may impact core DFO responsibilities;
3) Identify key knowledge gaps that limit DFO's ability to evaluate or inform management decisions regarding the impacts and consequences of these HAEs; and

4) Recommend actions to address these knowledge gaps.

The study included ways to expand existing work and strengthen connections to related programs, such as environmental monitoring and invasive species studies and to provide more HAB information for Canada. The potential for linkages between Canadian interests and the priorities of international networks, such as ICES WGHABD, IOC IPHAB and Global HAB, were also be addressed. Several documents (primary publications, technical reports, a CSAS Research Document and CSAS Science Advice Report) will be produced from this process. An important source for the 30-year HA review were the HAEDAT records. This information provided the Canadian contribution to the ICES and Global HAB status report and was included in the special issue of Harmful Algae on HAB status and HAEDAT. Summary of harmful algal events for Canada –

2017, 2018, 2019. In 2017 there were 21 harmful algal events in Canada, with 13 PST events (eight Atlantic, five Pacific), two AST events (Atlantic) three DST events (Atlantic) and three fish kill events (Pacific). In 2018, there were 20 events in Canada with eight PST events (Atlantic data unavailable, eight in Pacific), six AST events all in Atlantic Canada, four DST events (two each Atlantic and Pacific). In 2019, there were more than seven events (three PST, two AST and one DST- all in NS and NB- and one reported aquaculture fish kill event in the Pacific) with several additional closures in both Atlantic (Quebec) and Pacific regions. Phycotoxin closure information for British Columbia (BC) and Quebec (QC) was not available at the time of this report and HAEDAT information will be updated for 2019 when this information is available.

Atlantic Coast of Canada (ICES regions)

ASTs Quebec Region

In Quebec Region, areas are closed permanently to the harvest of razor clams and arctic wedge clams (not monitored and historically prone to biotoxin contamination). Biotoxin closures, or closures due to cessation of biotoxin monitoring, are therefore issued mainly to allow for harvest of aquaculture species (blue mussels and/or softshell clam) which are tested during harvest periods. Closures issued for these purposes are normally revoked at the beginning of the following season. All DA toxin data reported by CFIA in 2018 remained below the regulatory limits within this region, however several closures were implemented at in October and November when biotoxin monitoring ceased for the year. In 2018, some precautionary closures took place on the North West Coast/Anticosti Channel [CA-03] due to reported low levels of domoic acid (max of 1.8 ug/g DA). A closure was issued for Arctic wedge clam, Atlantic razor clam, and blue mussel on October 5. Precautionary closures also took place along the North Coast/St. Lawrence Estuary [CA-05] due to reported low levels of domoic acid (max of 1.1 ug/g DA). Closures were issued for Arctic wedge clam, Atlantic razor clam, Blue mussel on October 1 and October 11. The Lower St. Lawrence Estuary [CA-06] also had reported low levels of domoic acid (max of 1.0 ug/g DA). A closure was issued for Arctic wedge clam, Atlantic razor clam, Blue mussel on October 12. The Magdalen Islands [CA-23] CFIA samples reported low levels of domoic acid (max 4.7 ug/g DA) with closures due to biotoxins were issued on October 25 and November 1 and November 16. AST data was unavailable for 2019.

Nova Scotia

On June 29 to September 20, 2017 Indian Point was closed due to ASTs, it was closed again in December 2017. Again in 2018, on the Eastern Shore/St. Margaret's Bay/Mahone Bay [CA-17] CFIA reported domoic acid over the regulatory limit in shellfish samples in November and December (max of 45 ug/g DA). A closure order for all bivalve shellfish was issued on November 8 for Mahone Bay. Below regulatory levels of DA were also reported on the Western Shore/Bier Island/Long Island area [CA-19] in October. There were two closures in 2019 on the western portion of Mahone Bay [CA17] one on January 11 (toxin levels 30ug/g) and again on April 5 (toxin levels 15 ug/g) opened one-week later April 12, 2019.

New Brunswick

In 2018, a closure order was recommended for bivalve shellfish (excluding sea scallops) on October 10 for the outer Bay of Fundy [CA-22] due to the risk of ASP (levels were 15 ug/100g DA on that date). CFIA had informed DFO that domoic acid levels were rising rapidly and contamination was expected to occur by October 12, 2018. The area was issued a closure order on October 12 which included areas from Campbells Point to Wiley's Corner.

Newfoundland and Labrador

Some AST shellfish biotoxin closure orders from previous years are still in effect in the region.

PSTs

There were five closures reported in Quebec in 2017. On June 14 to July 24 the Cap Maria area of the Gaspé Pennisula (CA 10) was closed due to PST levels (75ug/100g to 208 ug/100g). This was extended June 21 and July 4 to other areas of La Baie de Gaspe [CA 09] and [CA 08; 315ug/100g]. A closure at Anse Choinard [CA 04] lasted from July 4 to July 28, 2017 as the toxin results stayed at 70ug/100g for all three weeks. A closure at Ile Verte [CA 07] between September 11 and Sept 14 was short term as it was determined that the shellfish were not the source of an intoxication. Several closures as noted above however, no phycotoxin information was available for 2018 and 2019.

Nova Scotia and New Brunswick

Red Head and Blacks Harbour [CA 22] were closed March 10, 2017 due to high levels of PST, it was noted that it was probably exposure from the previous year. Northern Harbour of Deer Island [CA 22] was closed July 21 to August 11, 2017 due to increased PST levels. Little Lepreau Basin [CA 21] was closed from June 22 to September 29, 2017 due to high levels of PST. PST data was not available 2018. The western areas of the Bay of Fundy [CA 22] was closed for extended periods from May 2, 2019 to October 15, 2019 due to PST values that ranged from 81ug/100g to 400 ug/100 (July 5, 2019).It was closed again December 9, 2019 due to unacceptable levels of PST (83ug/100g).These areas in NB included Hills, Bliss and Frye Island, Simmons Cove, Grand Manan, Letand Harbour and River, Letete Passage, Campbells Point and Wileys Cove. CA 21 was also closed due to PST levels on June 12, 2019 (increasing values 64 ug/100g) and extended July 5, 2019. There were no PST events in Prince Edward Island or Newfoundland and Labrador during the three-year period. Several areas in Newfoundland and Labrador remain closed due to the presence of PST containing cysts in the sediment.

DSTs

Nova Scotia and New Brunswick

Richibucto Harbour and Shediac Bay, NB [CA 12] were closed June 22 to July 17 due to DST levels (0.13 ug/g DTX1). Indian Point, NS [CA 17] and Ship Harbour, NS [CA 16] and were closed July 4 and July 27, 2017 due to DST levels. In 2018 for Chedabucto Bay/Eastern Shore of Nova Scotia [CA-16]) CFIA reported okadaic acid group toxins over the regulatory limit in shellfish samples (max of 2.4 ug/g OA total). OA levels below regulatory limits were also report on the Victoria Shore to Richmond Shore [CA15] and the Eastern Shore/St. Margaret's Bay/Mahone Bay [CA-17]. CA -17 on the western portion of Mahone Bay was closed from July 5 to July 19, 2019 due to rapidly rising levels of DST (from .08 to .17 ug/g in one week).

Prince Edward Island (PEI)

In 2018, CFIA reported 0.15 ug/g total OA on July 19 for the Eastern Shore of PEI [CA24]). A closure order was issued on July 19 for Bar Clams, Soft Shell Clams, Bay Quahaugs, Razor Clams, Clams, Mussels, Oysters, Bivalve Molluscs, Bay Scallops at Boughton River. On July 20 to 26 CFIA also reported okadaic acid group toxins above the regulatory limit (max of 0.56 ug/g total OA) within this grid code.

Newfoundland and Labrador

In 2018, in St. Mary's Bay/Placentia Bay [CA-30] CFIA detected the presence of low levels of okadaic acid group toxins in shellfish (0.06 ug/g OA total/DTX-1 esters). Other- Yessotoxins In 2018, in Newfoundland and Labrador, yessotoxin was detected in Bonavista Bay [CA28] in shellfish (max of 0.35 ug/g) and in Trinity Bay [CA-29] with a maximum value in shellfish (max of 0.35 ug/g) in 2018.

Pacific Region (PICES Region) British Columbia

ASTs

There were no closures due to ASTs in 2017. ASTs with detected below regulatory limit in all Pacific grid codes in 2018. No AST data was available for 2019 Pacific closures at the time of this report. PST There were five closures due to PST in BC in 2017. Espinosa Inlet [CA 35] April 30, 2017 and Spring Cove [CA 36] May 2, 2017due to high toxins. Okeover Inlet [CA37] closed May 22, 2017, Bold Point [CA 38] closed May 15, 2017 and Freeman Passage [CA 40] was closed April 28, 2017 due to PST toxins. In 2018, the Upper West Coast of Vancouver Island [CA-35] whole sea mussel samples were found to contain saxitoxin group toxins above the regulatory limit between July to November. Closures for all bivalve shellfish were issued on August 24, and December 6. For the Lower West Coast of Vancouver Island [CA-36] saxitoxin group toxins were found above the regulatory limit in Geoduck viscera, whole sea mussels, whole blue mussels, and whole oysters. Toxicity was detected in samples collected from April to November with a maximum of 540 STXdiHCl eq/100g detected in whole sea mussels in October. Closures for all bivalve shellfish species were issued on August 24 and November 21. For the Lower Strait of Georgia [CA-37] saxitoxin group toxins were found above the regulatory limit in sea mussel, blue mussel and weathervane scallop between May to December. Values ≥ 1000 ug STXdiHCl eq/100g were detected in blue mussel samples from October to November 2018 in 5 locations within this grid code. For the Upper Strait of Georgia [CA38] saxitoxin group toxins were detected above the regulatory limit (max of 210 ug STXdiHCl eq/100g) in geoduck viscera, whole butter clam, whole blue mussels, and whole sea mussels between May and December. Maximum STX-group toxin level was 410 ug STXdiHCl eq/100g found in whole sea mussel on July 31. For the Central BC coast [CA-39] butter clam samples tested above the regulatory limit on November 26. The toxin level ranged from 120-220 ug STXdiHCl eq/100g. A closure for all bivalve shellfish had been issued on January 24. For Haida Gwaii [CA-41] saxitoxin group toxins were found above the regulatory limit of in whole butter clam, geoduck viscera, and razor clams from July to October. The maximum toxin level detected was in whole razor clam at 300 ug STXdiHCl eq/100g on July 29. Closures were issued for all bivalve shellfish on January 24, November 22 and November 30. For the Northern BC coast [CA-40] saxitoxin group toxins were found above the regulatory limit in geoduck viscera, whole butter clam, whole blue mussels, and Japanese scallop viscera from July to December. The max toxin level detected was in blue mussels at 1100 ug STXdiHCl eq/100g on July 30. Closures were issued for all bivalve shellfish on January 24 and February 26. No PST data was available in 2019 at the time of this report.

DST

No closures due to DST were reported in 2017. In 2018, for the Lower Strait of Georgia [CA-37] okadaic acid group toxins were reported above the regulatory limit in late June to early July. Closures for all bivalve shellfish species were issued on August 16, and September 7. For the Upper Strait of Georgia [CA-38] okadaic acid group toxins were also reported over the regulatory limit in mid-October. Closures for all bivalve shellfish were issued on June 21, December 5 and December 31. Okadaic acid group toxins were detected below regulatory limit on the Upper West Coast of Vancouver Island [CA35],the Lower West Coast of Vancouver Island [CA-36], and the Northern BC coast [CA-40].

Other Yessotoxin, gymnodimines, pectenotoxins

For the Upper West Coast of Vancouver Island [CA-35] yessotoxins (max of 0.36 ug/g YTX total), and gymnodimines (0.01 ug/g) were also detected. On the Lower West Coast of Vancouver Island [CA-36], yessotoxin (max of 1.8 ug/g YTX total), and gymnodimines (0.01 ug/g) were detected. Near the Lower Strait of Georgia [CA-37] yessotoxin (from 0.05-11 ug/g) and gymnodimines (max of 0.02 ug/g) were detected. For the Upper Strait of Georgia [CA-38] yessotoxin (max of

0.99 ug/g YTX total) and gymnodimines (0.01 ug/g) were also reported. On the Northern BC coast [CA-40] yessotoxins (max of 1 ug/g YTX total) and Haida Gwaii [CA-41] yessotoxins (max of 0.1 ug/g YTX total) were detected. Pectenotoxins were detected below regulatory limits on the Lower West Coast of Vancouver Island [CA-36], the Upper Strait of Georgia [CA38] and Haida Gwaii [CA-41].

Other- Fish Kills

Three events of fish kills were reported in 2017. Clayoquot Sound [CA 36] had a fiveweek bloom of *Heterosigma akashiwo* (2,300,000 cells/L) from June 3 to July 28 and resulted in mass mortalities of aquaculture fish. Greenway Sound [CA 38] had an *Alexandrium catenella* bloom (5000,000 cells/L) from August 4, 2017 and lasted 2 weeks with mass mortalities of aquaculture fish. Jervis Inlet [CA 37] had a *Chaetoceros convolutes* (95,000 cells/L) *Chaetoceros concavicornis* (15,000 cells/L) bloom starting on March 6, 2017 and lasted 4 weeks and resulted in aquaculture fish mortalities. On the Upper West Coast of Vancouver Island [CA-35] from August 10 to September 22 2018 a widespread bloom of *Heterosigma akashiwo* (9,200,000 cells/L max) caused the mass mortality of aquaculture fish in Esperanza Inlet and Clayoquot Sound. For the Lower Strait of Georgia [CA-37] from May 29 to June 19, 2018 a bloom of *Heterosigma akashiwo* caused the mass mortality of aquaculture fish in Jervis and Schelt Inlets. Highest cell counts were seen in late August in Clayoquot Sound (9,200,000 cells/L). In November 2019, four salmon aquaculture sites in Clayoquot Sound, west coast Vancouver Island, reported fish kills caused by *Chaetoceros concavicornis* and *C. convolutes*.

Sources of data:

Compiled by Terri Wells and Megan Mews, DFO NL Region. Toxin data courtesy of Simon Cowell, CFIA; closure information obtained through the Canadian Shellfish Sanitation Plan online mapping tool & regional fishery opening and closure order automatic notifications*. Mass mortality event reports courtesy of Nicky Haigh, HAMP and Andrea Locke, Pacific region. * This summary does not quote closure orders still in effect from previous years. Only closure orders issued in 2017- 2019 are quoted in this report. Current regulatory limits for biotoxins in Canada: Saxitoxin group toxins - 80 ug STXdiHCl eq/100g; Domoic acid – 20 ug/g Okadaic acid group toxins – 0.2 ug/g total OA; Pectenotoxins – 0.2 ug/g *There is currently no regulatory limit set for yessotoxin, or gymnodimines in Canada.

Canadian HA Reviews Bates, S.S., D.G. Beach, L.A. Comeau, N. Haigh, N.I. Lewis, A. Locke, J.L. Martin, P. McCarron, C.H. McKenzie, C. Michel, C.O. Miles, M. Poulin, M.A. Quilliam, W.A. Rourke, M.G. Scarratt, M. Starr, and T. Wells. 2020. Marine harmful algal blooms and phycotoxins of concern to Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 3384: x + 322 p. http://waves-vagues.dfo-mpo.gc.ca/Library/4088319x.pdf McKenzie CH, Bates SS, Martin JL, Haigh N, Howland K, Lewis NI, Locke A, Peña A, Poulin M, Rochon A, Rourke WA, Scarratt MG, Starr M, Wells T (2020) Three decades of Canadian marine harmful algal events: Phytoplankton and phycotoxins of concern to human and ecosystem health. Harmful Algae https://doi.org/10.1016/j.hal.2020.101852.

Denmark: National Report 2017–2019

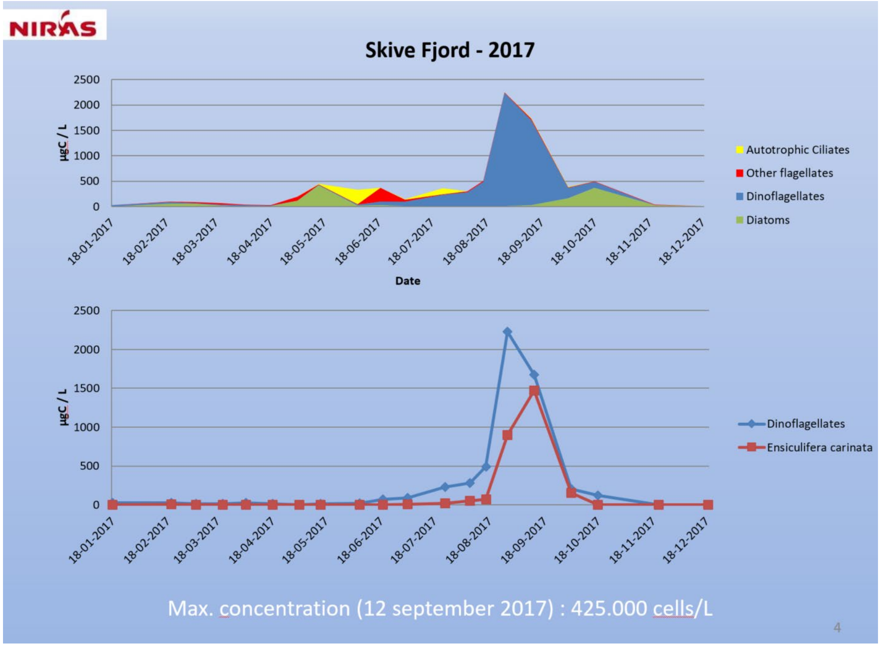
Per Andersen, Aarhus University, Denmark e-mail: pean@bios.au.dk

Harmful Algal Blooms (HABs) are common in Danish coastal waters and fjords. High biomass HABs (e.g. *Pseudochattonella* spp. and *Pseudo-nitzschia* spp.) are likely to be related to eutrophication. Some HAB species might be introduced to the area, such as species of *Pseudochattonella*. Blooms of cyanobacteria, e.g. the toxic species *Nodularia spumigena,* are transported to the Kattegat/Belt area from the Baltic.

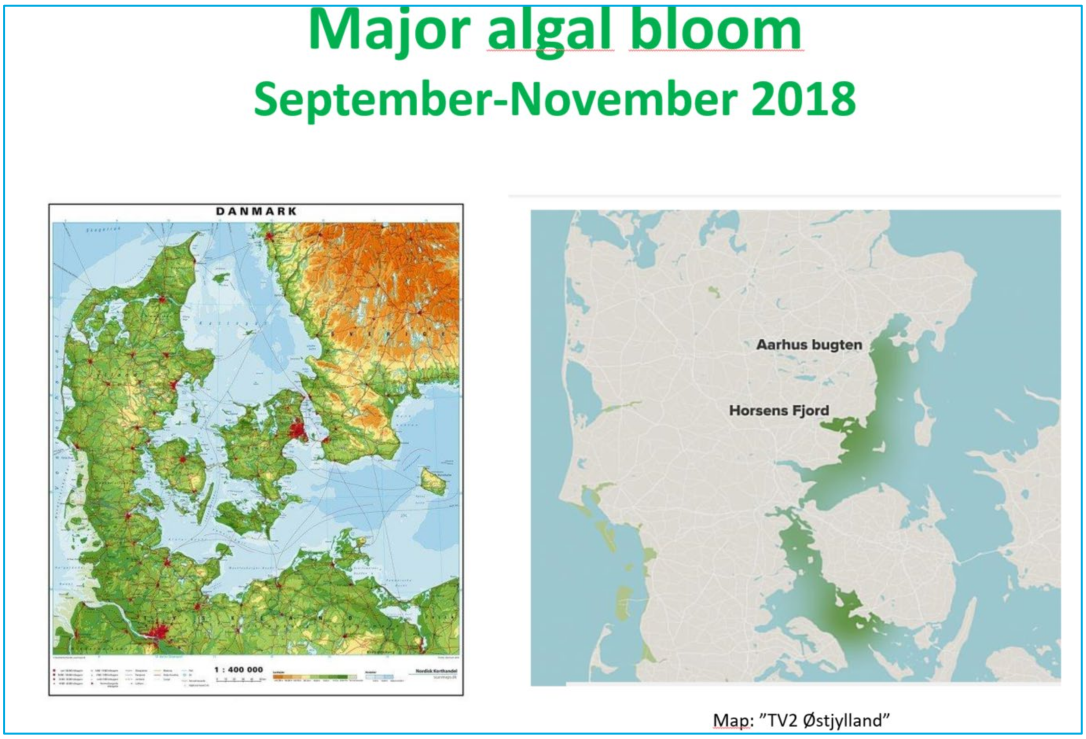
In Denmark, the aquaculture of mainly rainbow trout in coastal waters is concentrated in the southern part of the Kattegat. Commercial farming and harvesting of wild mussels and oysters for human consumption is concentrated in the Limfjord area with additional harvest of wild mussels also in the southwestern part of the Kattegat and in the Little Belt area and in the Wadden Sea area. HABs in the waters of Skagerrak and the Kattegat as well as at the North Sea coast including the Danish part of the Wadden Sea and the Limfjord, include fish killing species and species that produce toxins that accumulate in filter feeders (e.g. mussels).

New species/exceptional blooms

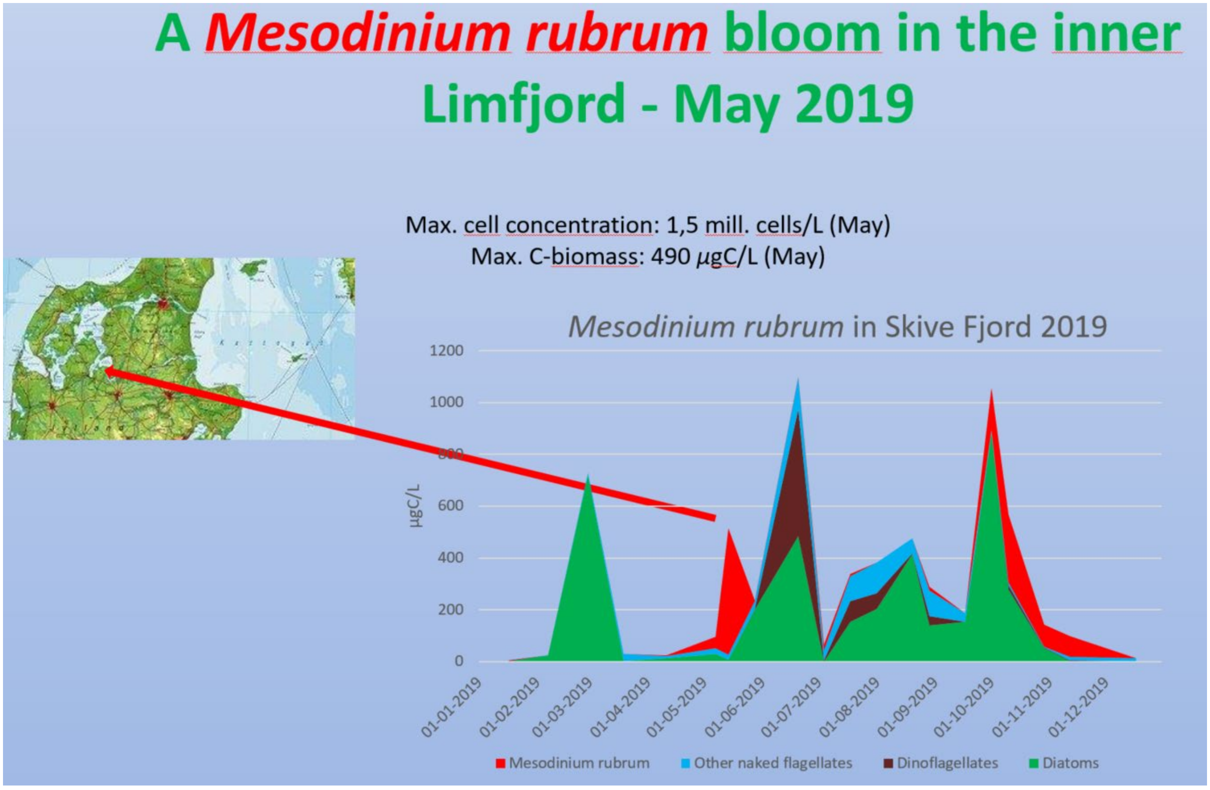
2017: An exceptional bloom of the dinoflagellate *Ensilculifera carinata* was recorded in the inner part of the Limfjord. No immediate harmful effects were observed.



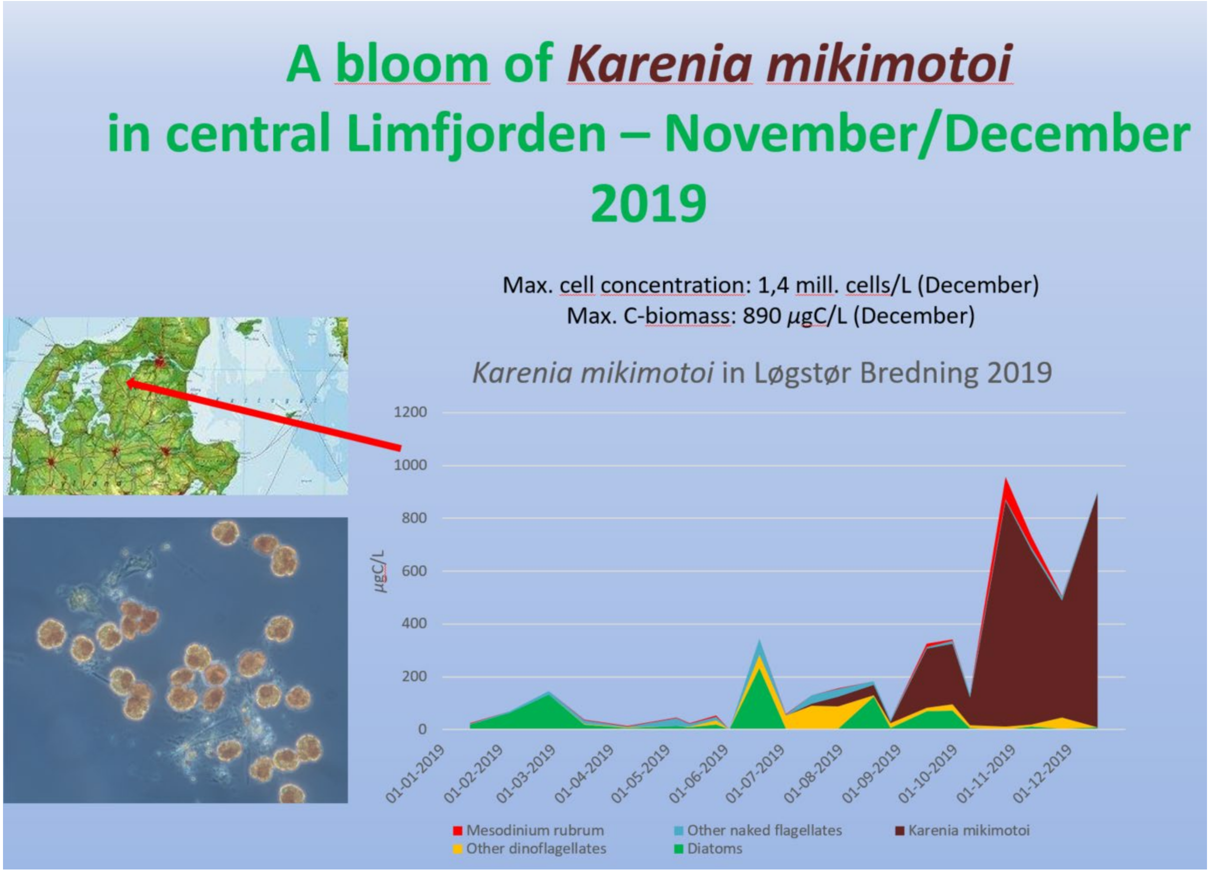
2018: A major bloom of the green dinoflagellate *Lepidodinium* cf. *chloroforum* was observed at the east cost of Jutland in late summer/autumn causing beach closures but no other harmful effects were observed.

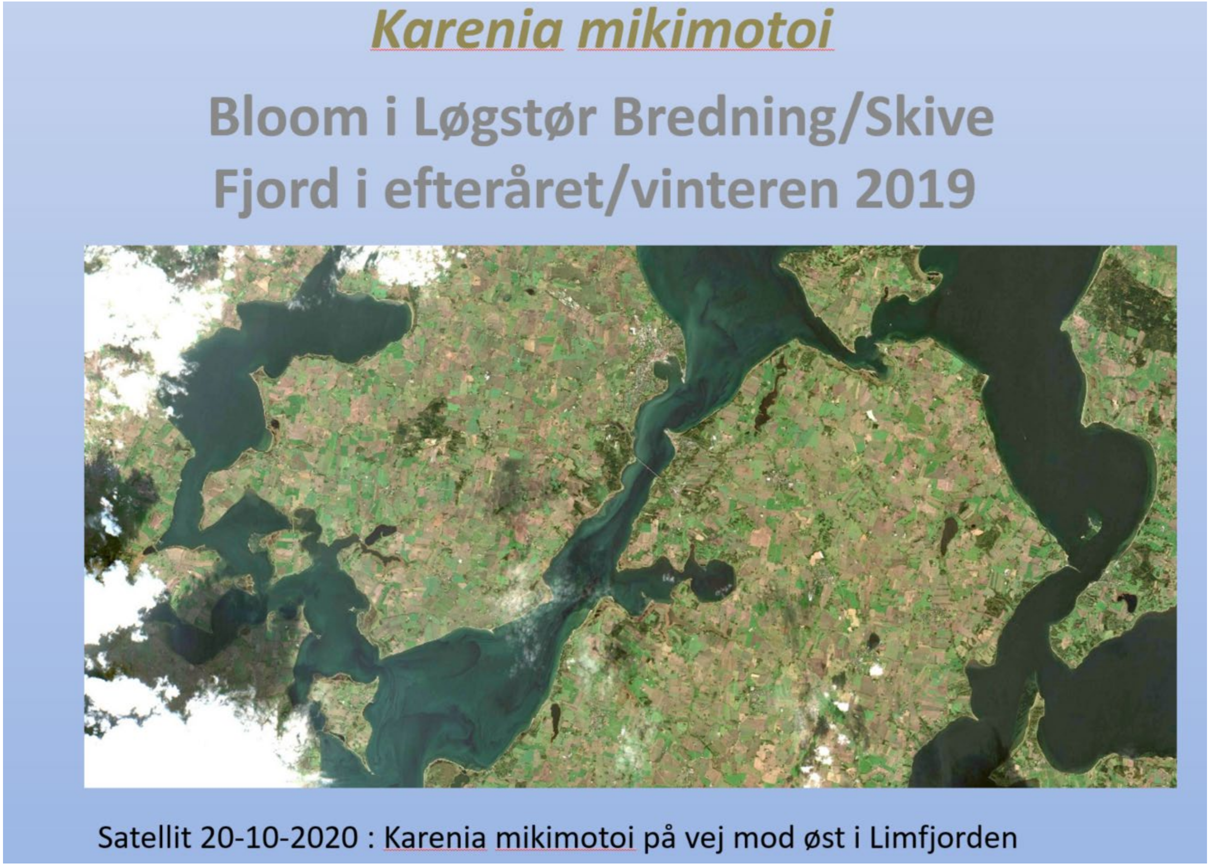


2019-1: A major bloom of the mixotrophic ciliate *Mesodinium rubrum* was recorded in the inner part of the Limfjord causing discoloration of the water (red water) in May. A maximum concentration of 1,500,000 cells L^{-1} were recorded.

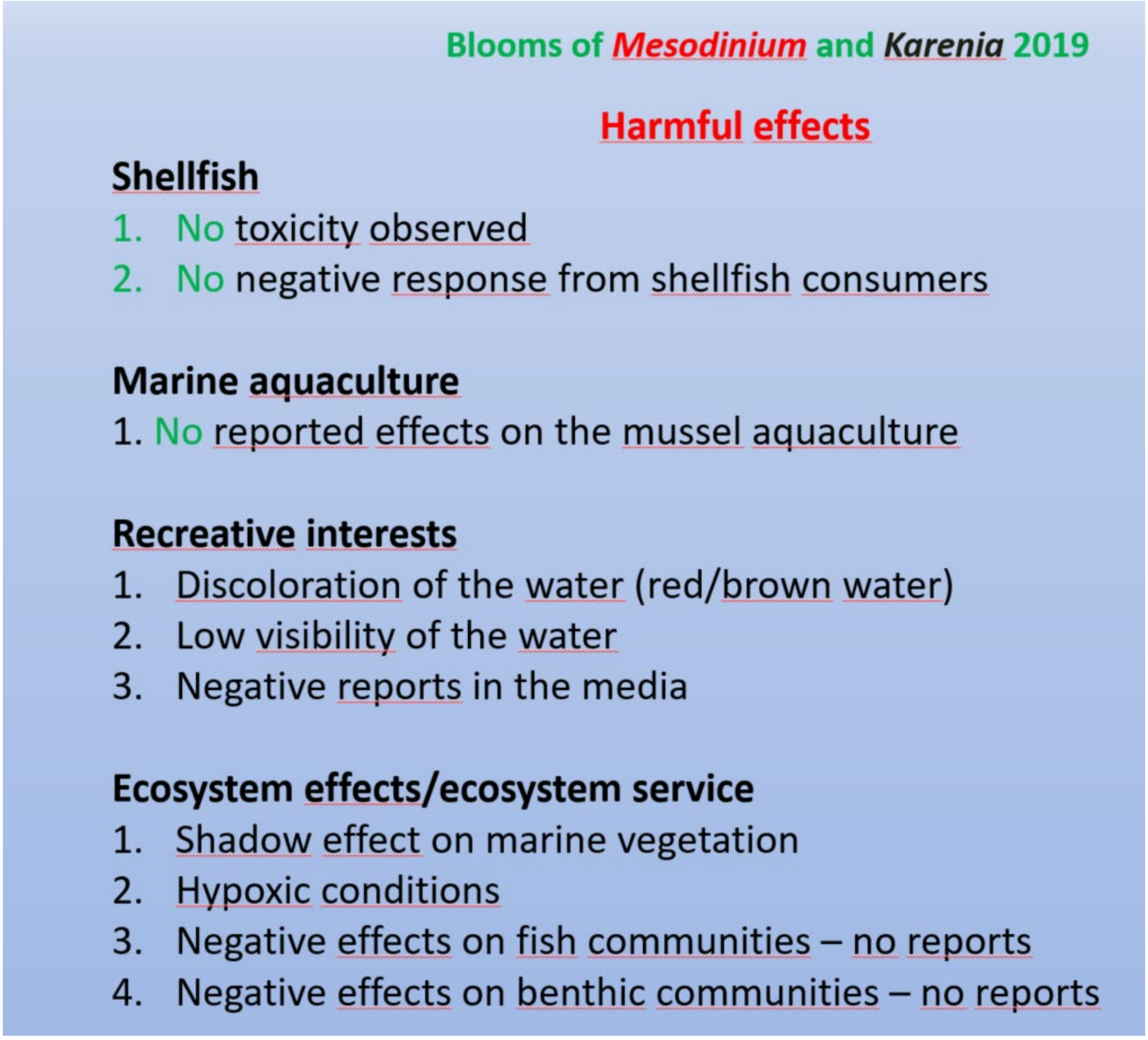


2019-2: A major bloom (September-December) of *Karenia mikimotoi* was recorded in the central part of the Limfjord. A maximum concentration of 1,400,000 cells L^{-1} was recorded. No harmful effects were observed but exceptional mortalities of wild herring were observed during the following spring, just after the disappearance of the bloom which extend into January 2020.





Satellite documentation of high chlorophyll in the western part of the Limfjord extends eastward into the central part of the fjord. Picture taken on 20-10-2020.



2019-3: Blooms of *Noctiluca scintillans* causing red-water during summer on the Danish North Sea coast induced occasional beach closures.

Noctiluca scintillans at the Danish North Sea coast – summer 2019. Foto: T. Ødum)

Cyanobacteria

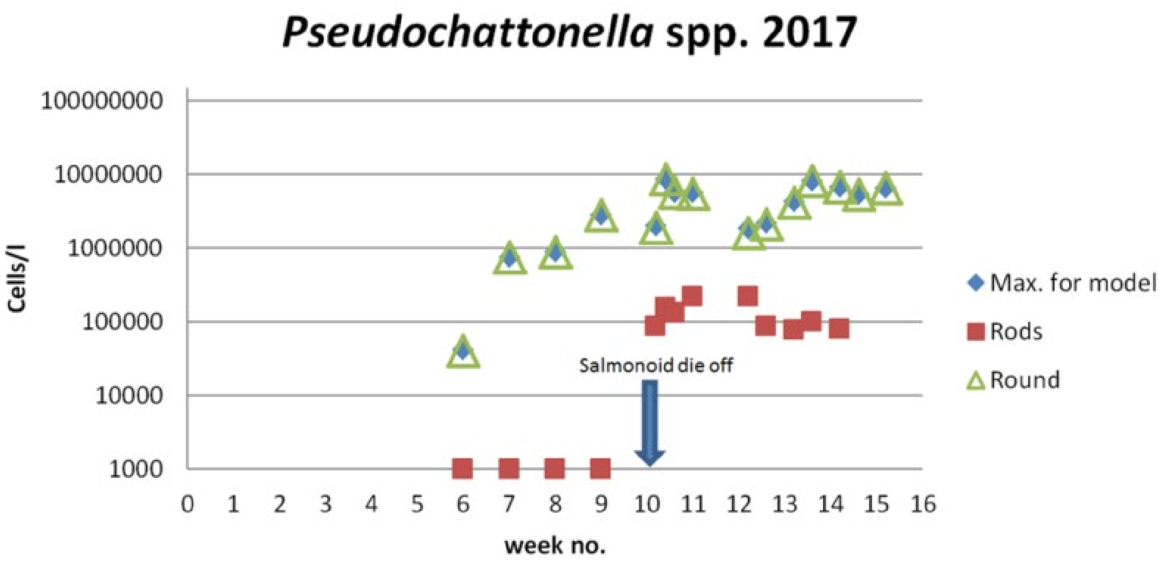
2017: no cyanobacteria blooms to report

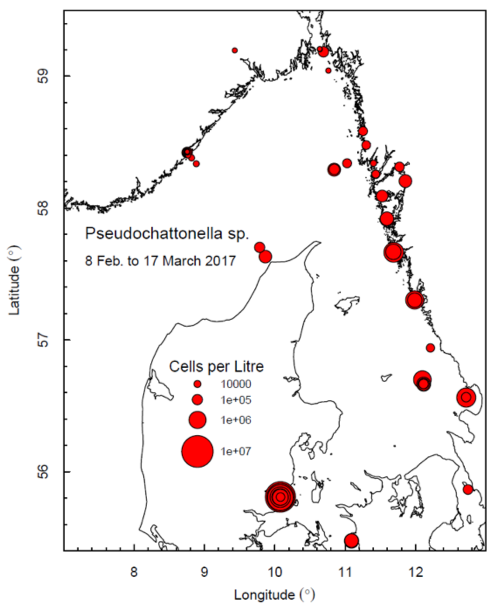
2018: Cyanobacteria blooms observed (*Nodularia spumigena*). Many beach closures in the Øresund and on the north coast of Sealand.

2019: no cyanobacteria blooms to report

Fish killing algae

2017: A harmful bloom of *Pseudochattonella* spp. was observed in the early spring 2017 causing salmonoid die off (fish overwintering in pens), and delayed the release of new fish in suspended aquaculture pens in the south-western Kattegat. The bloom was part of a more extensive event covering the Danish part of the Kattegat, the Swedish west coast up to the southern coast of Norway.

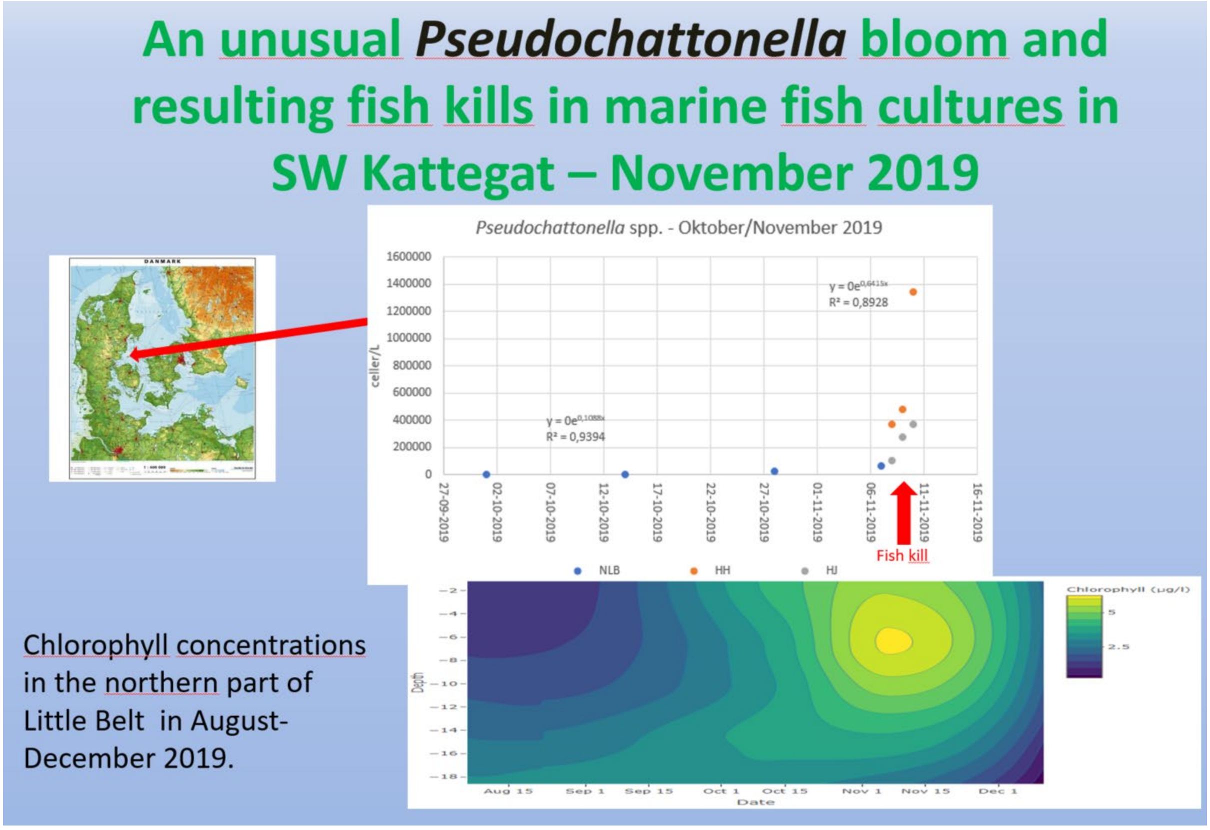




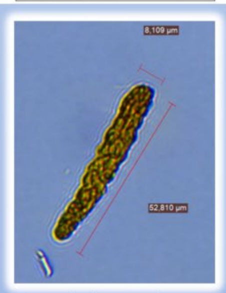
Cell abundances of Pseudochattonella spp. 8 Feb. to 17 March 2017. Several different organisations have contributed data.

2018: No fish kills or delayed release of fish in aquaculture pens due to HABs

2019: No harmful blooms were observed in the spring. But an very unusual late autumn/winter bloom of *Pseudochattonella* spp. caused fish kill in fish cultures in south western Kattegat in November. This is the first reported bloom of *Pseudochattonella* causing fish kills in Scandinavian waters during late autumn/winter. The total loss of fish was 400-500 tons. See summary in slide below.



An unusual *Pseudochattonella* bloom and resulting fish kills in marine fish cultures in SW Kattegat – November 2019



Pseudochattonella sp. from the November bloom 2019, Photo: Per Andersen

Summary

Date of incident: 8-11 november 2019

Weather conditions: Prior to the incident - weakly easterly wind, followed by strong westerly winds (causing "up-welling"). The incident ended with strong westerly winds that mixed/diluted the surface water with high algal concentrations.

Temperature of water: 8-9 ºC

Salinity: approx. 20 o/oo.

Oxygen conditions: > 100% saturation.

Secchi depth: 8th of November approx. 5 m , 9-10th of November approx. 3 m.

Color of water during bloom: brownish

Fisk: Rainbow trout (*Oncorhynchus mykiss*)

Fish weight: Approx. 3 kg

Mortality: Hundshage = approx. 100%, Hjarnø Sund = approx. 66% dødelighed. Weight of dead fish: 400-500 tons

Management actions: Feeding stopped. Transport of fish to the area to be slaughetered – stopped.

Observed concentrations of *Pseudochattonella* spp. (mainly large elongated cells): 0,4 – 1,3 mill. cells/L.

Algae causing shellfish toxicity

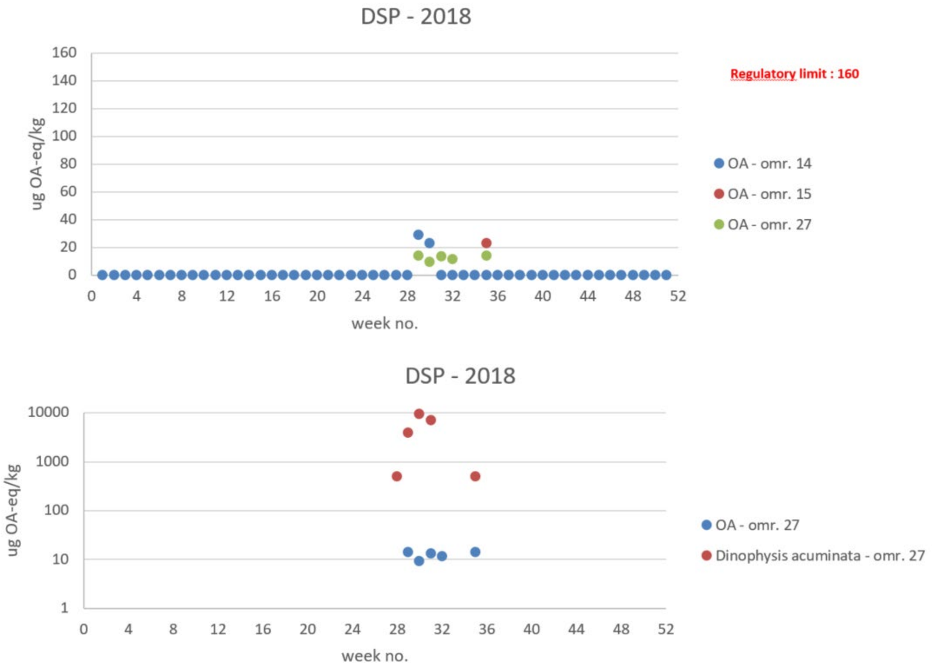
The Danish National Food Agency governs the monitoring of biotoxins producing algae and of algal toxins in bivalves. Private companies perform analysis of plankton samples. Blue mussels (*Mytilus edulis*), common cockle (*Cardium edule*), flat oysters (*Ostrea edulis*), and pacific oysters (*Crassostrea gigas*) and other species were harvested in 2017-2019.

DSTs and Dinophysis

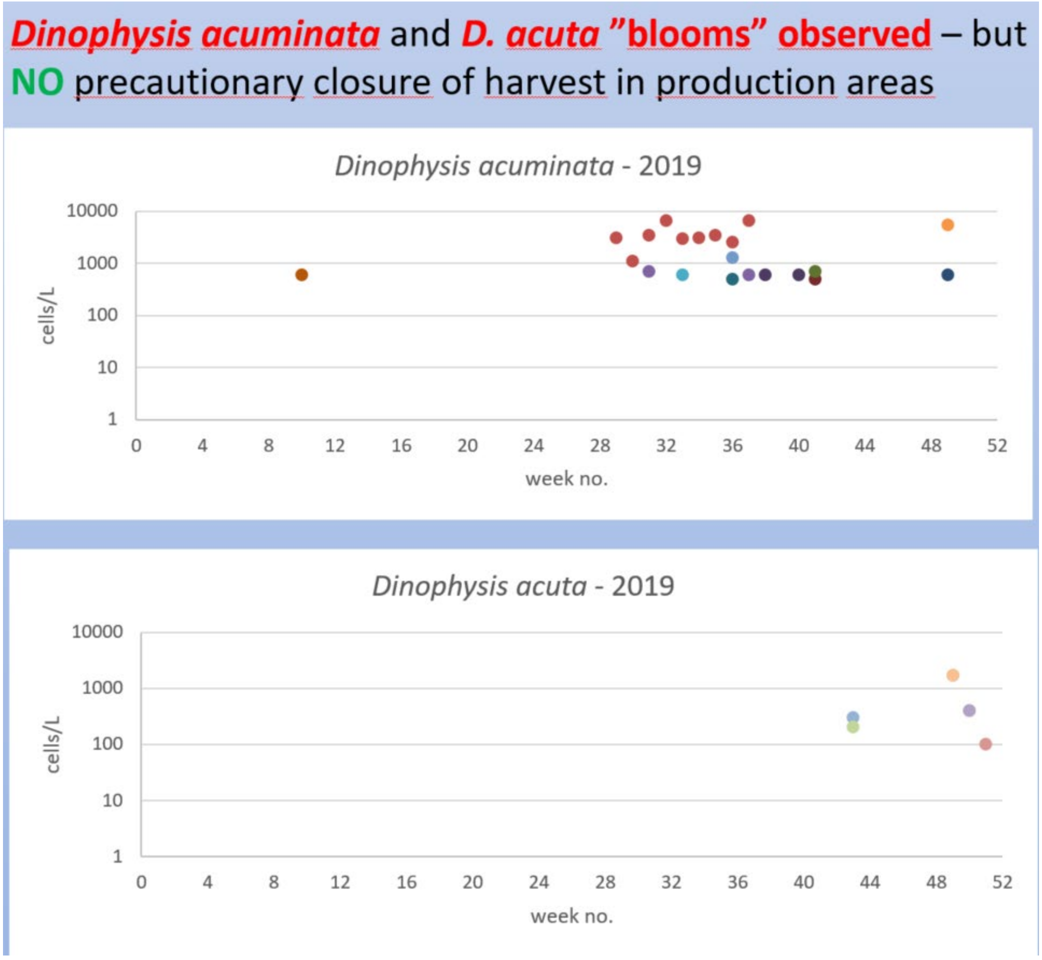
2017: Elevated concentrations of DSTs (weeks 24 + 35-42) in the Wadden Sea area, but below regulatory limit. No observations of *Dinophysis acuminata* during the event.

2018: Elevated concentrations of DSTs (but below regulatory limits) during a bloom of *Dinophysis acuminata* in one production area in the Limfjord. The harvest area was precautionary closed.

Precautionary closure of harvest in prod. area 27



2019: Elevated concentrations of DSTs (but below regulatory limits) during a bloom of *Dinophysis acuminate and D. acuta*. No precautionary closures in relation to the blooms.



PSTs and Alexandrium

2017: Detection of low concentrations of PSTs in the Limfjord (weeks 21-22). *Alexandrium* spp. were not observed.

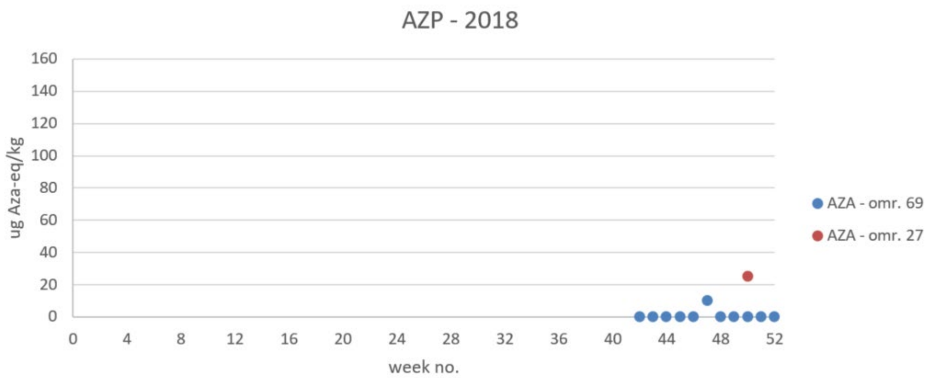
2018: No PSTs detected

2019: No PSTs detected

AZAs and Azadinium

2017: No observations of AZAs.

2018: Low concentrations (below the regulatory limit) of AZAs in blue mussels in two production areas in the Limfjord during late autumn/winter.



2019: AZAs detected below the regulatory limits in week 2 in the Limfjord

ASTs and *Pseudo-nitzschia* spp.

2017: Amnesic Shellfish Toxins (ASTs) were not detected. Blooms of *Pseudo-nitzschia* spp. (> 1, 000 000 cells L^{-1}) were observed.

2018: No ASTs detected

2019: No observations of ASTs but several blooms of *Pseudo-nitzschia* spp. (> 1,000 000 cells L^{-1}) were observed.

Finland: National Report 2017–2019

Sanna Suikkanen, Finnish Environment Institute

2017

From mid-July, filamentous cyanobacteria were abundant in the open sea areas of the N Baltic proper, Western Gulf of Finland, Southern Archipelago Sea and Åland Sea. In August, cyanobacteria were also occasionally abundant in the Southern Bothnian Sea and Eastern Gulf of Finland. However, winds kept cyanobacteria mixed in the water column. In the coastal areas, cyanobacteria were observed mainly in the Gulf of Finland and Archipelago Sea. The high risk for cyanobacterial blooms, forecast in early summer for the coastal Gulf of Finland based on winter and spring nutrient concentrations, modelling and expert assessment, was not fully realized due to the low temperature of the seawater. Additionally, due to mixing of surface water caused by occasional strong winds, the cyanobacteria did not form conspicuous surface accumulations. According to the Finnish Meteorological Institute, the surface temperatures of the open sea areas were lower compared to previous summers, although they were close to the long-term average. In addition, surface temperature in the coastal Gulf of Finland was lower than that of the open sea, due to upwelling of cooler deep water at the coastline. No HAEDAT events were recorded, as the cyanobacterial bloom situation was typical for the area and did not cause any management actions.

2018

In the Finnish sea areas, the most intensive cyanobacterial blooms of the decade were observed in summer 2018. Cyanobacteria started to become more abundant in the S and SW sea areas of Finland in the second week of July and the blooms were most intensive in mid-July. The blooms covered at worst almost the entire Gulf of Finland, being especially abundant along the Finnish coast. Cyanobacteria were also abundant in the S Archipelago Sea and Åland Sea. In the Bothnian Sea, there was also an extensive cyanobacterial bloom that covered the sea area between the Åland Islands in the south up to the town of Pori in the north. At the turn of August, winds mixed the cyanobacteria into the water column, where they kept being abundant for the rest of the month. However, in August the most intense surface accumulations of cyanobacteria occurred further south in the Baltic Sea, outside the Finnish sea area. The risk assessment for cyanobacterial blooms, published in early June, was realized rather well regarding the surface bloom area predicted. Weather conditions of the summer were however exceptionally favourable for cyanobacterial growth. The high surface water temperature promoted the growth of cyanobacteria and the calm period in the second week of July enabled the formation of extensive surface accumulations. The cyanobacterial species composition differed slightly from the typical in the area: the dominating cyanobacteria belonged to the genera *Aphanizomenon* and *Dolichospermum,* the latter of which may form toxins. The hepatotoxic *Nodularia spumigena,* which typically forms extensive surface accumulations in the open Baltic Sea during warm water, was present only in small amounts. The cyanobacteria bloom of 2018 was reported as a HAEDAT event, because it was declared exceptional by the Finnish authorities.

Cyanobacterial blooms continued in the Gulf of Finland until late autumn and winter. Mass occurrences of *Aphanizomenon*, which also thrives in cold water, widely occurred under the sea ice in early January 2019. The phenomenon was noted and confirmed after several reports on blue-green or turquoise-coloured ice, water and shorelines received by the Finnish Environment Institute. The colour is caused by the phycocyanin pigment released from dying cyanobacterial cells. In the microscopy samples taken under ice, most *Aphanizomenon* cells were decaying. Continued growth of cyanobacteria was likely promoted by warmer than usual seawater and elevated surface concentrations of phosphate in the autumn and early winter.

In addition to cyanobacteria, strong bioluminescent blooms of the neurotoxic dinoflagellate *Alexandrium ostenfeldii* were reported from two sites at the SW coast of Finland in September 2018. The reports came from previously known bloom sites of the species in Raseborg and Åland arhipelagos. The water temperature during the blooms was >19 °C. No HAEDAT events were recorded for *A. ostenfeldii*, as the blooms did not cause any known negative effects on other organisms or management actions.

2019

Winds kept the cyanobacteria mostly mixed in the water column, but some surface accumulations also formed. Cyanobacteria were observed especially in the N Baltic proper, at the entrance to the Gulf of Finland and south of the Åland Islands and Archipelago Sea, but also in the Åland Sea, the Gulf of Finland especially near the Finnish coast, north of the Åland Islands and in the southern and central parts of the Bothnian Sea. In contrast to earlier years, cyanobacteria were also observed in the N Bothnian Sea. In coastal areas, cyanobacteria occurred in the Archipelago Sea, Gulf of Finland, Bothnian Sea and the Quark.

In September 2019, also a strong bioluminescent bloom of *Alexandrium ostenfeldii* with ca. 30×10^3 cells L^{-1} was observed at a previously known bloom site of the species in a shallow, eutrophic inner bay in SW Finland. No HAEDAT events were recorded, as the cyanobacterial bloom situation was typical for the area, and the *A. ostenfeldii* bloom did not cause any known negative effects or management actions.

France: National Report 2017–2019

Maud Lemoine, IFREMER, France

Data for this national report comes from two distinct programmes monitoring phytoplankton in coastal waters and toxins in shellfish from harvested areas or from fishing zones:

- REPHY: French observation and surveillance network for Phytoplankton and Hydrology in coastal waters (3 components: Research, WFD/MSFD Monitoring and health risk monitoring). 187 Sampling stations were sampled. DOI: 10.17882/47248
- REPHYTOX: French monitoring network for Biotoxins in marine shellfish. 241 sampling stations were sampled. DOI: 10.17882/47251

During the past three years, different toxin syndromes were reported. The number of samples analysed is presented in Table 1.

Table 1. Number of samples and of group of toxin analysis

	Number of shell-fish samples	Toxins analysis		
		DST	PST	AST
2017	1517	1555 Including 107 > RT*	485 Including 13 > RT*	672 Including 46 > RT*
2018	2040	1944 Including 209 > RT*	588 Including 0 > RT*	693 Including 31 > RT*
2019	2108	2055 Including 244 > RT*	711 Including 0 > RT*	793 Including 26 > RT*

*RT = regulatory threshold

DSTs

Dinophysis cells (several species) were observed along a large part of the French coast in the past three years. The highest concentration was recorded in Normandy, with up to 60,200 cells L^{-1} in Seine estuary (Antifer) in 2018 (Figure 1). In 2018, the occurrence of *Dinophysis* started earlier and lasted longer than in previous years.

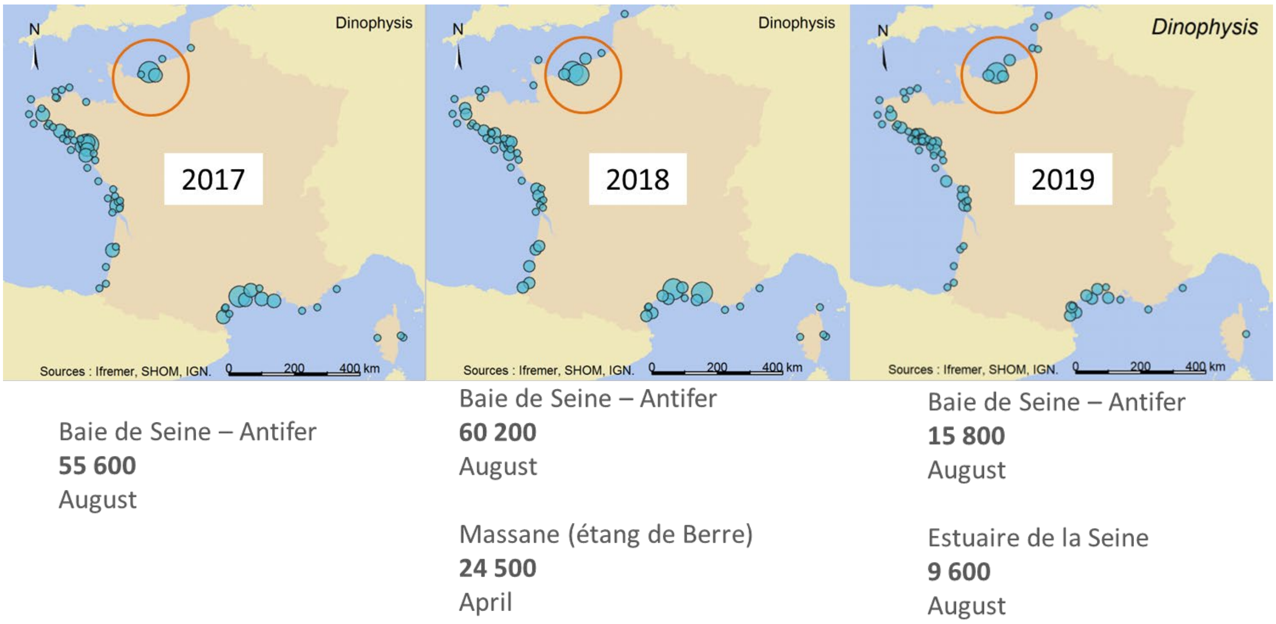


Figure 1. Highest concentrations (cell L^{-1}) of *Dinophysis* in 2017, 2018 and 2019 on the French coasts. The red circles are the highest concentration.

Toxic episodes with toxin results above the regulatory threshold (160 µg $kg^{-1}$for the group of OA+DTXs+PTXs), resulting in shellfish closures were observed mainly along South Brittany, on the Atlantic coast during the past three years, affecting especially mussels and *Donax* (Figure 2). A very few other sites were affected, in the Channel (mussels and scallops), and in Mediterranean (mussels, oysters and *Donax*). The highest toxin concentrations were observed in 2018 in mussels (*Mytilus edulis*) of the bay of Seine (Normandy) with 4423 µg kg^{-1}. In 2018 *Donax* (*Donax trunculus*) of Douarnenez bay were also affected with 2892 µg kg^{-1}.

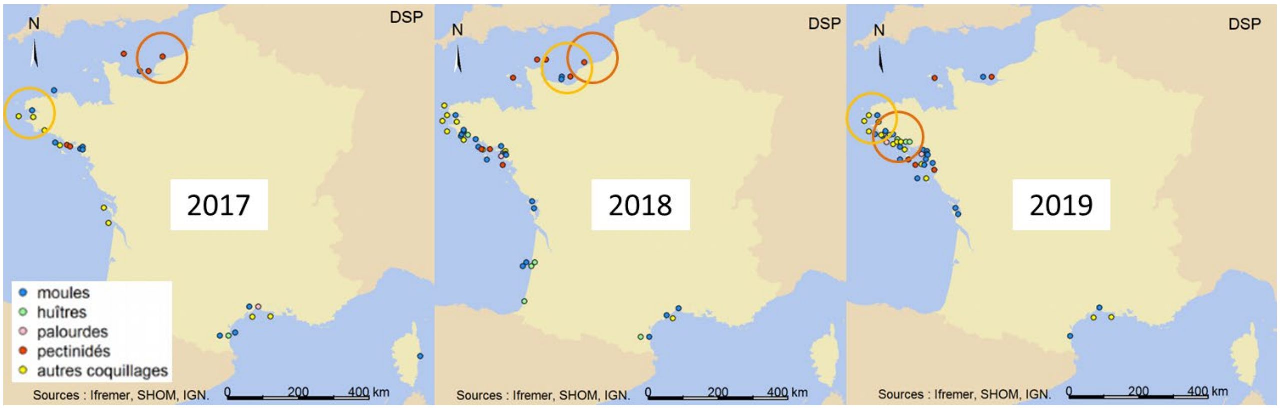


Figure 2. Occurrence of DSTs above the regulatory threshold in shellfish in harvesting area. Circles are the highest concentration (red>orange) in µg kg^{-1}.

Table2. Maximum concentration of DST measured in 2017-2018-2019

	Maximum concentration OA+DTXs+PTXs	Shellfish
2017	3634 µg kg^{-1}	Mussels
2018	4423 µg kg^{-1}	Mussels
2019	1980 µg kg^{-1}	Mussels

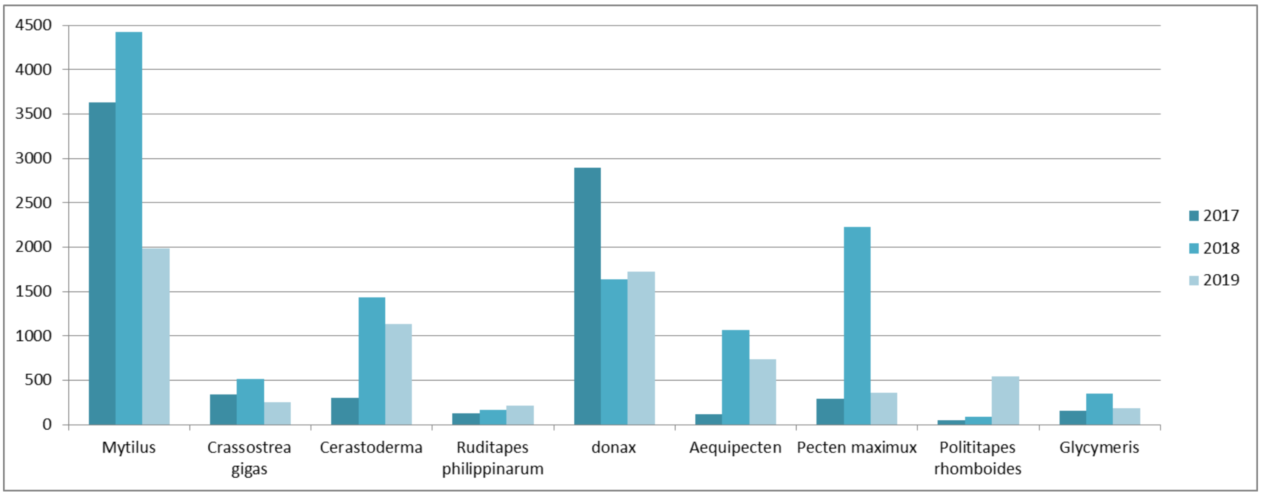


Figure 3. DST concentrations (µg kg^{-1}) in different shellfish in 2017, 2018 and 2019.

All results for Azaspiracids and Yessotoxins, if detected, were below the European regulatory threshold: 0.053 mg kg^{-1} AZAs in mussels in 2017 and 1.72 mg kg^{-1} YTXs in mussels in 2018.

PSTs

Alexandrium was observed with a maximum concentration of 705,900 cell L^{-1}in a Mediterranean lagoon in 2017. No toxic episode was recorded and no toxin was detected in 2018 and 2019

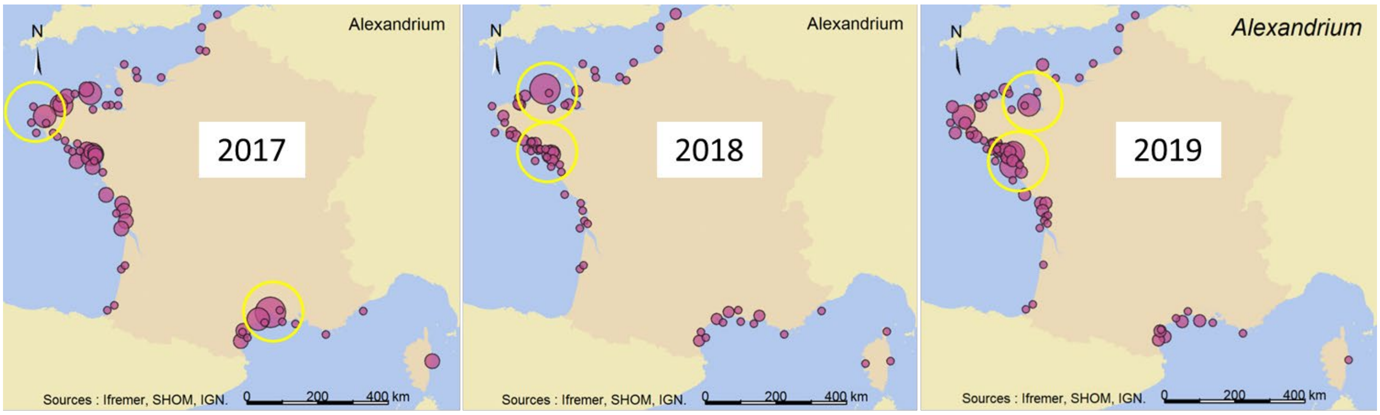


Figure 4. Highest concentrations (cell L^{-1}) of *Alexandrium* in 2017, 2018 and 2019 on the French coasts. The yellow circles are the highest concentration in cells $^{-1}$.

Figure 5. Occurrence of PST above the regulatory threshold in shellfish in harvesting area. The yellow circle shows the location of the site with the highest concentration of toxins.

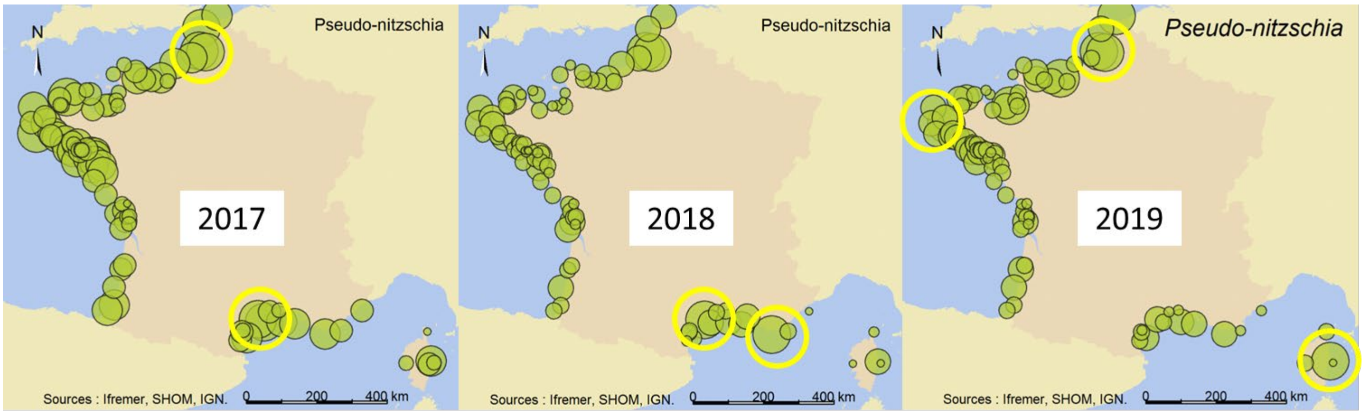
Table3. Maximum concentration of PST measured in 2017-2018-2019.

	Maximum concentration PST	Shellfish
2017	3169 µg kg^{-1}	Mussels
2018	-	-
2019	-	-

ASTs

Several species of *Pseudo-nitzschia* were observed along the whole French coast at high concentrations during spring. The highest cell density was recorded in 2017 with 11 900 000 cells L^{-1} in bay of Somme (North of France). High concentrations were also observed in 2017 in a Mediterranean lagoon with 11 000 000 cells L^{-1} and in 2019 in the bay of Douarnenez (West Brittany) with 10 600 000 cells L^{-1}.

Toxic episodes, with toxin results above the regulatory threshold (20 mg kg^{-1}), were observed in Western Brittany only, affecting mainly *Pecten maximus*. The highest toxin concentration was observed in scallops (*Pecten maximus*) in the bay of Brest with almost 400 mg kg^{-1}.



Baie de Somme
11 901 911
May

Côte Languedocienne
11 000 800
October

Lazaret
2 875 000
October

Bouzigues
1 240 000
May

Baie de Douarnenez
10 600 000
May

Baie de Somme
7 012 000
May

Diana lagoon
4 340 000
November

Figure 6. Highest concentrations (cell L^{-1}) of *Pseudo-nitzschia* in 2017, 2018 and 2019 on the French coasts. . The yellow circles how the location of the sites with the highest *Pseudo-nitzschia* cell densities.

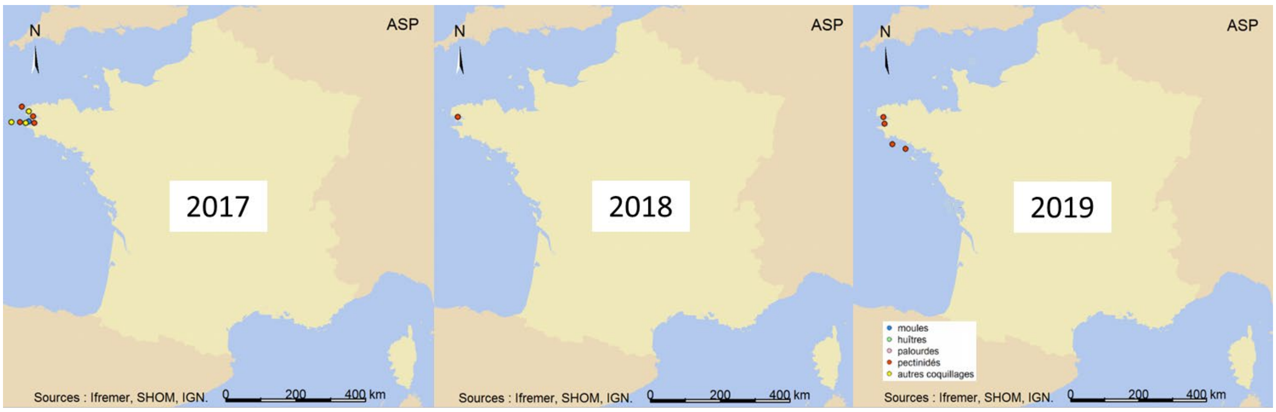


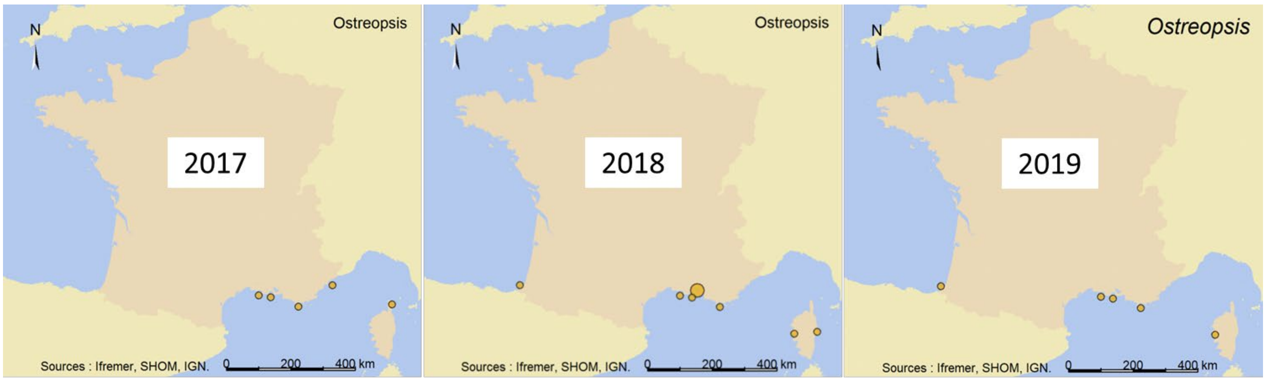
Figure 7. Occurrence of AST above the regulatory threshold in shellfish in harvesting area.

Table 4. Maximum concentration of AST measured in 2017-2018-2019

	Maximum concentration AST	Shellfish
2017	399,6 mg kg^{-1}	*Pecten maximus*
2018	290,1 mg kg $^{-1}$	*Pecten maximus*
2019	87,2 mg kg $^{-1}$	*Pecten maximus*

Other species

Ostreopsis was observed in very low concentrations, with 1200 cells L^{-1}. No palytoxins analysis was performed.



Mediterranean
100

Etang de Berre
1 200
March

Pays Basque
50
May

Mediterranean
100
May

Figure 8. Highest concentrations (cells L^{-1}) of *Ostreopsis* in 2017, 2018 and 2019 on the French coasts.

Ireland: National Report 2017–2019

Dave Clarke, Marine Institute, Ireland

In Ireland, the National Monitoring Programmes (NMP) for the quantification of marine biotoxins and toxigenic/harmful algal bloom (HAB) phytoplankton species identification and enumeration, are conducted by the Marine Institute laboratories, under the auspices of the Irish competent authorities, Food Safety Authority of Ireland and Sea Fisheries Protection Authority. All results of these NMPs are published on the Marine Institute's HABs website; http://webapps.marine.ie/habs

The following tables detail the closures of production areas per annum per toxin group with the concentration observed:

2017 Closure Table by Production Area, Toxin Concentration and Toxin Group

	Apr				May					Jun				Jul					Aug				Sep				Oct		
SouthWest	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Ardgroom					20.9																								
Gouleencoush					33.4																								
Kilmakilloge					42																								
Castletownbere									0.36	0.59			0.31	0.39															
Snave									0.16	0.26						0.19			0.21										
South Chapel										0.2		0.18								0.16									
North Chapel										0.17		0.18									0.18								
Tahilla											0.3	0.18	0.26	0.2	0.4														
West																													
Mweeloon Bay						28.9																							
Kinvarra						37.3																							
Aughinish						75.3																							
Island eddy						54																							
Killeenaran					70.6	22.6																							
Killary Harbour Outer																0.32		0.34	0.27	0.23									
Killary Harbour Middle																				0.24									
South																													
North Channel													1174																
Youghal Bay															0.32														
Closed - ASP µg/g																													
Closed - DSP µg/g																													
Closed - AZP µg/g																													
Closed - PSP µg/kg																													

2018 Closure Table by Production Area, Toxin Concentration and Toxin Group

	Mar				Apr					May				Jun				Jul					Aug				Sep				Oct				Nov		
SouthWest	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	44	45	46	47
Adrigole					35	42										0.3																					
Castletownbere						40					0.2			0.3	0.3		0.2				0.4	0.3	0.8		0.2	1.3	0.32	0.49		0.41		0.33	0.23				
Beare Island														0.2					0.2		0.2					0.2				0.29							
Newtown					22									0.6																							
North Chapel					34									0.3	0.4		0.2	0.5																			
Snave						29								0.2		0.5		0.4			0.3																
South Chapel					22									0.3	0.7		0.2	0.4																			
Tahilla																0.2							0.4														
Cleandra																											0.19										
Cromane East																																0.37	0.52	0.20			
Banc Fluich																																	0.32	0.18	0.17		
South																																					
Youghal Bay																				0.2																	
West																																					
Killary Harbour Inner																							0.2	0.2	0.2												
																							0.2														
Killary Harbour Middle																							0.3	0.7	0.3	0.2											
																							0.3														
Killary Harbour Outer																							0.3	0.8	0.7	0.2		0.21			0.21		0.27				
																							0.3		0.2						0.20		0.34				
NorthWest																																					
Mountcharles																																				0.16	
Closed - ASP µg/g																																					
Closed - DSP µg/g																																					
Closed - AZP µg/g																																					

2019 Closure Table by Production Area, Toxin Concentration and Toxin Group

		Apr					May				Jun				Jul					Aug				Sept					Oct	
SouthWest	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Adrigole			58.7									0.35								1.64						0.31				
Castletownbere			33	43.2						0.18	0.27	0.72	0.77	0.61	0.42	1.89	1.39		1.55	0.16		1.07		0.49	0.24			0.18		0.18
Glengarriff			99.5							0.26		0.78																		
Newtown			52.1							0.24		0.61	0.58	0.49	0.44	0.79			0.69	0.62	0.38	0.35	0.24	0.17						
North Chapel			62.9							0.37	0.16	0.28	0.5	0.44	0.57	0.65			0.92	0.46	0.46	0.48		0.24						
Snave			49	29.1					0.16	0.56	0.24	0.49			0.58								0.38	0.19						
South Chapel			81.8							0.31		0.42	0.34	0.41	0.43	0.52				0.43	0.28	0.23	0.29	0.3	0.16					
Tahilla											0.21	0.41	0.35	0.7	0.71	0.4	1.22	0.72		1.05	0.65	0.48	0.57	0.44	0.19	0.27				
Beare Island			53.5	68.3								0.18			0.33	0.86			1.9			1.03		0.65	0.41	0.48		0.25		
Cleandra			58.6	83.9												0.86	2.61		3.21					0.38						
Cromane East																				0.27	0.39	0.36								
Banc Fluich													952							0.18	0.35	0.36	0.16							
Ardgroom			40.9	60.4														0.27	0.19	0.21	0.59	0.31	0.29	0.21						
Kilmakilloge			41.1	161											0.18	0.2		0.66	0.28	0.68	0.54	0.28	0.3	0.2						
Gouleencoush			62.5																											
Dunmanus Inner				20										0.22																
Roaringwater Bay																		0.29	0.19											
Whiddy Point																							0.3							
West																														
Killary Harbour Inner												0.16																		
Killary Harbour Middle																			0.17											
Killary Harbour Outer												0.2	0.24	0.33	0.26		0.28	0.28	0.29	0.56	0.28	0.22	0.17							
Killala Bay				0.16																										
Corraun				0.19												0.17														
Ballynakill																														
NorthWest																														
Mountcharles																							0.18							
South																														
North Channel													1080																	
Youghal																		0.28												

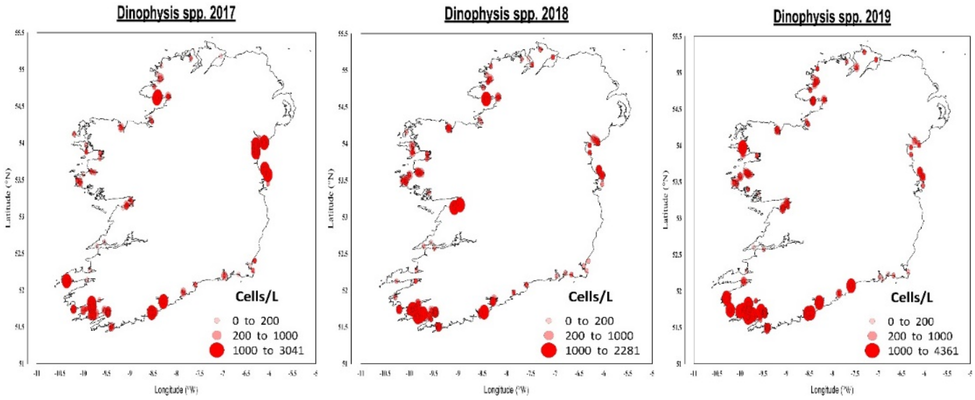
Closed - DSP µg/g
Closed - AZP µg/g
Closed - ASP mg/kg
Closed - PSP µgSTXdiHC

The following table details the maximum concentrations observed per toxin group per species reported annually from 2017 – 2019. The values in red denote concentrations above regulatory levels as laid down in EU 853/2004.

Highest Concentration reported for each Toxin Group per Shellfish Species 2017 -2019

	DSTs µg/g			AZTs µg/g			ASTs mg/kg			PSTs µg STX diHCL equiv. /Kg		
	2017	2018	2019	2017	2018	2019	2017	2018	2019	2017	2018	2019
M.edulis	0.59	1.32	3.21	0.34	0.52	0.08	48.7	42.4	161.3	1174	565	1080
S. solida	0.32	0.19	0.28	0.03	0.03	0.03	54	<LOD	2	N.D.	-	N.D.
C.gigas	0.12	0.14	0.16	0.11	0.13	0.19	75.3	12.7	12.1	221	194	194
O.edulis	<LOD	0.02	<LOD	0.03	0.1	0.02	<LOD	1.5	<LOQ	-	-	<LOQ
C. edule	0.04	0.09	0.12	0.07	0.04	0.06	1.3	<LOD	<LOQ	N.D.	N.D.	50
Ensis spp.	<LOQ	0.06	0.08	0.02	0.01	0.02	1.4	<LOQ	1.3	N.D.	N.D.	N.D.

Diarhettic Shellfish Toxins (DSTs)



2017 – 2,276 samples were analysed for the NMP for DST's, of which 25 (1.1%) were observed to be above regulatory levels. Closures of *M. edulis* production areas in the Southwest (Bantry & Kenmare) were observed from June to August, where the highest concentration observed in 2017 was 0.59µg/g (590µg/kg). Closure of *M. edulis* production areas were also observed in the West (Killary Harbour) during the month of August, and also a short closure period was observed in the South (Youghal) in July for the harvesting of *S. solida*.

Highest *D. acuta* cell count 2,560 cells/l off South coast, and for *D. acuminata* 3,040 cells/l in the Southwest.

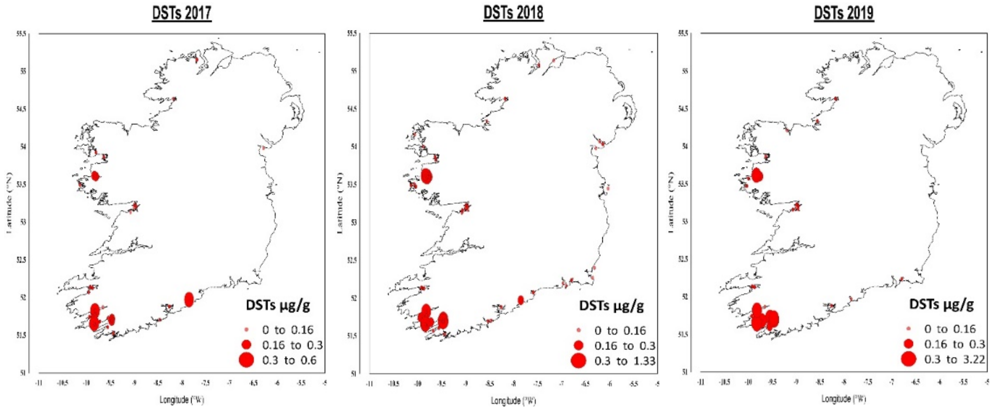
2018 – 2,784 samples were analysed for the NMP for DST's, of which 52 (1.9%) were observed to be above regulatory levels. Closures of *M. edulis* production areas in the Southwest (Bantry & Kenmare) were observed from June to October, where the highest concentration observed in 2018 was 1.32µg/g (1320µg/kg). Closure of *M. edulis* production areas were also observed in the West (Killary Harbour) during the months of August to October, and also a short closure period was observed in the South (Youghal) in July for the harvesting of *S. solida*.

Highest *D. acuta* cell count 2,280 cells/l off Southwest coast, and for *D. acuminata* 1,840 cells/l in the Northwest.

2019 – 2,507 samples were analysed for the NMP for DST's, of which 134 (5.3%) were observed to be above regulatory levels. Closures of *M. edulis* production areas in the Southwest (Bantry, Dunmanus, Roaringwater, Castlemaine & Kenmare bays) were observed from end of May to October, where the highest concentration observed in 2019 was 3.21µg/g (3210µg/kg). Additionally in Bantry Bay, there was a short closure period observed for *C. gigas* which was at the regulatory level (0.16µg/g (160µg/kg).

Closure of *M. edulis* production areas were also observed in the West (Killary Harbour, Ballynakill) during the months of June to August, and also short closures period were observed in the South (Youghal) in July for the harvesting of *S. solida*, and the Northwest (Donegal harbour) in August for the harvesting of *M. edulis*.

Highest *D. acuta* cell count 4,360 cells/l off Southwest coast, and for *D. acuminata* 2,760 cells/l in the Southwest.



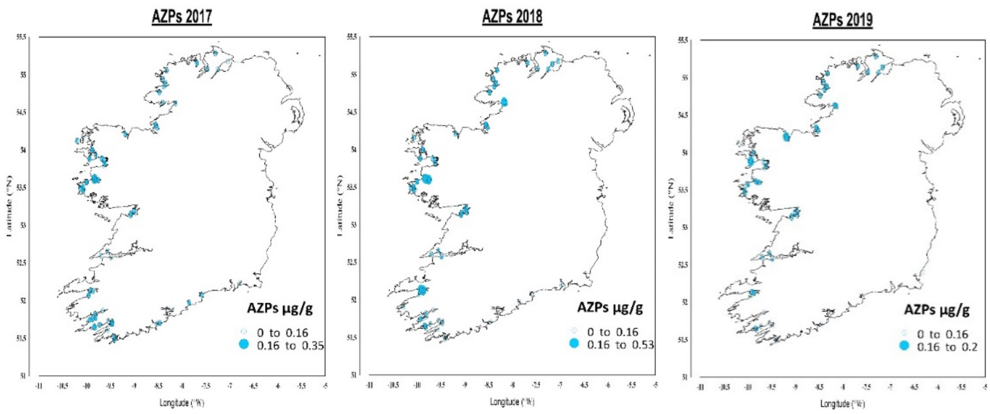
Azaspiracids (AZPs)

2017 – 2,275 samples were analysed for the NMP for AZP's, of which 4 (0.2%) were observed to be above regulatory levels**.** Closures of *M. edulis* production areas in the West (Killary harbour) were observed from July to August, where the highest concentration observed in 2017 was 0.34µg/g (340µg/kg). Quantifiable concentrations below regulatory levels were observed in other production areas and species in the Northwest, West and Southwest from June to October.

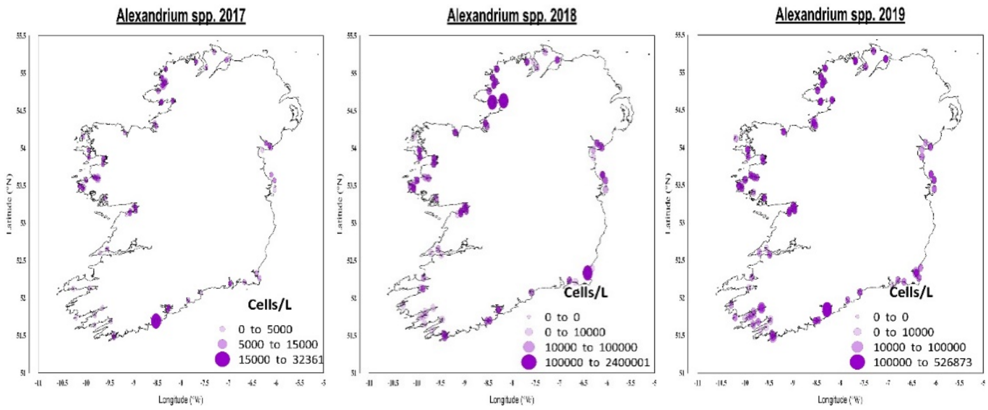
2018 – 2,784 samples were analysed for the NMP for AZP's, of which 13 (0.5%) were observed to be above regulatory levels**.** Closures of *M. edulis* production areas in the West (Killary harbour) were observed in August and October, where the highest concentration observed in the West in 2018 was 0.34µg/g (340µg/kg).

Additionally, closures of *M. edulis* production areas in the Southwest (Castlemaine harbour) were observed in October to November, where the highest concentration observed in the Southwest in 2018 was 0.52µg/g (520µg/kg). Also in November a *M. edulis* sample was observed to be at the regulatory level (0.16µg/g (160µg/kg)) in the Northwest (Donegal harbour).

2019 – 2,509 samples were analysed for the NMP for AZP's, of which 2 (0.1%) were observed to be above regulatory levels**.** Closures of *C. gigas* production areas in the West (Killala and Achill South) were observed for a one-week period in April, where the highest concentration observed in 2019 was 0.19µg/g (190µg/kg). Quantifiable concentrations below regulatory levels were observed in other production areas and species in the Northwest, and West from Jan to May, and also July to August. Moderate AZP concentrations in samples of *Venerupis corrugata* were also observed throughout the year in one production area in the West.



Paralytic Shellfish Toxins (PSTs)



2017 – 234 samples were analysed for the NMP for PST's in 2017, of which 1 sample (0.4%) (0.4%) was observed to be above regulatory levels**.** This was observed in a sample of *M. edulis* from the South (Cork harbour) during the end of June 2017 for a 1-week period, where the highest concentration for 2017 was observed at 1174 µg STXdiHCl equivalents/Kg. Quantifiable PSTs' concentrations in Cork harbour were observed to be increasing at the beginning of June in both *M. edulis* and C. *gigas* samples, reaching maximum concentrations at the end of June and decreasing to low concentrations throughout July to November. The highest PST concentration observed in *C. gigas* from Cork harbour was 221 µg STXdiHCl equivalents/Kg.

In the adjacent production areas to Cork harbour, extremely low PST concentrations were observed in samples of *C. gigas* from Oysterhaven and Kinsale Bridge analysed from July to September. An extremely low PST concentration was also observed in a sample of *M. edulis* from the Northwest (Donegal harbour) in May 2017.

Highest *Alexandrium spp.* cell count 32,360 cells/L off the South coast in August 2017.

2018 - 255 samples were analysed for the NMP for PST's in 2018, of which no samples were observed to be above regulatory levels**.** Quantifiable PST's concentrations in Cork harbour were observed to be increasing at the end of May in both *M. edulis* and C. *gigas* samples. For *M. edulis*, maximum PST concentrations were reached by early June and observed to be decreasing to low concentrations throughout June to October. For *C. gigas* samples, PST concentrations were observed to be at low concentrations from June to August, and increased to peak concentrations in September. The highest PST concentrations observed in *C. gigas* from Cork harbour was 194 µg STXdiHCl equivalents/Kg, and for *M. edulis*, also from Cork harbour, was 565 µg STXdiHCl equivalents/Kg.

In the adjacent production areas to Cork harbour, extremely low PST concentrations were observed in samples of *C. gigas* from Oysterhaven and Kinsale Bridge analysed from June to September. Extremely low PST concentration was also observed in samples of *M. edulis* from the West (Killary harbour) and also the Southwest (Bantry) in October 2018.

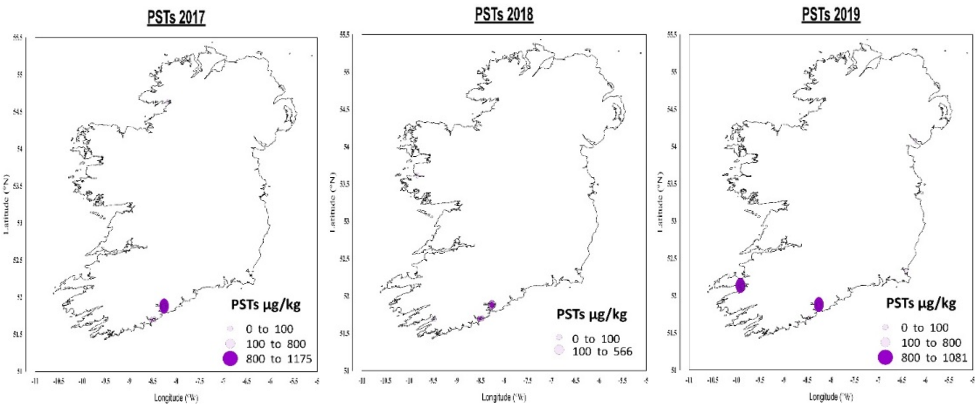
Highest *Alexandrium spp.* cell count 2,400,000 cells/L off the Northwest coast in May 2018.

2019 - 290 samples were analysed for the NMP for PST's in 2019, of which 1 sample (0.3%) was observed to be above regulatory levels**.** For the first time since PSP monitoring commenced in the 1990's in Ireland, PST's were reported above regulatory levels outside of Cork harbour (South coast), which, up until 2019, was the only production area to regularly record a near annual occurrence of PST's in *M. edulis* samples above regulatory levels. The production area, Castlemaine harbour, Southwest, reported quantifiable PST concentrations from June 2019 in samples of *M. edulis, C. gigas, C. edule*, reaching a peak concentration above regulatory levels of 952 µg

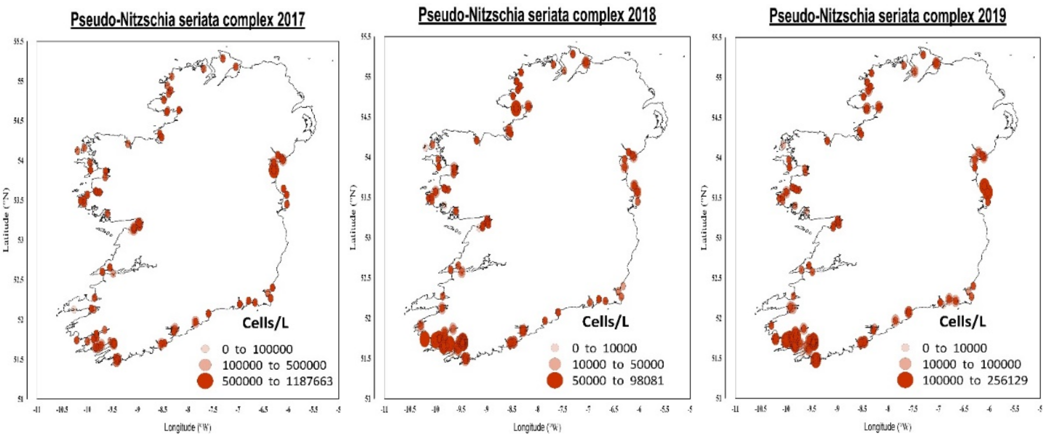
STXdiHCl equivalents/Kg in *M. edulis* in mid-July for a one-week period. Though below regulatory levels, the highest PST concentrations in *C. gigas* was 86 µg STXdiHCl equivalents/Kg, and for *C. edule* was 50 µg STXdiHCl equivalents/Kg.

Elsewhere, in the South (Cork Harbour), PST concentrations above regulatory levels were observed in mid-June in a sample of *M. edulis* for one week, at 1080 µg STXdiHCl equivalents/Kg. Though below regulatory levels, quantifiable PST concentrations were also observed in samples of *C. gigas*, highest concentration recorded was in mid-June 2019 at 194 µg STXdiHCl equivalents/Kg.

Highest *Alexandrium spp.* cell count 526,872 cells/L off the South coast at the end of June 2019.



Amnesic Shellfish Toxins (ASTs)



2017 – 2,107 samples (excluding scallops - *P. maximus*) were analysed for the NMP for ASTs in 2017, of which 10 samples (4.7%) were observed to be above regulatory levels. Closures of *M. edulis* production areas occurred for a one-week period in early May in the Southwest (Kenmare bay) where the highest observed AST concentration was 33.4 mg/kg. Also in early May, closures of production areas in the West (Clarinbridge, Aughinish, Kinvarra and Mweeloon) for a one-week period in the West also occurred, where the highest observed concentrations were; *C. gigas* 75.3 mg/kg, *M. edulis* 48.7 mg/kg, and *S. solida* 54 mg/kg.

From April to July, low quantifiable AST concentrations below regulatory levels were observed in South, Southwest, West and East in samples of *M. edulis, C. gigas, S. solida,* and *Ensis* spp.

Highest *Pseudo-nitzschia seriata* complex cell count was 1,187,662 cells/L off the East coast in June 2017.

2018 – 2,691 samples (excluding scallops - *P. maximus*) were analysed for the NMP for ASTs in 2018, of which 7 samples (2.6%) were observed to be above regulatory levels. Closures of *M. edulis* production areas occurred for a one-week period in early April in the Southwest (Kenmare & Bantry bay) where the highest observed AST concentration was 42.4 mg/kg.

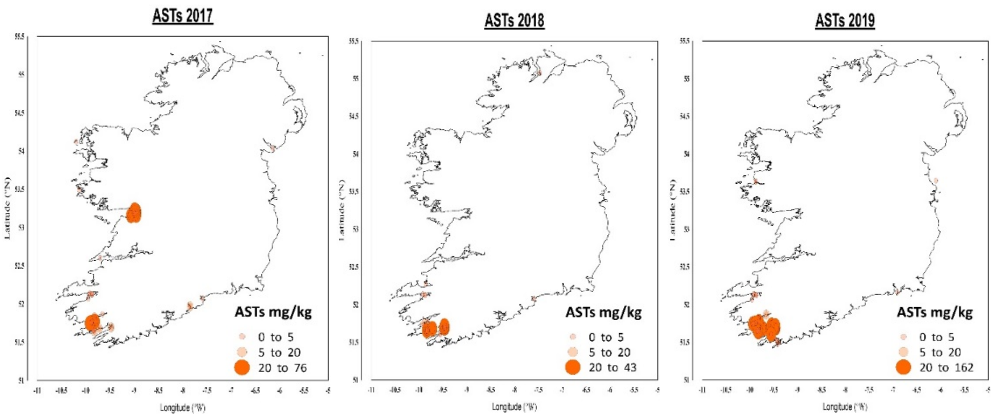
From March to May, low quantifiable AST concentrations below regulatory levels were observed in Southwest (*M. edulis* & *C. gigas*), and additionally in September in the South (*C. gigas*) and in *O. edulis* samples from North West and West.

Highest *Pseudo-nitzschia seriata* complex cell count was 98,080 cells/L off the Southwest coast in early April 2018.

2019 – 2,522 samples (excluding scallops - *P. maximus*) were analysed for the NMP for ASTs in 2019, of which 7 samples (2.6%) were observed to be above regulatory levels. Closures of *M. edulis* production areas occurred for a two-week period in early to mid-April in the Southwest (Kenmare, Dunmanus & Bantry bay) where the highest observed AST concentration was 161.3 mg/kg.

From May to June, low quantifiable AST concentrations below regulatory levels were observed in West (*Ensis* spp., *M. edulis* and *C. gigas*), South (*S. solida*).

Highest *Pseudo-nitzschia seriata* complex cell count was 256,128 cells/L off the Southwest coast in early April 2019.



Pectenotoxins (PTXs)

During 2017–2019, 7,226 samples were analysed for the presence of PTX's, all were below regulatory levels where 7,209 samples were <LOD. The highest quantifiable concentrations observed during this three-year period was in July to August 2019, in samples of *M. edulis* from the Southwest (maximum concentration was 0.07µg/g (70 µg/kg)).

Yessotoxins (YTXs)

During 2017–2019, 5,810 samples were analysed for the presence of YTX's, all were below regulatory levels where all samples were <LOD (n=5,808) or <LOQ (n=2). Where no quantifiable concentrations were observed during this three-year period.

Norway: National Report 2017–2019

Lars-Johan Naustvoll, IMR, Norway

National monitoring program – shellfish toxicity

Along the Norwegian coast approximately 38 stations, spread along the whole coastline, have been monitored annually from 2017 - 2019. The stations have been sampled for quantitate analysis of phytoplankton weekly from week 10 to 40 (March to October), except for routine stations that are monitored all year. The Institute of Marine Research is responsible for the phytoplankton monitoring program. In addition, blue mussels' (*Mytilus edulis*) are sampled monthly at each station for toxin analyses and bi-weekly at selected routine stations, analyzed by Norwegian University of Life Sciences. The monitoring program is directed by the Norwegian Food Safety Authority and is the basis for weekly advice regarding toxin accumulation and ban of mussel harvesting in various areas along the coast (https://www.matportalen.no/verktoy/blaskjellvarsel/). The program mainly focuses on blue mussels (*Mytilus edulis*), but at some stations scallops and oysters have been included.

Shellfish toxicity

Historically the main problem in Norwegian waters has been accumulation of DST (Diarrhetic Shellfish Toxins). The main producer of DST in Norwegian waters is *Dinophysis acuta*, however other species within the genus *Dinophysis* produce DST and has been associated with DST accumulation in mussels. DST has been mostly a problem along the Norwegian Skagerrak coast and the west coast of Norway. There was a marked change in the DST problem at the Skagerrak coast around 2002, with a decline in abundance of *D. acuta,* DST accumulation in mussels and closures (Naustvoll *et al.* 2012). The other main group of toxins accumulating in blue mussel is PST (Paralytic Shellfish Toxins). In Norwegian waters *Alexandrium* spp is the producer of PST. Over time, the main problem area of PST has been from the mid-Norway and north along the coast.

The period 2017-2019.

The numbers of weeks with shellfish harvest closures for the different main toxin groups are given in Table 1. The number of weeks with closures due to DST was the same in 2017 and 2019, while there were significantly less problems with DST in 2018. The same pattern was observed for PST. For AST there were closures for harvesting scallops in 2018, and a short closure of mussel harvesting in 2017. Closure due to AZA is more sporadic in Norwegian waters, with closures in 2017 and 2019.

Table 1. Summarizing the numbers of week closed for harvesting in the years 2017,2018, and 2019 for the different to toxins groups. Summarized for the Norwegian coastline, based on the National monitoring program for phytoplankton toxins and advice given regarding ban of harvesting.

	DST	PST	AST	AZA
2017	63	136	3	9
2018	34	92	11*	-
2019	63	125	-	2

*Scallops only

<u>*DSTs*</u>

Along the Norwegian coast there are regional differences in the accumulation of phytoplankton toxins and presence of toxin producing algae (Fig. 1-3). Even though there are some period of closure due to DST on the west coast and northern part of Norway, the problem with DST is still mainly for the Skagerrak coast. In 2017 and 2019 there several periods with a ban of harvesting between July and October at the Skagerrak coast. 2019 deviates with having a longer period in the spring and less problems in the autumn. For other part of the coastline the problem with DST is more sporadic.

<u>*PSTs*</u>

PST accumulation and ban due to PSTs is mostly a problem along the west coast and northern part of Norway. In 2019 there were some shorter periods with ban of harvesting due to PST in Skagerrak (Fig 3), but no closures in 2017 and 2018 (Fig 1-2). In all three years there has been closure due to PST at the west coast – mid-Norway in spring (April-May), due to *Alexandrium* spp. In the Northern part of Norway (Nordland and Troms county) *Alexandrium* spp has become more numerous in summer and throughout the autumn (July- September), causing accumulation of PST in blue mussels and closures.

<u>*AZT, AST, and YTXs*</u>

Yessotoxins (YTX) has not be measured in mussels above the regulatory levels in the period 2017-2019. The main producers, *Lingulodinium polyedra*, *Protoceratium reticulatum*, and *Gonyaulax spinifera* are common in Norwegian waters. Azaspiracid shellfish toxins (AZT) accumulation in blue mussels has caused closures in 2017 and 2019, in mid-Norway and Northern Norway, respectively (Fig 1 and 3). The main producer *Azadinium* spp. has been observed along the whole coast, but only sporadically and in low abundance. Amnesic Shellfish Toxins (AST) has not been found above regulatory levels in the period 2017-2019 in blue mussels (*Mytilus edulis*). In 2018 the were a longer closure of harvesting scallops (*Pecten maximus*) in the autumn at the south coast of Norway due to accumulation of AST (Fig 2). The producer of AST, *Pseudo-nitzschia* spp, are observed along the whole Norwegian coast.

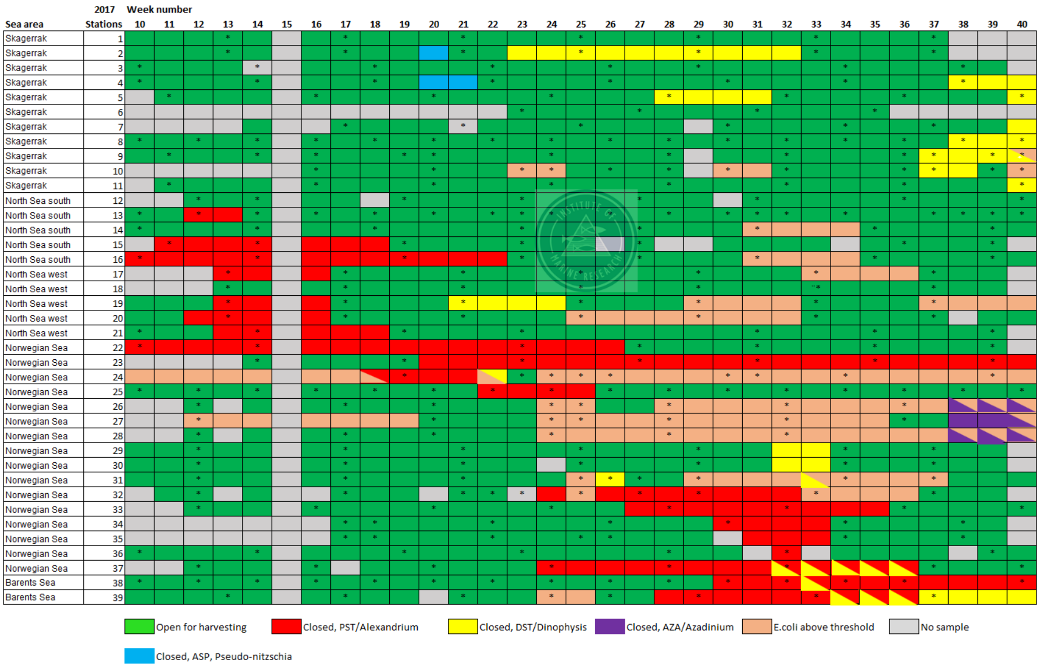


Figure 1. Closure due to accumulation of algae toxins in blue mussel, National monitoring program 2018. Color indicates toxin group; red PST, Yellow DSP, blue ASP, Purple AZA, pink E.Coli, green no regulation.

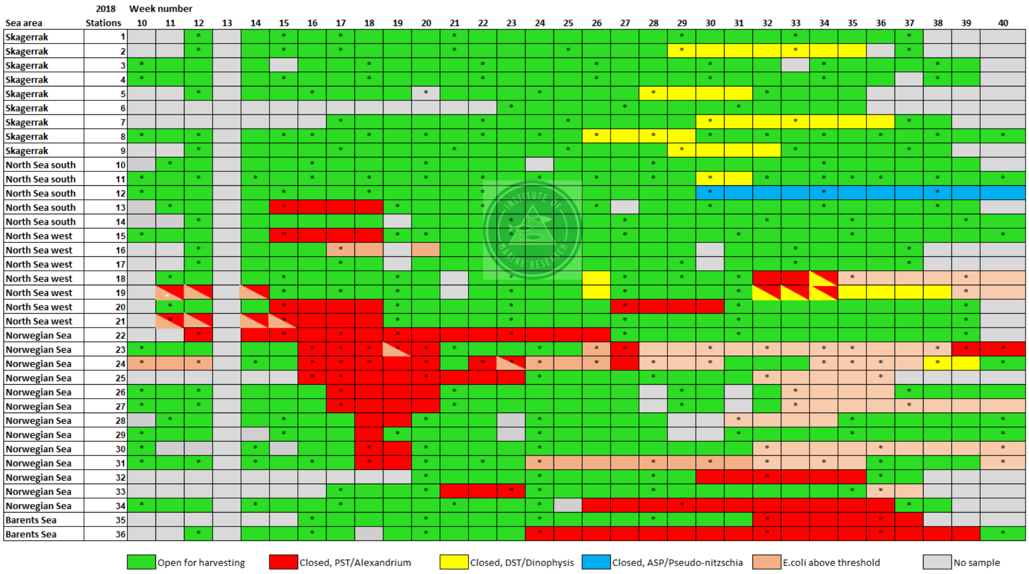


Figure 2. Closure due to accumulation of algae toxins in blue mussel, National monitoring program 2018. Color indicates toxin group; red PST, Yellow DSP, blue ASP, pink E.Coli, green no regulation.

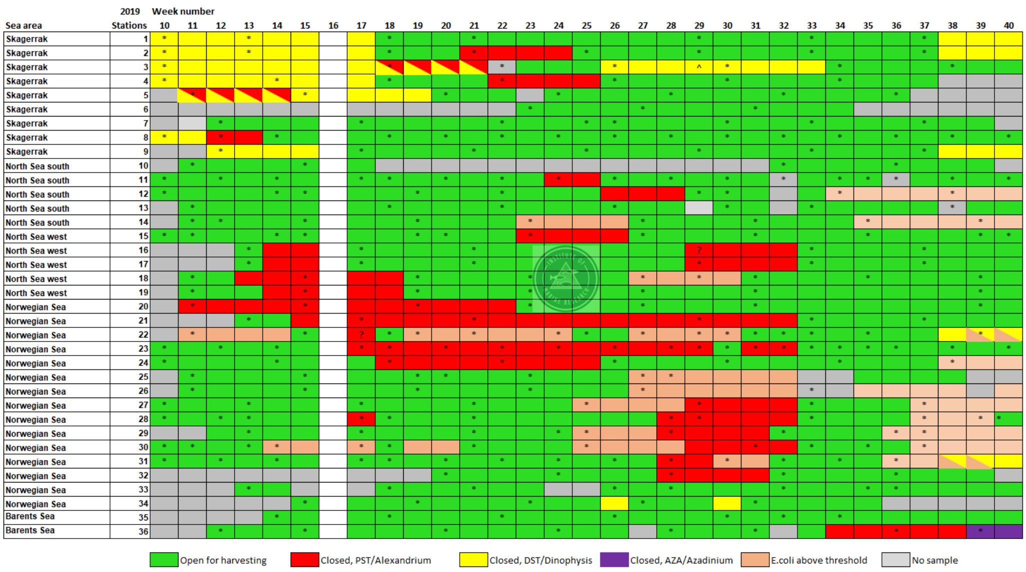


Figure 3. Closure due to accumulation of algae toxins in blue mussel, National monitoring program 2019. Color indicates toxin group; red PST, Yellow DSP, blue ASP, pink E.Coli, green no regulation.

Fish Mortality

Several species have form blooms in Norwegian waters over the years, resulting in mortality of fish (*Salmo salar* mainly) in fish farms along the coast. In the 2017-2019 period there has been documented two cases of fish mortality in Norwegian waters. In the spring (March) 2017 a bloom of *Pseudochattonella* sp. result in mortality at one fish farm at the Norwegian Skagerrak coast. The bloom covered a larger area, from Danish part of Kattegat, along the Swedish west coast, and along the Norwegian Skagerrak coast down to Agder county.

Chrysochromulina leadbeateri bloom. In May 2019 *Chrysochromulina leadbeateri* formed a large bloom in the Northern part of Norway (Fig 4). A large area was affected in the period 10. May to 10. June 2019. The main areas, with observed mortality were in Ofotfjorden, Astadfjorden, Tysfjord, and at one location outside Tromsø. The bloom started in Astadfjord and Ofotfjord around the 10. May, reaching maximum abundance and geographic distribution in the end of May (Fig. 4). In the end of May fish mortality were reported from Atsadfjorden and Ofotfjorden. In the beginning of June there were also report on mortality from Tysfjorden. In the end of May there were observed high concentration of *Chrysochromulina leadbeateri* around Tromsø and in the beginning of june there were reports on mortality in one smaller area outside Tromsø. During the bloom approximately 14 000 tons of caged salmon died. However, there were no report of fish mortality of wild fish during the bloom. There has been estimated an economic loss between 2,3-2,9 billion (NOK, direct and indirect gross) (Marthinussen *et al.* 2019) due to the *Chrysochromulina leadbeateri* 2019 bloom.

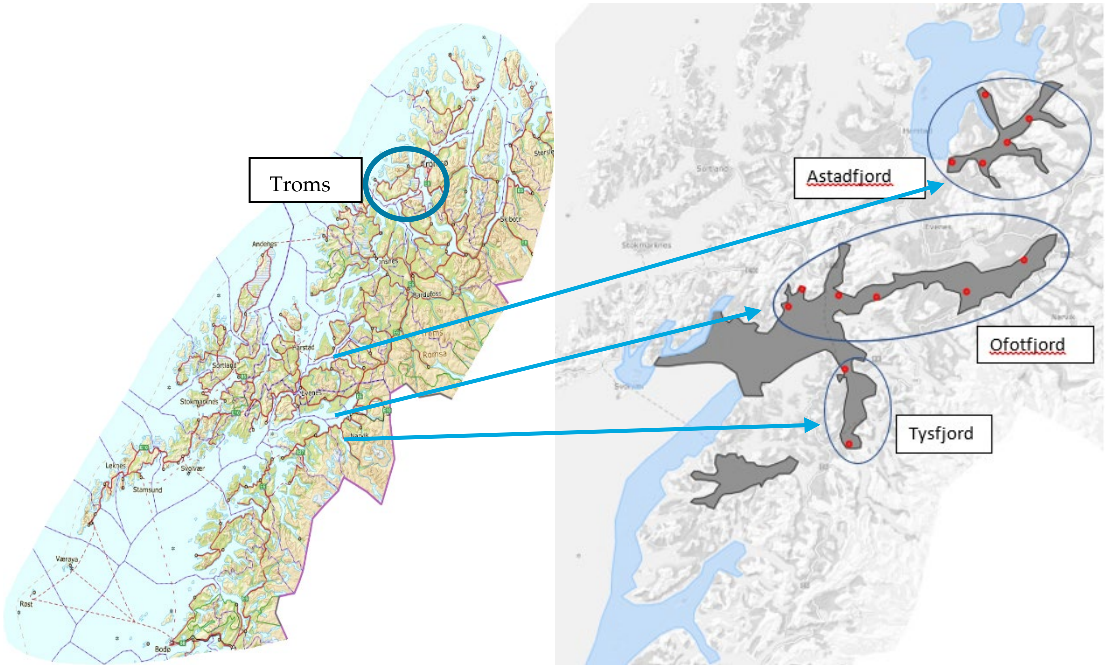


Figure 1. *Chrysochromulina leadbeateri* bloom in 2019. Mapping showing moderate concentration (blue) and high abundance (black) of *Chrysochromulina leadbeateri* duirng the period from 10 May to 10 June 2019. Red dots indicate areas with fish mortality. Redrawn from Cembella *et al.* (in press).

Poland: National Report 2017–2019

Justyna Kobos, Agata Błaszczyk, Hanna Mazur-Marzec

In the Polish coastal zone of the Baltic Sea, there are three HAEDAT areas: PL-01, PL-02 and PL-03. In this area, there are more than 150 beaches that are open during the summer season. The quality of bathing water during the bathing season in Poland is regularly monitored by the bathing water administrator and by the state sanitary inspection. In June and July, when a high biomass of cyanobacteria occurs in coastal waters, the beaches are temporarily closed for swimmers. The decisions are undertaken in line with the regulations included in Bathing Water Directive (2006/7/EC). The list of bathing waters, as well as up-to-date information about their quality can be found on the Chief Sanitary Inspectorate website: https://sk.gis.gov.pl/index.php/strona/content/7

2017

In the summer of 2017, in open and coastal waters of the Gulf of Gdansk (Southern Baltic), the phytoplankton community was characterized by summer (July) dominance of *Nodularia spumigena* Mertens ex Bornet & Flahault (nodularin producer) and *Aphanizomenon flosaquae* Ralfs ex Bornet & Flahault (non-toxic). The presence of *Dolichospermum lemmermannii* (Ricter) P.Wacklin, L.Hoffmann & J.Komárek was also observed. In the coastal waters of the Gulf of Gdańsk, toxic cyanobacteria occurred less frequently and at lower biomass than in previous years. On 20 July, cyanobacteria warnings were issued for eight beaches (PL-1). On 22-24 July, three bathing sites were closed, due to the decreased water transparency. At the turn of July and August, the surface accumulation of cyanobacteria was observed in PL-2 area. The highest biomass of *Nodularia spumigena* (1.38 mg L^{-1}) and the highest concentration of nodularin (1.97 µg mL^{-1}) were recorded on 1 August. *Aphanizomenon flosaquae* (0.98 mg L^{-1}) and *Dolichospermum* spp. (0.2 mg L^{-1}) were also present.

This year, the occurrence of *Alexandrium ostenfeldii* (Paulsen) Balech & Tangen was not recorded.

2018

In the summer of 2018, the total number of beach closures was 64, with record number of harmful events in PL-01 (28) and PL-02 area (27). This year, the bathing sites were closed for a longer time than in previous years. In PL-01 and PL-02, people had to refrain from bathing for 12 and 14 days respectively. In PL-03, nine bathing sites were closed only for one day.

The first, transient bloom was observed on 11-13 July. It was mainly formed by the long, curled *N. spumigena* morphotype (847 mg L^{-1} of biomass; 97% of total phytoplankton biomass). At that time, the concentration of nodularin (NOD) in coastal waters reached 6,750 µg L^{-1}. During the second peak of cyanobacterial bloom (23 July -3 August), the phytoplankton community was dominated by *N. spumigena* morphotype characterized by long, straight filaments. Then, the concentration of NOD in the coastal zone reached up to 30,000 µg L^{-1}. At the end of the bloom, the contribution of cyanobacteria of the genus *Dolichospermum* significantly increased (to 50% of total phytoplankton biomass), and high concentrations of microcystins (MC-LR 5,040-6,640 µg/L, MC-RR 840 µg/L) were determined.

In 2018, *Alexandrium ostenfeldii* occurred in Puck Bay (inner part of the Gulf of Gdansk) in August. A bioluminescent bloom of *A. ostenfeldii* was observed on 20/21 September 2018 off Osłonino.

2019

In July 2019, along the Polish coast line, *N. spumigena*, *A. flosaquae* and different species of *Dolichospermum* were detected. The bloom of cyanobacteria was not so intense as in 2018. Cyanobacteria appeared in the form of streaks and surface patches floating on the water surface. As a result, the bathing sites were closed and open repeatedly between 15 July and 8 August.

In 2019, the total number of beach closures was 42, mainly in PL-01 (9), and PL-02 area (27). This year, people had to refrain from bathing for 1-6 and 1-7 days, respectively. In PL-03, 6 bathing sites were closed only for one day. The concentration of toxins and the cyanobacterial biomass were analyzed only in samples from area PL-01. The highest biomass of *N. spumigena* (3.6 mg L^{-1}) and the highest concentration of nodularin (390 µg L^{-1}) were recorded on 16 July. In sample collected on that day, *A. flosaquae* (1.1 mg L^{-1}) and *Dolichospermum* spp. (0.03 mg L^{-1}) were present.

Alexandrium ostenfeldii occurred in Puck Bay (inner part of the Gulf of Gdansk) in July and August. The highest cell number (880 cells L^{-1}) of this species was observed on 27 August off Rewa. However, bioluminescence was not observed.

Portugal: National report 2017–2019

A. Silva and M.A. Castelo-Branco, Phytoplankton Laboratory and M.J. Botelho, Marine Biotoxins Laboratory, IPMA

The Portuguese Monitoring of HABs and marine toxins, carried out by IPMA (Portuguese Institute for the Sea and Atmosphere, www.ipma.pt/), covers the whole coast of Portugal except for the Madeira and Açores archipelagos. The sampling grid covers 11 coastal areas (212 stations) and 28 estuaries+coastal lagoons (35 stations). The sampling of water and bivalve species is carried out on a weekly basis: Fifty six samples come from bivalve harvesting areas and phytoplankton retention areas (90% of the stations are coincident for water and bivalve samples and 10% are sentinel stations for HABs initiation). In 2018 the accreditation scope of IPMA was extended to include the counting phytoplankton method (Utermhol) used by the Phytoplankton Laboratory and the chromatographic methodology coupled with mass spectrometry used by the Marine Biotoxins Laboratory to determine the lipophilic toxins of ocadaic acid group (ocadaic acid, DTX1 and DTX2). Accreditation was renewed in 2019.

IPMA is currently improving the communication of HAB warnings and bivalves production area bans to the stakeholders. The information on marine toxins (https://www.ipma.pt/pt/bivalves/index.jsp) and on toxic phytoplankton cells in the water (https://www.ipma.pt/pt/bivalves/fito/index-map-dia-chart.jsp) is now available as soon as monitoring results are obtained. Being tested for dissemination to the public, is trends on the development of cells in the water and the implementation of a semi-automated bulletin. Numerical models and algorithms are being tested, within several research projects, to advance the implementation of an early warning system for HABs and Marine Toxins.

From 2017–2019, the number of toxic events have been slightly increasing irrespective if it is in a coastal area or estuary/lagoon (20017-32, 2018-35, 2019-36) (Fig.1). An event, is a closure and events are merged for a given area if separated by a period of less than two weeks. A closure lasts a minimum of two weeks to nine months depending on the phytoplankton/bivalve species and time of the year. The sentinel bivalve species was *Mytillus spp.* in 90% of the stations.

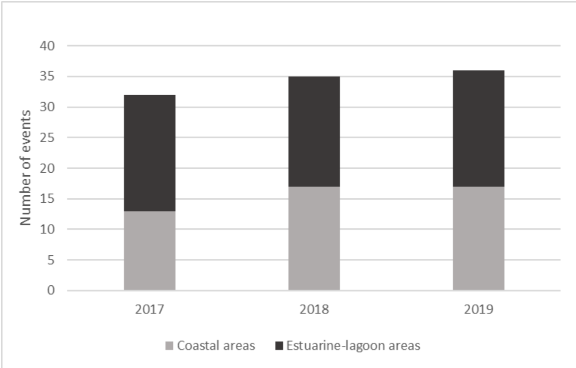


Fig.1. Number of events (2017-2019) in coastal areas and estuaries/lagoons.

From 2017–2019 the number of DST events varied between 24, 27 and 21 respectively and are the most recorded events in Portugal due to recurrent blooms of *D. acuminata* (Fig.2).

AST events varied from absent as in 2018 (besides the occurrence of large blooms of *Pseudo-nitzschia* but from the *delicatissima complex*), to ten in 2019 associated with blooms of *Pseudo-nitzschia seriata* complex. PST events are due to the presence of *Gymnodinium catenatum.*

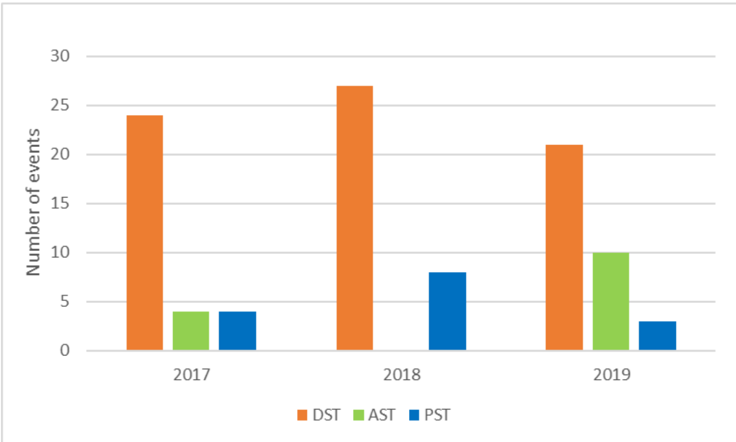


Fig.2. Number of events per type of toxin produced (Diarrheic-, Amnesic- and Paralytic- Shellfish Toxins).

DSTs

Most events started in March-April and persisted until December. The highest concentration of *D. acuminat*a was observed in 2018 with 18,240 cells L^{-1} (221 µg OA equiv. kg^{-1}) on the S coast. This was the dominant species all three years but in 2019, a single event of *D. acuta*, on the NW coast, reached 11 160 cells L^{-1} (550 µg OA equiv. kg^{-1}). Besides these two species of *Dinophysis*, *D. caudata* and *D. acuminata*/*D. ovum* complex are usually observed but in lower concentrations. Thresholds for early-warning (100 cells L^{-1}-200 cells L^{-1}) are under evaluation to better support the sector (without compromising public health): can be adjusted to be species specific and differ according to the coastal configuration and hydrological/productive regimes (increase of the true positives in an early warning context).

PSTs

Events are observed, either in the 1st quater (2017 – January-February), the 4th (2018, October-December) or along the year (2019, February-October). The highest concentration of *G. catenatum* was observed in 2017 with 19040 cells L^{-1} (4155 µg STX equiv. Kg^{-1}) on the NW coast. *G. catenatum* size and morphology can be very compromised with Lugol's iodine preservative making it similar to another non-toxic species that co-occurs (*G. impudicum*). Molecular analysis is a resource when warning thresholds are reached (500 cells L^{-1}).

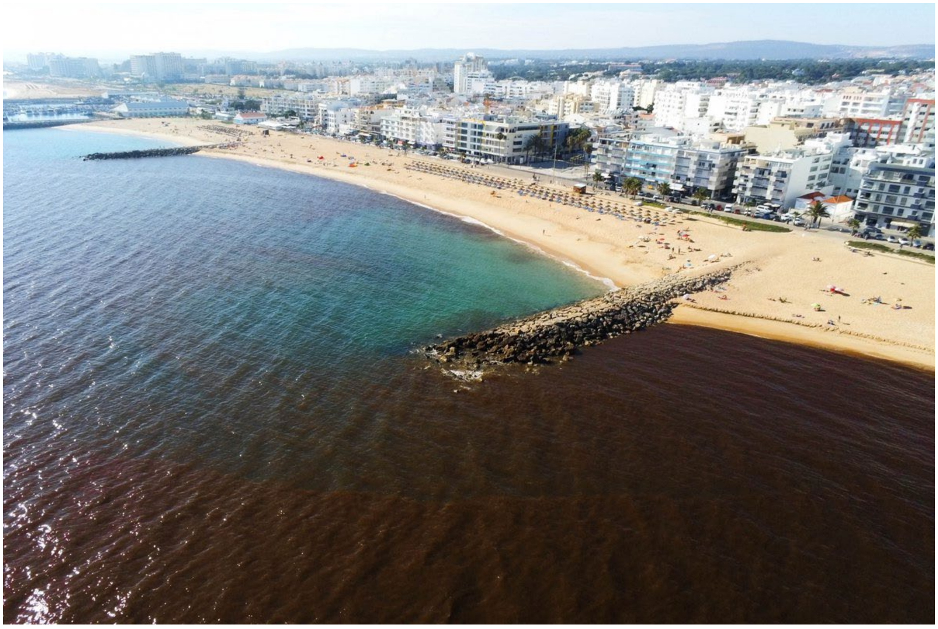
ASTs

Pseudo-nitzschia species are regularly observed in water samples mainly in spring (most in March-April). Events normally last one week but in 2019 they lasted longer, 2-8 weeks. The highest concentration observed was registered in 2019, comprised 399 220 cells L^{-1} of *Pseudo-nitzschia seriata* group (32 mgDA Kg^{-1}). Thresholds for early-warning ($100x10^3$ cells L^{-1}) and closure (200 $x10^3$ cells L^{-1}) are under evaluation to be group specific (*seriata vs delicatissima*) as bans are usually due to *P.nitzschia seriata* group of species. This group can be either distinguished by microscopy, between *Pseudo-nitzschia* (*seriata* group) and (*delicatissima* group) based on cell width, and thought molecular identification. *P.delicatissima* group can be equally or most abundant (increase false positives as no toxic events are registered).

YTXs

A large and persistent bloom of *Lingulodinium polyedra* occurred on the south coast of Portugal. The highest concentration recorded was 662 400 cells/L on June 17th and yessotoxins in bivalves detected almost 15 days later (July 1st until September 2nd) with 0.2mg/YTX/Kg quantified (20x the QL of the method but still far from the legal closure value 3.75mg/YTX/Kg).

Blooms occur almost every year with more or less persistence with no toxic impact on shellfish. Usually impacts are on tourism, bans were preventive due to a "potentially danger to public health".



Red Tide of *Lingulodinium polyedra* in Algarve (June 2019). Image from Tiago Nunes, https://youtu.be/Kq3k1KLy4Rw

Table 1. Spatial and temporal distribution of ban-on-harvesting periods in 2017-2019 (Portugal).

Year	Coast of Portugal	Areas code name	Week nº
2017	NW and Center	PT-01	ASP
		PT-02	ASP
		PT-01	PSP
		PT-02	PSP
		PT-03	PSP
		PT-02	PSP
		PT-01	DSP
		PT-02, PT-03, PT-04	DSP
		PT-01	DSP
		PT-02	DSP
		PT-03	DSP
		PT-03	DSP
	SW	PT-04	ASP
		PT-04	DSP
		PT-04	DSP
		PT-05	DSP
		PT-05	DSP
	S	PT-06	DSP
		PT-06	DSP
		PT-06	DSP
		PT-06, PT-07	DSP
		PT-07	DSP
		PT-07	DSP
		PT-07	DSP
		PT-07	DSP

Year	Coast of Portugal	Areas code name	Type of aquatic system	Syndrome
2018	NW and Center	PT-01	E	DSP
		PT-01	C	DSP
		PT-02	E	DSP
		PT-02, PT-03	C	DSP
		PT-03	E	DSP
		PT-03	E	DSP
	SW	PT-04	C	PSP
		PT-04	E	PSP
		PT-04	E	PSP
		PT-04, PT-05	C	PSP
		PT-05	E	PSP
		PT-05	C	PSP
		PT-04	C	DSP
		PT-04	E	DSP
		PT-04	E	DSP
		PT-05	E	DSP
		PT-05	C	DSP
	S	PT-06	C	PSP
		PT-07	C	PSP
		PT-06	E	DSP
		PT-06	E	DSP
		PT-06	C	DSP
		PT-07	E	DSP
		PT-07	E	DSP
		PT-07	E	DSP
		PT-07	E	DSP
		PT-07	C	DSP

E-estuaries, rias and coastal lagoons; C - coastal

Year	Coast of Portugal	Areas code name	Type of aquatic system	Syndrome
2019	NW and Center	PT-01	C	ASP
		PT-01	E	ASP
		PT-02	E	ASP
		PT-01	C	DSP
		PT-02	C	DSP
		PT-03	E	DSP
		PT-03	C	DSP
		PT-03	E	DSP
	SW	PT-04	E	PSP
		PT-04,PT-05	C	PSP
		PT-04	C	DSP
		PT-04	E	DSP
		PT-04	C	DSP
		PT-04	E	DSP
		PT-05	E	DSP
		PT-05	C	DSP
		PT-05	C	DSP
	S	PT-07	E	YTX
		PT-07	C	YTX
		PT-06	C	ASP
		PT-07	E	ASP
		PT-07	E	ASP
		PT-07	C	ASP
		PT-07	E	ASP
		PT-06	E	DSP
		PT-06	C	DSP
		PT-06, PT-07	C	DSP
		PT-07	E	DSP
		PT-07	E	DSP
		PT-07	E	DSP

E-estuaries, rias and coastal lagoons; C - coastal

Spain: National Report 2017–2019

Report compiled by Margarita Fernández Tejedor (IRTA)

Basque Country

Marta Revilla (AZTI-Pasaia) and Aitor Laza (University of the Basque Country-Leioa)

https://www.azti.es/

In the Basque country, shellfish harvesting has been permanently prohibited since 2018, at the three estuaries (Butroe, Oka and Bidasoa) where it was previously allowed. For that reason, the monitoring has been cancelled in these areas since 2018. A pilot-scale farm was installed in open marine waters (2 km off the coast) for research purposes; a monitoring program has been conducted in that experimental farm since 2014. The farm became commercial in June 2019. At the farm, phytoplankton is monitored at least monthly by the hose method (0-10 m, 10-20 m, 20-30 m); biotoxins are monitored at least monthly throughout the year and weekly during spring. During 2017 when shellfish harvesting was still allowed at the Oka and since that it was still monitored every week from January to March and from October to December, toxins were below regulatory levels in all samples. *Pseudo-nitzschia galaxiae* (21240 cells/L), *Pseudo-nitzschia multistriata* (400 cells/L) and other unidentified *Pseudo-nitzschia* species (10^2-10^3 cells/L) were observed in the phytoplankton samples from this estuary.

Main events at the pilot scale farm during 2017-2019

PSTs

The results of the samples analyzed were always below the quantification limit in 2017, but were above regulatory levels in autumn 2018 and 2019. *Alexandrium ostenfeldii* was pointed as the causative species for the event in 2018, not for 2019 when the samples collected in October and November did not show any potential PSP producer.

DSTs

Okadaic acid was above the regulatory threshold during most of the spring 2017. *Dinophysis acuminata* was considered the causative species as it was present during that period and reached a maximum of 1980 cells/L in April 2017, together with the maximum levels of OA. During these events, other potentially DSP producers were observed (*Dinophysis acuta, Dinophysis caudata, Dinophysis fortii* and *Phalacroma rotundatum*), but in less samples and at a lower concentration (< 100 cells/L). During 2018, okadaic acid was detected at low concentrations in February, the concentration increased in shellfish samples in May (1693 µg/kg) and was above the regulatory threshold in June, its concentration decreased during the following moths but were over quantification level (40 µg/kg) until the end of August. At the time when the maximum concentration of okadaic acid was detected in May, *Dinophysis acuminata* was observed from the surface to the bottom of the water column (42 m) and it reached about 2500 cells/L at 17 and 24 m depth. In these samples, *Dinophysis acuta* and *Phalacroma rotundatum* were also observed (20 cells/L).

During 2019, okadaic acid was detected from late February to middle August, and it was above the banning threshold in March, April and May. During these DSP events, *Dinophysis acuminata* reached higher abundance in surface waters (0-10 m), although it could be found up to 30 m. Its maximum was recorded in April (580 cells/L). *Dinophysis tripos* and *Dinophysis fortii* were also observed in early spring, and later *Dinophysis caudata* and *Dinophysis acuta*; all of them in lower abundance.

ASTs

Domoic acid exceeded the quantification limit in April 2017 but it was below the regulatory level. At that time, un-identified cells of the genus *Pseudo-nitzschia* were registered in high abundance (up to 5.6 x 10^5 cells/L), together with *P. pungens* (20390 cells/L), *P. americana/brasiliana* (3398 cells/L) and *P. multistriata* (180 cells/L). During the year 2018, domoic acid did not exceeded quantification limit (2 mg/kg) during 2018 in spite of the fact that un-identified cells of the genus *Pseudo-nitzschia* were usually observed. The maximum was registered in September (152 x 10^3 cells/L) being composed by thin cells (< 5 µm transapical axis); a secondary peak of larger cells (> 5 µm transapical axis) was observed in August (35 x 10^3 cells/L). Domoic acid exceeded the regulatory limit in January 2019 (19.7 ± 2.3 mg/kg) coinciding with a bloom of *Pseudo-nitzschia* spp. (> 5 µm transapical axis) in relatively high concentration (14000-90000 cells/L) throughout the water column.

Other toxins

AZAs did not exceed the quantification limit in any sample during 2017.

Yessotoxins exceeded quantification limit in May 2017 but below the regulatory level, it was coincident with the presence of *Lingulodinium polyedra* (80 cells/L) and *Protoceratium reticulatum* (20 cells/L). During 2018, yessotoxins were detected only in summer and at concentrations much lower than the regulatory threshold. The maximum (0.592 eq. YTX/kg) was observed at the beginning of July and coincided with the presence of *Gonyaulax spinifera* (20 cells/L). Yessotoxins were also detected from May to September 2019, always below the regulatory threshold. The highest concentration was found in June-July (0.600-0.912 mg eq. YTX/kg)

Cantabria

María Pérez Mora (Consejería de Medio Rural, Pesca y Alimentación)

Closures due to levels of DSTs exceeding regulatory thresholds are recurrent events during the months of April-May, these events are coincident with the presence of *Dinophysis acuminata* in low abundance. As an example, *Dinophysis acuminata* was in the range of 0-200 cells/L during the shellfish closures in May 2019.

Asturias

Carmen Rodríguez (Centro de Experimentación Pesquera)

https://tematico.asturias.es/dgpesca/din/exper.php

In 2018 there were two closures due high concentrations of DSTs, one from the 19th of April to the 21st May and the second from the 24 May top the 12 July. Both events were associated to *Dinophysis acuminata*. On the 23rd April there was a bloom of *Pseudo-nitzschia* but domoic acid in shellfish was below regulatory level. During 2019 Ría del Eo was closed from the 25th April to the 21st June due to the detection of okadaic acid above regulatory levels, *Dinophysis acuminata* was present at the time of the event.

Galicia

Yolanda Pazos and Silvia Calvo (INTECMAR)

http://www.intecmar.gal/

Phytoplankton and Biotoxins Monitoring Program in Galicia

The Technological Institute for the Monitoring of the Marine Environment in Galicia (INTECMAR), set up by law in 2004 as a public institution, is an official tool that belongs to the autonomic administration of Galicia. The objectives of the INTECMAR are the fulfilment of current legislation regarding the quality of production areas as well as follow-up, control and research of environmental quality of coastal waters in Galicia, especially regarding oceanographic conditions, marine biotoxins, chemical pollution, microbiology and pathology. A complete control system was designed and implemented to work with small-size production units, with a very intense sampling frequency, able to cover all the production areas along the Galician coastline and to monitor the different groups of species subject to commercial exploitation, coming either from fisheries or from aquaculture.

In the Order of 14 November 1995, laying down the programme for the monitoring of marine biotoxins in bivalve molluscs and other organisms in the fishing, shellfish and aquaculture, Action Plans are defined and classified in four main types:

- Type A: situation without any kind of risk of uptake of toxins by bivalve molluscs.
- Type B: situation of alert of possible uptake of toxins, with progressive increase of the alert in phases B1, B2 and B3.
- Type C: prohibition of harvesting due to toxicity levels being above the legal limits. Decreasing toxicity levels direction C1-C2-C3.
- Type D: The closed production area is re-opened but there is still residual toxicity in the molluscs

Sampling network in the monitoring system

The monitoring system in Galicia is based on the establishment of an extensive sampling network, covering all production areas present along the coast.

The sampling network for monitoring marine biotoxins in bivalve molluscs cultured in rafts, established in the Order of 14 November 1995 and later modifications, has 53 fixed primary points that are sampled with a minimum weekly frequency and complemented with 128 secondary fixed points which were chosen to facilitate, if necessary, a more detailed information about the situation in relation to the degree of accumulation of toxins by mussels in the production zones. The mussel samples are usually analyzed as a homogenate from three depths but if it is necessary, for instance to re-open a closed production zone, the three samples (corresponding to different depths) are analyzed separately. In the production zones where there is no mussel culture in rafts, wild mussels are used as a bioindicator by means of 16 primary sampling points. Sampling points for monitoring wild mussels, infaunal benthic molluscs (35 production zones) and epifaunal benthic molluscs (16 production zones) are established in the Order of 24 January 2013.

The sampling network for monitoring oceanographic conditions and phytoplankton populations has 58 stations (43 oceanic stations and 15 coastal stations) which are sampled weekly. At each station water samples are collected to obtain qualitative and quantitative information about phytoplankton populations (toxic and nontoxic), photosynthetic pigments and multiparametric probes are used to determinate oceanographic conditions (physical-chemical variables). The phytoplankton samples are usually analyzed as a homogenateof three depths but if necessary, samples of different depths are analyzed separately. In addition, all this information is complemented with water samples from the production zones in floating mussel rafts, collected simultaneously as the sampling of biotoxins. These samples provide real-time information on the status of phytoplankton communities in these production areas.

Information and communication

Toxicity Assays Report: Daily. Results of biotoxins analysis

Daily changes report: Daily. All the administrative situation changes in the production areas

Action Plans Report: Twice a day. This report is elaborated from the information obtained in the production areas, both in terms of the content of biotoxins and the phytoplankton populations present in the water samples

Administrative Resolutions: official document of opening or closure of production zones

Technical Report of the Toxic Phytoplankton Identification and Recounts: Each time results of the recount are gathered and once a week a Complete Technical Report of the Toxic Phytoplankton Identification and quantification is elaborated.

Weekly Report: Elaborated from the qualitative and the total counts of the phytoplankton communities (toxic and non toxic species) and the determination of the photosynthetic pigments. In this report, the information coming from the multiparametric probes provides information weekly about the physical and chemical variables of the water.

The results of the work carried out at INTECMAR are communicated to the relevant different departments of the Regional Government, to the corresponding fisheries and aquaculture organizations – namely, Fishermen's Associations, Producers' Organizations and Professional Associations – and to society, in general.

The administrative departments and sector entities involved also receive the preliminary reports on phytoplankton composition and abundance via email.

The information concerning the situation of the marine environment and the different shellfish growing areas obtained at INTECMAR can be viewed on the Intecmar website.

Main events during 2017-2019

PSTs

Events associated with *Alexandrium minutum*.

Blooms of *Alexandrium minutum* did not affect mussel rafts in any occasion during the year 2017. Areas of infaunal molluscs were closed in Ría de Ares from May to early June due to blooms of *Alexandrium minutum*. The maximum abundance of *Alexandrium minutum* (10388 cells/L) in Ría de Ares was detected on the 8th of May. From the end of June to middle July, closures occurred in Camariñas where the maximum abundance (17066 cells/L) of *Alexandrium minutum* was detected on the 26th of June.

During 2018, blooms of *Alexandrium minutum* affected mussel rafts in Pontevedra and Ría de Vigo where shellfish closures occurred during July, as well as in Ría de Baiona where closures extended from June to August and from mid-November to mid-December. Areas of infaunal molluscs were also closed in Camariñas, Ría de Vigo and Ría de Pontevedra. The maximum abundance of *Alexandrium minutum* in Ría de Pontevedra (1548855 cells/L) and Ría de Vigo (277695 cells/L) was detected on the 17th of July, while in Camariñas the maximum (277695 cells/L) was detected on the 27th of August.

During 2019, blooms of *Alexandrium minutum* affected mussel rafts in Baiona from mid-January to mid-February and June. The maximum abundance (256905 cells/L) was detected on the 25th of May in Baiona. An area of infaunal molluscs in Camariñas (Costa da Morte) was also affected from the end of April to the end of May. The maximum abundance (5936 cells/L) in Camariñas was detected on the 3rd of June.

Events associated with *Gymnodinium catenatum*.

There were some events associated with blooms of *Gymnodinium catenatum* during 2017. Mussel rafts were closed in January in Pontevedra and Vigo. In both cases it was probably due to remnants of PST events that occurred in 2016. Another early event started in mid-February and effected mussel rafts in Ría de Pontevedra, outer and middle parts of Ría de Vigo, Ría de Baiona and south of Ría d'Arousa until mid-March attaining maximum abundance of 360 cells/L on the 6th of February. Another event affected mussel rafts in Ría de Pontevedra from August to September and one infaunal area in Ría de Vigo in September, the maximum abundance (3840 cells/L) was detected on the 28th of August.

During 2018, *Gymnodinium catenatum* was detected from August to September in Ría de Pontevedra in a range of 1000-3200 cells/L. PSP toxins were below regulatory levels in shellfish during this bloom.

During 2019, the maximum abundance of *Gymnodinium catenatum* were detected in Ría de Pontevedra and Ría de Ares-Betanzos in the range of 1000-3200 cells/L from August to September. There were no closures associated with these bloom.

DSTs

Closures associated with DSTs in shellfish rafts occurred from March to mid-June 2017 due to *Dinophysis acuminata* in Ría de Muros-Noia, Ría de Pontevedra, Baiona, Ría de Ares-Betanzos, some areas of Arousa and external areas in Ría de Vigo. More exactly, the first closures occurred in March in Ría de Pontevedra and in some locations from Ría de Vigo, extending to the rest of the mentioned areas until the end of June. The maximum abundance detected was 360 cells/L in Vigo on the 6th of February. A second event started at the end of August in many sampling stations from Ría de Pontevedra and Ría de Muros-Noia, extending to the rest of stations from both Rías, as well as Ría de Ares-Betanzos, Ría de Vigo, Ría de Baiona, and many stations from Ría de Arousa. This event was due to the presence of *Dinophysis acuminata* and *Dinophysis acuta* and probably *Dinophysis caudata*, which was observed until the end of November, extending to the end of the year in one sampling station for the Ría de Muros-Noia. The maximum abundance of *Dinophysis acuminata* (4200 cells/L) was detected at the Ría de Pontevedra on the 10th of October. The maximum abundance of *Dinophysis acuta* (1480 cells/L) and *Dinophysis caudata* (1360 cells/L) were detected in Ría de Pontevedra on the 28th of August and 16th of August respectively. In relation to infaunal molluscs the were more intense DST closures from April until June that affected the northern Rías, Costa da Morte, Muros-Noia and some sites in Pontevedra. All of these areas except the northern ones were always affected by irregular periods of closures from August to beginning of November.

During 2018, DST closures in shellfish rafts began in all Galician Rías at the beginning of March. These closures were continuous in parts of Ría de Ares-Betanzos, Ría de Muros-Noia and the whole Ría de Pontevedra, lasting until the end of July. In almost all stations of Ría de Muros, the whole Ría de Arousa and the external areas of Ría de Vigo, this closure period was intermittent: from the beginning of March to beginning of May and from middle of May to the end of July, extending of August in Ría de Baiona. In the inner areas in Ría de Vigo, the closures were shorter, lasting from March to the end of April. The maximum abundance of *Dinophysis acuminata* (6920 cells/L) was detected in Ría de Muros on the 12th of June. A second increase of *Dinophysis acuminata* was observed in Ría de Sada, Ría de Muros-Noia and Ría de Pontevedra from middle October to middle November, and until the second week of December in Ría de Pontevedra associated with advective processes typical of autumn. The maximum abundance of *Dinophysis acuminata* (1720 cells/L) was detected in Ría de Ares-Betanzos on the 17th of October. *Dinophysis acuta* was also recorded but in low abundance, therefore its contribution to DSP toxicity was small. Maximum abundance of *Dinophysis acuta* (160 cells/L) was detected in June in Ría de Arosa. Growing areas of infaunal molluscs suffered a long period of closures from April to October affected mainly Ría de Ribadeo. The rest of the coast as more or less affected intermittently between April-July and September-October, Ría de Vigo was continuously affected from June to October.

During 2019, from mid-January to the beginning of February, there was a brief period of DST closures in Ría de Baiona. The main period of closures started at the beginning of March in Ría de Muros-Noia, part of Ría de Arousa, Ría de Pontevedra, part of Ría de Vigo and Ría de Baiona. In Ría de Ares-Betanzos, most of Ría de Arousa and the inner part of Ría de Vigo, this period started later, around mid-April. During that period, closures were continuous in almost all of the areas except Ría de Muros-Noia and some areas in Ría de Arousa, Pontevedra and Vigo that showed a certain intermittency between closures and openings. The first period of closures finished at the end of March in most of Ría de Muros, Ría de Arousa, the inner part of Ría de Vigo, at the beginning of July in some areas of Ría de Ares-Betanzos, Ría de Muros, Ría de Pontevedra, outer part of Ría de Vigo and Ría de Baiona. The maximum abundance of *Dinophysis acuminata* during these events was detected in Ría de Pontevedra (14640 cells/L) on the 24th of April. A second period of closures, associated with advective processes typical of autumn, started from middle August and lasted until the beginning of October in Ría de Muros-Noia and November or mid-December in the other Galician Rías. During this second period, the closures were due to the presence of *Dinophysis acuminata* and *Dinophysis acuta*. The maximum abundance of *Dinophysis acuminata* (2520 cells/L) was detected in Ría de Pontevedra on the 27th of August. The maximum abundance of *Dinophysis acuta* (6680 cells/L) was detected in Ría de Ares-Betanzos on the 26th of August. Areas of infaunal molluscs were also affected by DSP closures. The longer period of DST closures for infaunal molluscs was from March to July and affected Ría de Viveiro-Celeiro. The rest of Galician Rías were more or less affected and more or less intermittently between April-June and only a few infaunal molluscs areas were affected by the closures in a second period between August-September (Ría de Ferrol, Ares-Betanzos and Coruña, Costa da Morte and Muros-Noia). During 2019, there were no closures due to DSTs in areas of infaunal molluscs located in Ría de Arousa.

ASTs

During 2017, neither mussel rafts, nor infaunal molluscs areas were affected by AST closures. During 2018, mussel rafts were affected by AST toxins. There were closures in September in Ría de Muros-Noia, and in October in Ría de Ares-Betanzos and some locations in Ría de Pontevedra. Closures in areas of infaunal molluscs occurred in May in Viveiro-Celeiro, Cedeira and Camariñas; in May and July in parts of Ría de Vigo, from the end of August to the beginning of September in areas of Costa da Morte, and from mid to the end of September in Ría de Muros-Noia. The maximum of abundance was 4635197 cells/L on the 18th of June in Ría de Pontevedra. During 2019, mussel rafts in Ría de Baiona, were affected by AST closures during 4 weeks between January and February. In addition, areas of infaunal molluscs experienced closures between January and July in Costa da Morte, while in April and October in Ría de Ferrol, Ares-Betanzos and Coruña, and during September in Ría de Muros-Noia. The maximum abundance of *Pseudo-nitzschia* spp. detected during 2019 was 5936 cells/L on the 5th of August in Ría de Muros-Noia.

Canary Islands

HABs Observatory of the Canary Islands

Javier Arístegui and Emilio Soler

An intense bloom of *Trichodesmium* was detected in June 2017 and lasted during several months. The bloom covered a large area and affected the islands of El Hierro, Tenerife, Gran Canaria, Lanzarote. *Trichodesmium* bloomed another time in 2018 but at a lower abundance. The bloom in 2017 coincided with abnormally high temperatures and reduced wind intensity. Similar blooms already happened in the past in August 2004 and October 2011. The bloom alarmed the inhabitants of the islands since it produced an unpleasant color and smell that made them suspect a possible spill of a contaminant.

Ciguatera

Margarita Fernández (IRTA)

In April 2017 there were 2 cases of ciguatera intoxication in Gran Canaria after eating *Mycteroperca fusca* (8 kg) and *Epinephelus* spp. (29 kg). The presence of ciguatoxins was confirmed in both cases. In Tenerife, there were 4 cases after eating *Canthidermis sufflamen* (3.2 kg) in September 2018, in these last 4 cases there were no samples of fish available to confirm the presence of ciguatoins. These cases are recorded by the Ciguatera Epidemiological Surveillance System of the Canary Islands (SVEICC-Servicio Canario de Salud, Dirección Genarl de Salud Pública).

The results of the monitoring program for the surveillance of ciguatoxins in fish caught in the Canary Islands show that on average 13% of the samples contain ciguatoxins. There are some differences between islands. In the Table below the results of the analysis as % of positive samples during the years 2017-2018 is shown for each island for the species *Epinephelus marginatus* and *Seriola* spp. (*Seriola dumerili, Seriola fasciata, Seriola carpenteri, Seriola rivoliana*). The monitoring program also covers other species such as *Acanthocybium solandri* and *Pomatomus saltatrix*. Every single fish caught in the waters of the Canary Islands from the list of monitored species over a certain weight has to be analyzed before going to the market. The list of species and weights is revised every year after reviewing the trends in the results of the analysis.

The % of *Seriola* spp and *Epinephelus marginatus* containing ciguatoxins during 2017 - 2018

% of *Seriola* spp and *Epinephelus marginatus* samples containing ciguatoxins during 2017-2018 on each island for the species (Table adapted from *https://www.gobiernodecanarias.org/agp/sgt/temas/estadistica/pesca/index.html*)				
	Seriola spp		*Epinephelus marginatus*	
	2017	2018	2017	2018
Lanzarote	11	12	13	18
Fuerteventura	15	25	9	10
Gran Canaria	6	27	0	43
La Gomera	2	7	-	-

El Hierro	7	23	27	45
La Palma	3	10	0	23
Tenerife	8	12	20	48

Andalucía

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PSTs

During 2017, there were several PST closures along the Mediterranean coast in January associated to the bloom of *Gymnodinium catenatum* that occurred at the end of 2016. These closures affected mainly mussel aquaculture. Another bloom of *Gymnodinium catenatum* started in September along the Mediterranean coast and affected mussel aquaculture as well as harvest of wild bivalve molluscs such as *Venus gallina*, *Callista chione* and *Venus verrucosa*. The closures for mussels lasted for 3 months, from September to December and from October to November for the harvest of wild bivalve molluscs. The contents of saxitoxin in mussels were higher than 4500 µgeq-STX diHCl/kg. The highest abundance of *Gymnodinium catenatum* (20600 cells/L) was detected near Algeciras (Cádiz) during the month of November.

Gymnodinium catenatum was present along the Atlantic coast (Huelva) during July-November 2018, which is not usual. The maximum abundance detected was 1280 cells/L, there were no closures associated with this bloom. Along the Mediterranean coast, blooms of *Gymnodinium catenatum* of low abundance (1000 cells/L) occurred in January-February and in October-November that affected only mussel aquaculture with some closures. There was another bloom along the whole Mediterranean coast of Andalucía during summer with the maximum abundance (6500 cells/L) detected in Algeciras (Cádiz) that produced closures affecting mussel aquaculture (*Mytilus galloprovincialis*) and wild harvest of bivalve molluscs (*Donax trunculus*, *Chamelea gallina*, *Venus verrucosa*).

During 2019, PST events occurred only along the Mediterranean coast associated with blooms of *Gymnodinium catenatum*. There were closures from July to October for *Mytilus galloprovincialis*, *Donax trunculus* and *Chamelea gallina*.

DSTs

There were some DST closures along the Atlantic coast (Huelva) that affected clams (*Donax trunculus*) associated to the presence of *Dinophysis acuminata* (4680 cells/L). Along the Mediterranean coast there were also some closures that affected clams (*Donax trunculus*) during summer associated to the presence of *Dinophysis acuminata* (500 cells/L).

Recurrent blooms of *Dinophysis acuminata* occurred along the Atlantic coast (Huelva) during spring (max. 1720 cells/L) and summer 2018. A closure was enforced after detection of okadaic acid over regulatory levels in mussels (*Mytilus galloprovincialis*) and clams (*Donax trunculus*) associated to the presence of *Dinophysis acuminata* (4500 cells/L) and *Dinophysis acuta* (2500 cells/L). Along the Mediterranean coast (Cádiz, Málaga and Granada) blooms of *Dinophysis acuminata* (max. 3000 cells/L in August 2018) and *Dinophysis acuta* (1000 cells/L in July 2018) were associated to detection of okadaic acid over regulatory level in clams (*Donax trunculus*) and mussels (*Mytilus galloprovincalis*).

During 2019, the recurrent spring-summer bloom of *Dinophysis acuminata* along the Atlantic coast (Huelva) was associated to closures of *Donax trunculus* for most of the year while other species such as *Chamelea gallina* were less affected. The highest concentration of okadaic acid (1373 micrograms of okadaic acid equivalents per kilogram) was detected in *Donax trunculus*. The maximum abundance of *Dinophysis acuminata* (15000 cells/L) was detected in March.

ASTs

Pseudo-nitzschia cf. *australis* was detected in high abundance in March 2017 along the Atlantic and Mediterranean coasts of Andalucía. The bloom started in the Atlantic coast and moved towards Mediterranean waters, the highest abundance (88400 cells/L) was detected on the 27th of March in San Roque (Cádiz). Domoic acid was over regulatory levels in one sample of clams (*Donax trunculus*) from Torremolinos (Málaga), and below regulatory levels in other samples along the Atlantic and the Mediterranean coasts during the month of March. During 2018, the highest abundance of *Pseudo-nitzschia australis* (80000 cells/L) was also detected in spring, during the months of March and April along the Atlantic and Mediterranean coasts. There were shellfish closures along the Mediterranean coast; the highest concentration of domoic acid (34.6 mg/kg) was detected in *Donax trunculus*. Spring was also the time of the year 2019 when domoic acid was detected over regulatory levels, although only along the Atlantic coast near Portugal. The highest concentration of domoic acid (28.6 mg/kg) was detected in *Donax trunculus*.

Murcia

Javier Gilavert Cervera (Polytechnic University of Cartagena)

Fish kills

During the "cut-off low" in September 2019 a high amount of freshwater and inorganic nutrients from the agriculture fields entered in the Mar Menor lagoon. As a result, the water column in Mar Menor was highly stratified. The increase in stratification together with the high levels of inorganic nutrients favored a bloom of phytoplankton that collapsed after few days. All of the organic matter consumed the oxygen at the deepest part of the water column. The anoxic layer remained during several weeks at the bottom until it was brought to the surface when the wind started to blow and mixed the water column in the northern area of Mar Menor. At that time, there was a massive mortality of fish and crustaceans that previously moved there from deep waters.

Valencia region

Miguel Lull (GENERALITAT VALENCIANA- Conselleria d'Agricultura, Desenvolupament Rural, Emergència Climàtica i Transició Ecològica) and Carolina Assadi (OCEANSNELL)

The toxin contents in all the shellfish samples analyzed during the years 2017-2019 have been below regulatory levels.

PSTs

Alexandrium pacificum and other species of the genus *Alexandrium*, were detected during the year 2017. The maximum abundance of the genus was detected in Peñíscola (15280cells/L) during the month of June, while during the same month at Puerto Nuevo the abundance was 700 cells/L. The abundance of *Alexandrium* species during the years 2018 and 2019 was low in all samples.

DSTs

During the year 2017, *Dinophysis acuminata*, *Dinophysis caudata* and *Phalacroma rotundatum* were detected in Sagunto, Puerto Nuevo and Xità at abundance below 100 cells/L. During, *Dinophysis acuminata*, *Dinophysis acuta*, *Dinophysis caudata*, *Dinophysis fortii* and *Phalacroma rotundatum* were detected in Sagunto, Puerto Nuevo, Xità and Cullera, always at low abundance. During the year 2019, *Dinophysis acuminata*, *Dinophysis caudata*, *Dinophysis sacculus* and *Phalacroma rotundatum* were detected in Puerto Nuevo, Xità and Gandía, always in low abundance. All the shellfish samples analyzed for okadaic acid, dinophysistoxins and pectenotoxins together were below regulatory level.

ASTs

Pseudo-nitzschia spp. were detected in most of the samples and reached abundance higher than 10^5 cells/L in June 2017, 2018 (Sagunto and Xità) and August 2017, 2018 (Puerto Nuevo). During the year 2019, *Pseudo-nitzschia* spp. reached very high abundance in Xità and Gandía. The maximum abundance (1783940 cells/L) was detected in Gandía during the month of September.

Benthic HABs

During 2017, cells of the genus *Ostreopsis* were detected in Xità and Puerto Nuevo from June to September, the maximum abundance (5000 cells/L) was detected in Xità during the month of July. During 2018, *Ostreopsis* was detected from July to August. The maximum abundance was detected in Sagunto (5500 cells/L) during the month of July. During the year 2019, *Ostreopsis* was detected at very high abundance, 59210 cells/L in Puerto de Valencia during the month of June. It was also present in Xità during the month of September.

Yessotoxins

Lingulodinium polyedra, *Gonyaulax spinifera* and *Protoceratium reticulatum* were detected in Sagunto, Xità and Puerto Nuevo, always below 2000 cells/L during the year 2017. During the year 2018, the same species were detected in Sagunto, Puerto Nuevo, Xità, Cullera and Gandía. The maximum abundance (2010 cells/L) was detected during the month of June in Xità. Yessotoxins were detected below regulatory levels (0.28 mg eqYTX/kg). During the year 2019, *Gonyaulax spinifera* and *Protoceratium reticulatum* were detected in all samples. The maximum abundance (12000 cells/L) was detected in Puerto Nuevo during the month of August. Yessotoxins were detected below regulatory levels.

Catalonia

Monitoring program of shellfish growing areas

Margarita Fernández, María Rambla and Jorge Diogène (IRTA)

PSTs

During 2017, a bloom of *Alexandrium minutum* lasted from February to April in Alfacs bay, the highest abundance detected was 8160 cells/L on the 13th of March, PSP toxins were detected in

13 shellfish samples, the highest concentration detected was 585 µgeq-STX diHCl/kg. *Alexandrium minutum* also bloomed in Vilanova where a preventive closure was enforced in Vilanova between 26th May-2nd June 2017. The highest abundance (795462 cells/L at the interior of the harbor and 2061 cells/L outside) was detected by the end of May 2017. In the year 2018, PSP toxins below regulatory levels (354-365 µgeq-STX diHCl/kg) were detected in 3 samples of mussels from Alfacs Bay during the recurrent bloom of *Alexandrium minutum*. The highest abundance (4080 cells/L) of *Alexandrium minutum* in Alfacs Bay during the year 2019 was detected in February, PSTs were detected below regulatory levels in one sample of mussels and one sample of razor clams collected in January and February 2019.

DSTs

Dinophysis sacculus was present a low abundance (560 cells/L) during the year 2017, okadaic acid was detected below regulatory levels in mussels from Alfacs Bay in February 2017 and clams from Vilanova and Roses during the month of March. During the year 2018, okadaic acid (47-60 micrograms equiv OA/kg) was detected in 6 samples of clams from the external coast of the Ebro delta that were collected in June. These detection was coincident with a bloom of *Dinophysis sacculus*.

DSTs

Pseudo-nitzschia spp. were present in most of the samples and reached frequently high abundance (> 1000000 cells/L). In spite of the high abundance of *Pseudo-nitzschia*, domoic acid was detected only at very low concentration in clams (*Donax trunculus*) during the year 2017. Domoic acid was not detected in samples collected during the year 2018, it was detected below regulatory level in clams collected along most of the areas of the coast during the months of March and April 2019.

Blooms of *Ostreopsis*

Report provided by ICM-CSIC. Contacts: Magda Vila (magda@icm.csic.es), Laia Viure (laiaviure@icm.csic.es), Elisa Berdalet (berdalet@icm.csic.es).

In 2017, the *Ostreopsis* bloom dynamics in Llavaneres followed the same pattern as the previous years, reaching huge abundances (above 10^5 cells/g FW macroalgae) during summer months. Low abundances were detected at the end of May and they surpassed the threshold of 10^5 cells/g FW macroalgae during the last week of June. Abundances above this threshold were maintained until mid-August, with a secondary bloom in October. As part of the OstreoRisk project, several people living or working in front the sampling station answered a poll on their irritated respiratory tract symptoms related to *Ostreopsis* blooms and they also indicated the days of affectation. In spite of the fact that the bloom lasted for more than 2 months, the (only) nine people who answered the questionnaires, all of them noticed the typical symptoms but only during one single week (from 3 to 9 July), which correspond to the end of the *Ostreopsis* exponential phase.

In 2018 and 2019, the *Ostreopsis* cf. *ovata* bloom was monitored in Sant Andreu de Llavaneres, a well characterized hotspot. In addition, several samplings were also conducted in July and August in other localities along the Catalan coast. In Sant Andreu de Llavaneres, the *O.* cf. *ovata* bloom dynamics in 2018 and 2019 followed the same seasonal pattern as in previous years. Blooms started in the second half of July, reaching values above the alert threshold ($2 \cdot 10^5$ cells/g FW) that remained high (up to $2 \cdot 10^6$ cells/g FW in 2018 and $7 \cdot 10^5$ cells/g FW in 2019) until the second week of September when storms and a sharp temperature drop led to the end of the proliferation. Few respiratory irritations were reported (5 to 10 people) with symptoms lasting for no more than 2 days at the end of July and early August. Thus, the beach was open for the two summer seasons although health alert posters information were installed. *O.* cf. *ovata* numbers above the alert threshold were also found in many beaches, with higher epiphytic concentrations in 2018 than in 2019. Maximum values were ca. $2.1 \cdot x\ 10^5$ cells/g FW in Empúries, $2.2\ x \cdot 10^5$ cells/g FW in Palamós, $9.3\ x \cdot 10^5$ cells/g FW in Tossa de Mar, $2.1 \cdot x\ 10^5$ cells/g FW in Sant Vicenç de Montalt, $3.7 \cdot x\ 10^5$ cells/g FW in Vilassar de Mar, $1.5 \cdot x\ 10^6$ cells/g FW in Sitges, $8.1 \cdot x\ 10^5$ cells/g FW in Vilanova i La Geltrú and $2.1 \cdot x\ 10^5$ cells/g FW in Cubelles. Mild respiratory and cutaneous irritations were reported at the end of July and the beginning of August in 2018 in Sitges and Cubelles, but the beaches remained open for the whole summer. Only the beach of Vilassar de Mar was closed for 3 days, after 11 people experienced respiratory irritation on August 22th, 2018. The symptoms associated with *Ostreopsis* blooms are mild and not specific; as a result they are underreported to the health care system.

The study was conducted in coordination with the Catalan Water Agency, the Public Health Agency of Catalonia, the city halls and safeguards of coastal localities, participation through the citizen science platform SeaWatchers (http://icmdivulga.icm.csic.es/ostreorisk) and support from the OstreoRisk (CTM2014-53818-R; with FEDER and AEI funds; https://ostreorisk.icm.csic.es/) and the CoCliME project (European Union Grant No. 690462, co-funded by FORMAS, Sweden).

Monitoring program in beaches along the Catalan coast

Nagore Sampedro (CSIC)

During the summer of 2019, there was a heavy and extensive bloom of *Alexandrium taylori* (4.6×10^6 cells/L) and *Gymnodinium litoralis* (7.4×10^6 cells/L) in Pals and Begur (Costa Brava). The seawater had a yellow color that alarmed the tourist of the area. The bloom occurred at the beginning of July after a strong heat wave. These species usually bloom in Costa Brava but they bloomed for the first time in Pals and Begur where they were not detected before.

Water discolouration from the *Alexandrium taylorii* and *Gymnodinium litoralis* bloom

Balearic Islands

José María Valencia Cruz (LIMIA)

A short DST closure due to the detection of okadaic acid over regulatory levels was enforced on the 13th of September and lasted until the 22nd of the same month. During 2018, there were no closures due to marine toxins, yessotoxins were detected below regulatory levels. There were some blooms of *Alexandrium* and *Pseudo-nitzschia* but neither PSTs, nor domoic acid were detected in shellfish samples.

Sweden: National Report 2017–2019

Bengt Karlson, SMHI

Harmful Algal Blooms (HABs) are recurrent phenomena in the waters surrounding Sweden. Most are likely to be of natural origin but some are related to eutrophication. Some HAB-species may have been introduced to the area. The HAB-problems for the waters surrounding Sweden are very different for the Baltic Sea and the Skagerrak-Kattegat areas. In the brackish water of the Baltic Sea blooms of cyanobacteria, e.g. the toxic species *Nodularia spumigena,* is the major problem while in the waters with higher salinities in the Skagerrak and the Kattegat fish killing species and species that produce toxins that accumulate in filter feeders (e.g. mussels) are the major concerns. However, both fish killing species and species causing shellfish poisoning occur in the Baltic Sea as well. Commercial farming and harvesting of wild mussels and oysters for human consumption is ongoing only along the Swedish coast of the Skagerrak at present.

The Baltic proper

Satellite observations

The cyanobacteria bloom in 2017 was normal when compared to the period 2002-2019 while the blooms in 2018 and 2019 were very extensive. A very warm summer in 2018 set off the cyanobacteria bloom early that year. Surface accumulations of cyanobacteria were observed already in late May in the southern part of the Baltic Proper. In July and until mid-August, a large part of the Baltic Proper was covered by cyanobacteria. Comparing with satellite data for the period 2002 to 2019 it was noted that the bloom in 2018 had the longest duration recorded. The bloom in 2019 was also very extensive

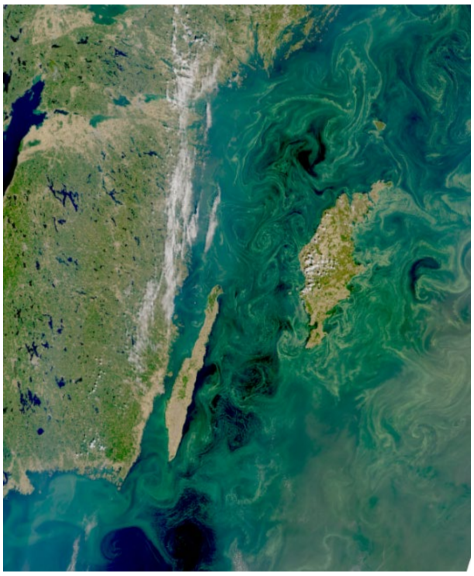
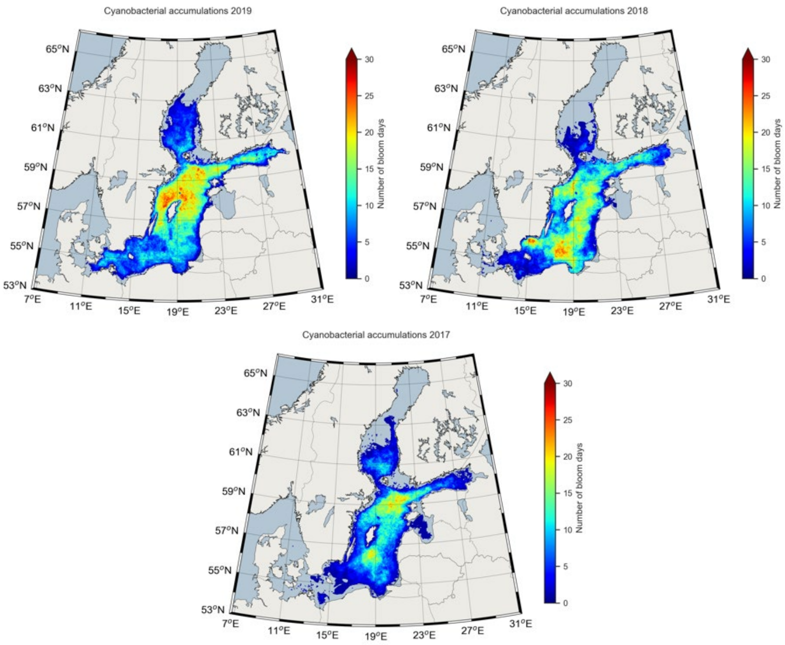
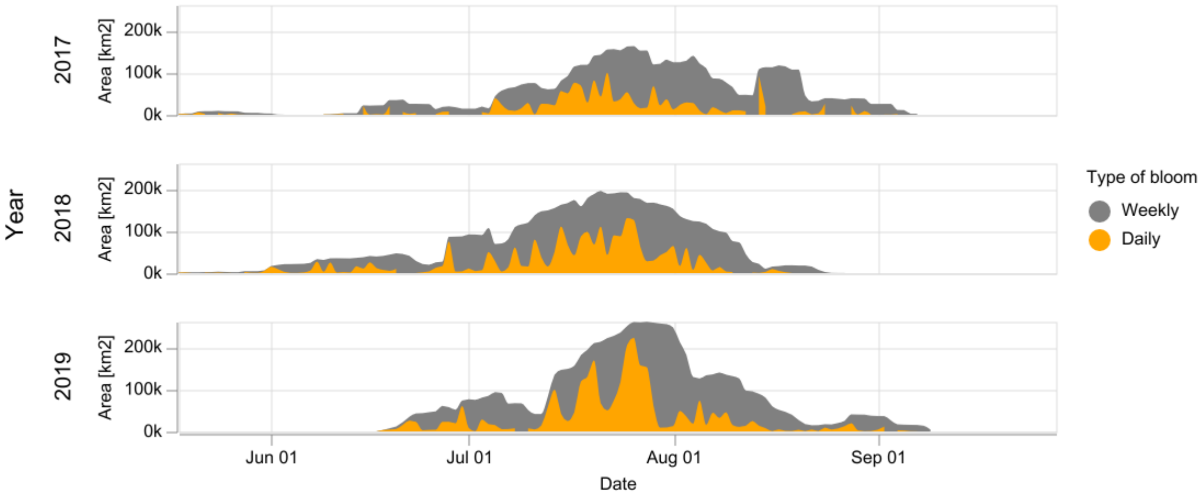


Fig. 1. Near surface accumulations of cyanobacteria in the Baltic Proper July 26th 2018. Satellite Sentinel 3A, OLCI-sesnsor, processed by SMHI.



The number of days of observations of cyanobacteria surface accumulations 1 June to 31 August 2017, 2018 and 2019. Data from the SMHI Baltic Algae Watch System. Johansson, J., pers. comm. Near coast and areas indicated with grey have been excluded from the analysis.

See also: https://www.smhi.se/klimatdata/oceanografi/algsituationen

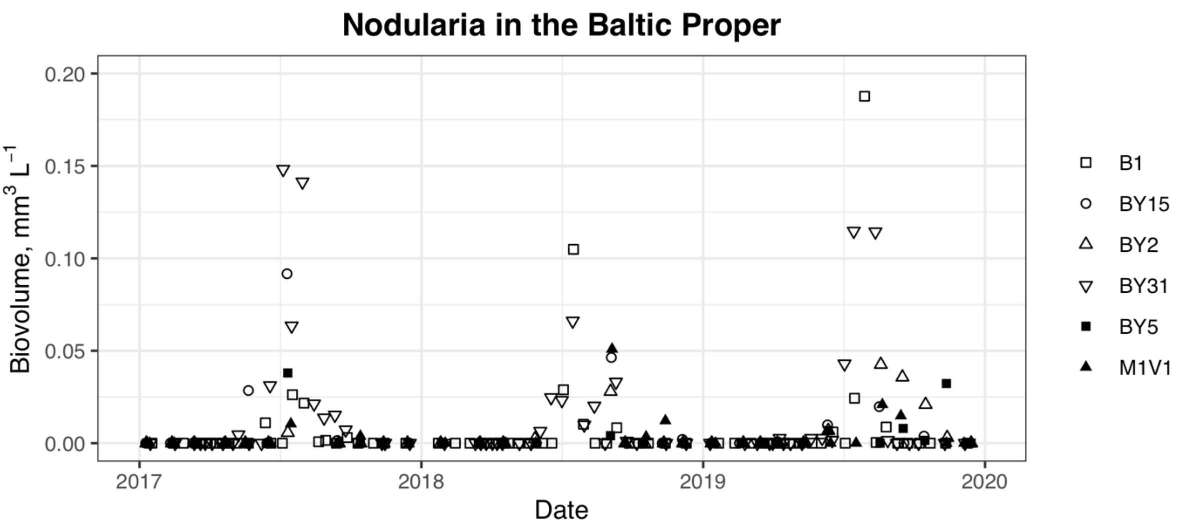


Area of cyanobacteria near surface accumulations in the Baltic Sea 2017, 2018 and 2019. Data from the SMHI Baltic Algae Watch System. Johansson, J., pers. comm.

See also: [*https://www.smhi.se/klimatdata/oceanografi/algsituationen*](https://www.smhi.se/klimatdata/oceanografi/algsituationen)

Water sampling and microscopy – preliminary data

The cyanobacteria *Aphanizomenon flos-aquae* and *Dolichospermum* spp. were observed in May. Sampling in June-August was largely disrupted due to problems with the availability of research vessels. Other data show that the toxin producing cyanobacteria *Nodularia spumigena* was very abundant in summer 2018.



The biomass of Nodularia spumigena *at six stations in the Baltic Proper 2017-2019. Data is from the national Swedish Marine Monitoring Program. Sampling was done using Lindahl tube 0- 10 m depth except for staions B1 and BY31 where 0-20 m depth was sampled.*

Cyanobacteria accumulations in archipelagos and along the coasts

Accumulations of cyanobacteria on beaches and in the archipelagos were observed in several places, e.g. in the Archipelago of Stockholm and along the coast southwards to Kalmar. There were also many reports from the Island of Öland and Gotland. The Swedish Information Centre for the Baltic Proper https://www.lansstyrelsen.se/stockholm/privat/djur-och-natur/vatten/vattnet-i-ostersjon---informationscentralen.html received many such reports and one report of a child being affected by cyanotoxin.

The Bothnian bay and the Bothnian Sea

Satellite observations

Surface blooms of cyanobacteria were observed in the southern Bothnian Sea mainly from the mid July to mid-August.

Cyanobacteria accumulations in archipelagos and along the coasts

Accumulations of cyanobacteria were observed in several places. The Swedish Information Centre for the Gulf of Bothnia received many reports of accumulations of cyanobacteria along the Swedish coast of the Bothnian Sea.

https://www.lansstyrelsen.se/vasterbotten/privat/djur-och-natur/vatten/vattnet-i-bottniska-viken---informationscentralen.html

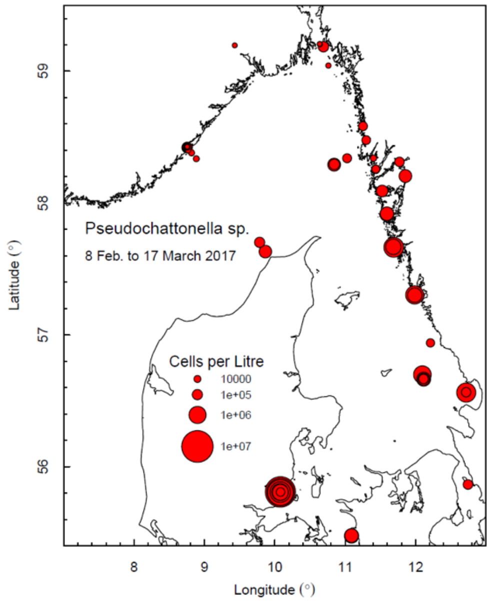
The Skagerrak and the Kattegat

Cyanobacteria

In late July-early August 2018 surface accumulations of cyanobacteria were observed in the Kattegat. The cyanobacteria had been advected from the Kattegat by ocean currents. Water samples collected using research vessels and using a ferrybox system on a merchant vessel were analyzed using microscopy. The presence of *Nodularia spumigena* was confirmed.

Fish killing algae

A bloom of *Pseudochattonella* sp. was observed in spring 2017. The first observations along the coast of Sweden were in February. The bloom extended from the Danish part of the Kattegat along the Swedish coast to the southern coast of Norway.



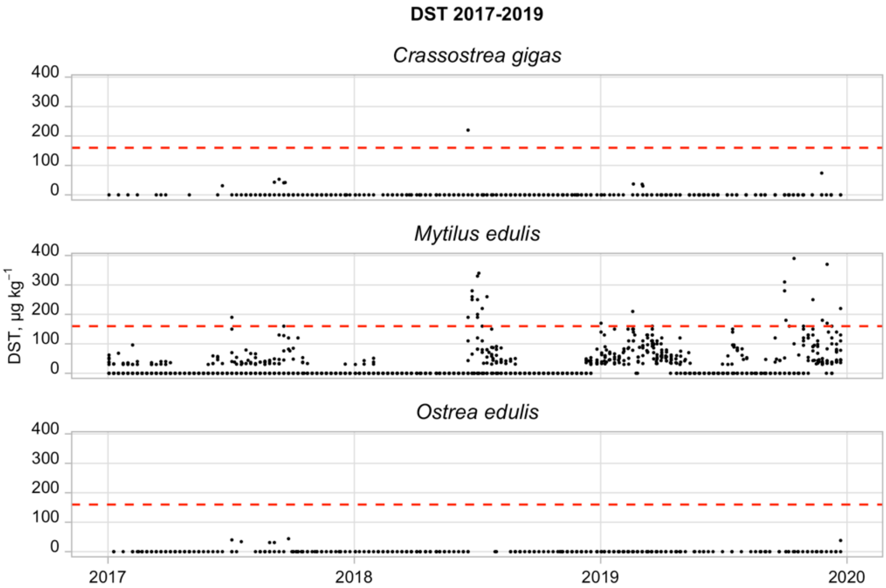
Cell abundances of Pseudochattonella *sp. 8 Feb. to 17 March 2017. Several different organisations have contributed data.*

Algae causing shellfish toxicity

The Swedish National Food Agency governs the monitoring of biotoxins producing algae and of algal toxins in bivalves. SMHI carries out analysis of plankton samples. Blue mussels (*Mytilus edulis*), flat oysters (*Ostrea edulis*), and pacific oysters (*Crassostrea gigas*) were harvested in 2017-2019.

DST and *Dinophysis*

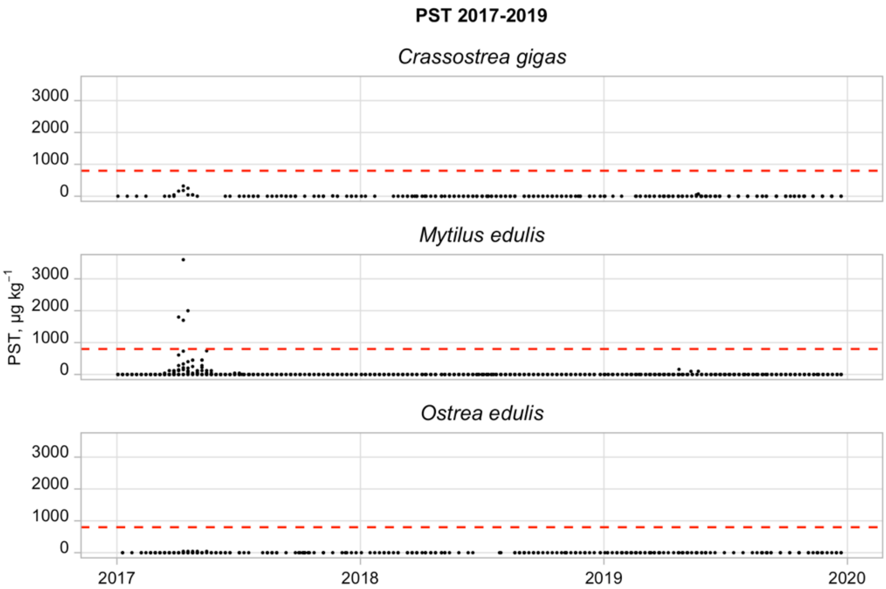
Concentrations of Diarrhetic Shellfish Toxins (DST) above the regulatory limit were detected in *Mytilus edulis* in summer 2018. *Dinophysis acuminata* is likely to be the causative organism.



Concentrations of Dinophysis Shellfish Toxins in bivalves from the Swedish Skagerrak coast 2017-2019. The red lines denotes the regulatory limit. Data from the Swedish National Food Agency monitoring program.

PST and *Alexandrium*

Concentrations of Paralytic Shellfish Toxins (PST) were above the regulatory limit in spring 2017. Harvesting areas were closed during these events. The high concentrations of PST in 2017 coincided with high abundances of *Alexandrium* spp. Concentrations of PST were below the regulatory limit in bivalves 2018 and 2019. Abundances of *Alexandrium* spp. were low these years.



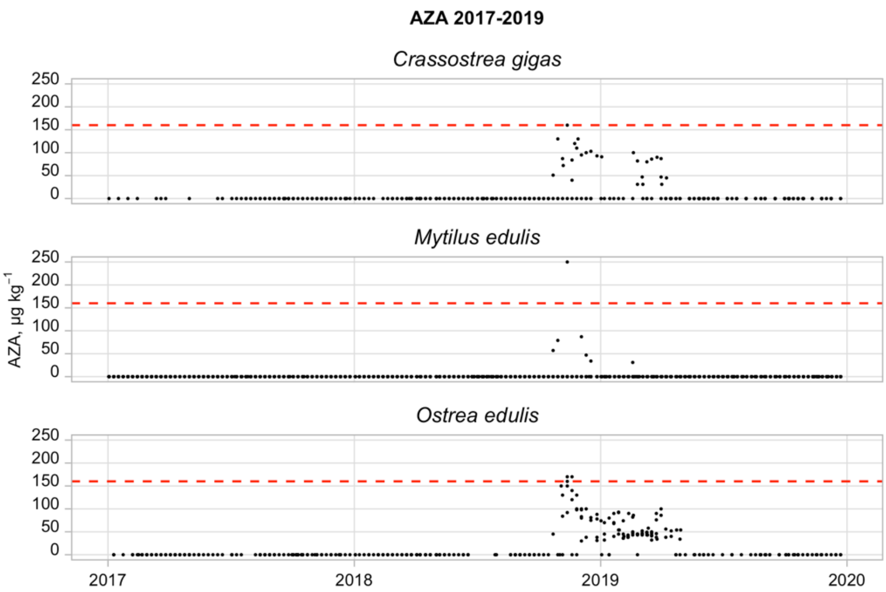
Concentrations of Paralytic Shellfish Toxins in bivalves from the Swedish Skagerrak coast 2017-2019. The red lines denotes the regulatory limits. Data from the Swedish National Food Agency monitoring program.

YTX, *Lingulodinium* and *Protoceratium*

Yessotoxins (YTX) above the regulatory limit were not detected in any of the harvested shellfish in years 2017-2019. The dinoflagellates *Lingulodinium polyedra, Protoceratium reticulatum* and *Gonyaulax spinifera* are common in the area and are likely to be the producers of yessotoxins.

AZT and *Azadinium*

Concentrations of Azaspiracidic Shellfish Toxins (AZT) above the regulatory limit were detected in *Mytilus edulis*, *Ostrea edulis* and in *Crassostrea gigas* in November 2018. This is the first report of AZT above the regulatory level for bivalves harvested in Sweden.



Concentrations of Azaspriacidic Shellfish Toxins in bivalves from the Swedish Skagerrak coast 2018. The red lines denotes the regulatory limit. The differents symbols represent different samling locations. Data from the Swedish National Food Agency monitoring program.

AST and *Pseudo-nitzschia* spp.

Concentrations of Amnesic Shellfish Toxins (AST) above the regulatory level were not detected in years 2017-2019. High cell numbers (100 000 to 250 000 cells L^{-1}) of *Pseudo-nitzschia* spp. were observed in October to December 2017.

The Netherlands: National Report 2017–2019

Marnix Poelman, Wageningen Marine Research, the Netherlands

Methodology

In 2017-2019 the shellfish production areas; North Sea, Lake Grevelingen, Wadden Sea, Oosterschelde and Veerse Meer were monitored for the presence of toxic phytoplankton and phycotoxins. This program is performed as part of the National Shellfish Food Safety Program, with sampling frequencies on a monthly basis from November until April and a weekly basis from May until October. The results are used as an early warning mechanism for potential presence of toxins in the shellfish (mussels, oysters, Ensis and cockles).

Wageningen Food safety Research (WFSR), Wageningen UR has been responsible for the toxin analysis. Wageningen Marine Research is responsible for phytoplankton analyses.

Results 2017

In total 337 phytoplankton samples have been collected at a total of 13 sampling locations.

Alexandrium ostenfeldii is reported in the marine system in Lake Grevelingen and Lake Veere. These reports were based on samples from the end of July and the beginning of august 2017, the cell counts were low with a maximum of 180 cells per litre. In the Eastern part of the Eastern Scheldt maximum levels below 80 were reported.

Dinophysis acuminata is mainly reported in the production areas Lake Veere and Lake Grevelingen. Abundance was highest, in Lake Veere in the end of July and August. *D. acuminata* levels reached up to 9.500 cells per litre in week 39. Toxins (OA eq) were found at levels up to 44 µg OA-eq per kg of shellfish product in week 30. Followed by a rapid decrease in the following two weeks.

In Lake Grevelingen *D. acuminata* has been found present throughout the period of June until September 2017. The observed pattern is fluctuating in cell concentrations, with regular drops in cell abundance. In weeks 31 through 36 only low back ground levels were reported. Two peaks of *D. acuminata* occurred in this area. Maximum levels in the first peak reached 1,700 cells per litre. During the second peak the maximum cell abundance was 600 cells per litre. No toxins were reported in this area.

The threshold value for *Pseudo-nitzschia* sp. was reached in May with maximum values of 1.5 million cells / litre, which was above the Dutch trigger limit of 500.000 cells / litre. The reports of these high values were in the production areas in the North Sea. *Pseudo-nitzschia sp*. was also reported in the Wadden Sea at levels up to 910,000 cells /per litre in week 20 (May). Toxicity of Domoic Acid has not been reported.

In 2017 no toxins were found above the regulatory limit, nor were they reported in back ground levels. Monitoring was performed for lipophilic toxins (OA, DTX, AZA), Domoic Acid (DA) and derivatives, STX and derivatives.

Spirolides were reported in back ground levels in most of the analysed samples. Wageningen Food Safety Research was responsible for the toxin analysis.

In 2017 monitoring on Tetrodotoxins (TTX) was also implemented in the official monitoring program, and additional research programs. The threshold level for TTX was set by the Dutch authorities at 44 ug per kg of shellfish product. TTX has been reported in the period of Mid-June until the beginning of July (3 weeks). These levels reached just below the threshold level. TTX peaked for one week and two weeks in different areas in the Eastern Scheldt (Eastern part and Northern branch) mussels followed by a decrease below detection levels. There were no closures of shellfish production areas.

Results 2018

In total 349 phytoplankton samples have been collected at a total of 13 sampling locations.

Alexandrium ostenfeldii is reported in the marine system in the Lake Grevelingen, Wadden Sea and Eastern Scheldt. These reports were based on samples from resp. week 25, 33, and 37, the cell counts were low with a maximum of 60 cells per litre. No toxins were observed.

Dinophysis acuminata was observed mainly in the production areas Lake Veere and Lake Grevelingen (results in Figure 1a). Abundance was highest, in Lake Veere in the end of July and August. *D. acuminata* levels reached up to 5,000 cells per litre in week 29-30. Toxins (OA eq) were found at levels up to 23 µg OA-eq per kg of shellfish product in week 30. Followed by a rapid decrease in the following two weeks.

In Lake Grevelingen *D. acuminata* has been found present throughout the period from June until September 2018. The pattern which was observed, showed fluctuating cell concentrations, with regular drops in cell abundance. In week 34 and 35 the maximum cell densities increased to 1300-1400 cells per litre. In weeks 30 through 37 only low back ground levels were reported (maximum 180 cells/litre). The second peak the maximum cell abundance was 600 cells per litre. No toxins were reported in this area.

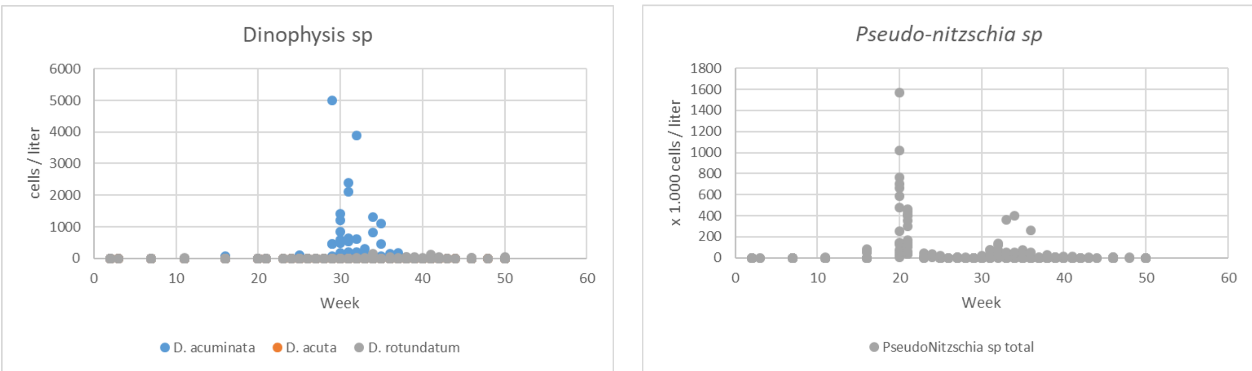


Figure 1a and b. Overview of potential harmful algae levels from Dutch monitoring data. A) *Dinophysis* species, mainly *Dinophysis acuminata* and *Phalacroma rotundatum* (*D. rotundata*). B) *Pseudo-nitzschia sp.*

The threshold value for *Pseudo-nitzschia* sp. was reached in May with maximum values of 1.5 million cells / litre, which was above the Dutch trigger limit of 500.000 cells / litre. The reports of these high values were in the production areas in the North Sea (figure 1b). *Pseudo-nitzschia sp.* was also reported in the Wadden Sea at levels up to 910.000 cells /per litre in week 20 (May). Toxicity of Domoic Acid has not been reported.

In 2018 no toxins were found above the regulatory limit, nor were they reported in back ground levels. Monitoring was performed for lipophilic toxins (OA, DTX, AZA), Domoic Acid (DA) and derivates, STX and derivates.

Spirolides were reported in back ground levels in most of the analysed samples.

Pinnatoxins were reported in back ground levels in most of the analysed samples. Pinnatoxin G was detected in shellfish from the North (Wadden Sea) in June and July (max ~20 ug / kg product). Pinnatoxin G is detected in shellfish from the Southern region throughout the period March till September. 13,19 SPX-1 most abundant in may till July in both areas (max 15 ug / kg product).

In 2018 monitoring on Tetrodotoxins (TTX) was also implemented in the official monitoring program, and additional research programs. The threshold level for TTX was set by the Dutch authorities at 44 ug per kg of shellfish product. TTX has been reported in the period of Mid-June until the beginning of July (3 weeks). TTX is detected in the Eastern Scheldt in levels below the Limit of quantification (< LOQ (20µg/kg)) in 3 mussel and 8 oyster samples. Maximum levels in the official programme were reported at 50µg/kg and 54µg/kg (both oyster) in (22-29 June 2018). TTX peaked for two weeks in different areas in the Eastern Scheldt (Eastern part) mussels followed by a decrease below detection levels. There was a three weeks closures of shellfish production areas (week 25-27).

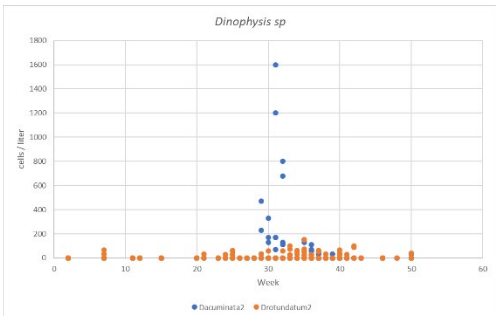
Results 2019

In total 423 samples were analysed for marine biotoxins (up to 07-10-2019), this year 321 phytoplankton samples have been collected at a total of 13 sampling locations.

Alexandrium ostenfeldii is not reported in the marine system as the previous years in Lake Grevelingen and Lake Veere.

Dinophysis acuminata is mainly reported in the production area Lake Grevelingen. Abundance was highest, in the end of July and August. *D. acuminata* levels reached up to1.600 cells per litre in week 31. Toxins (OA eq) were found at levels up to 21 µg OA-eq per kg of shellfish product in week 30. Followed by a rapid decrease in the following week. The detection of OA coincided with the detection of PTX, which matches a single point detection for *Phalachroma rotundatum*.

Phalocroma rotundatum has been seen in back ground levels (maximum 150 cells per litere) in the North Sea with different observations throughout the year (week 25 till week 42) and Wadden Sea (Figure 2a).



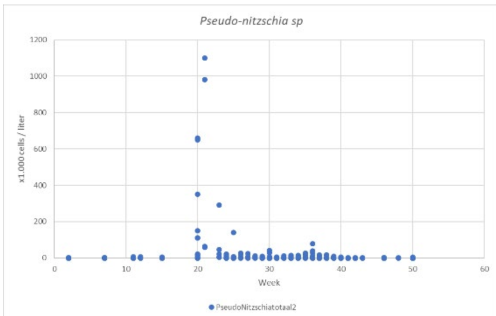


Figure 2a and b. Overview of potential harmful algae levels from Dutch monitoring data. A) *Dinophysis* species, mainly *Dinophysis acuminata* and *D. rotundata* (*Phalacroma rotundatum*). B) *Pseudo-nitzschia sp.*

The threshold value for *Pseudo-nitzschia* sp. was reached in May with maximum values of 1.1 million cells / litre, which was above the Dutch trigger limit of 500.000 cells / litre. The reports of these high values were in the production areas in the North Sea. *Pseudo-nitzschia sp*. was also reported in the Wadden Sea at levels up to 600.000 cells /per litre in week 20-40 (figure 2b). Toxicity of Domoic Acid has not been reported.

In 2019 no toxins were found above the regulatory limit, nor were they reported in back ground levels. Monitoring was performed for lipophilic toxins (OA, DTX, AZA), Domoic Acid (DA) and derivates, STX and derivates.

In 2019 monitoring on Tetrodotoxins (TTX) was as previous years implemented in the official monitoring program, and additional research programs (Figure 3). The threshold level for TTX was set by the Dutch authorities at 44 ug per kg of shellfish product. TTX has been reported in the period of Mid-June until the beginning of July (3 weeks). TTX peaked for one week and two weeks in different areas in the Eastern Scheldt (Eastern part and Northern branch) mussels followed by a decrease below detection levels. There were closures of shellfish production areas.

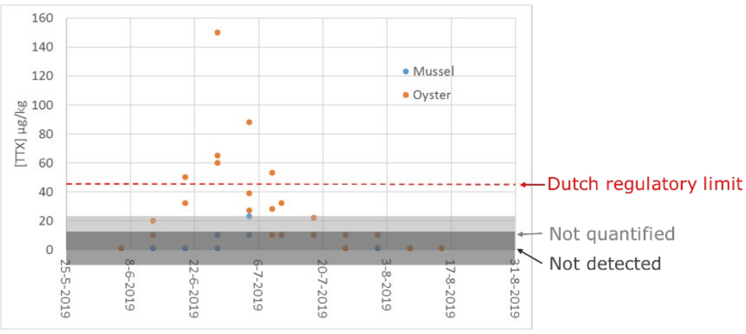


Figure 3. TTX levels from the Dutch official monitoring programme.

United Kingdom: National Report 2017–2019

Scotland

Sarah Swan, Scottish Association for Marine Science, UK

Pseudo-nitzschia and ASTs

During 2017 *Pseudo-nitzschia* spp. cells were found in 90.82% of all samples analysed and were present throughout the year. *Pseudo-nitzschia* spp. counts in excess of 50,000 cells per litre (threshold level) were recorded in 9.25% of the samples. Blooms were detected between March and October, and were most frequently observed in July. The densest *Pseudo-nitzschia* spp. blooms were observed in Aith Voe (Shetland Islands) on 10th July and Loch Roag: Linngeam (Lewis & Harris) on 20th June, where cell counts reached 2,380,351 and 1,979,708 cells/L, respectively. Domoic acid levels in shellfish did not exceed the regulatory limit of 20 mg/kg during the year.

During 2018 *Pseudo-nitzschia* spp. cells were present in 1,189 (91.4%) of the 1,301 samples analysed. Blooms occurred between March and October and were most frequently observed in June. *Pseudo-nitzschia* spp. counts at or above the trigger level (set at 50,000 cells/L for Scotland) were recorded in 59 samples (4.5%), with 13.7% of the samples analysed in June exceeding this level. The densest *Pseudo-nitzschia* spp. bloom of 2018 was recorded in East Loch Tarbert (Lewis & Harris) on 27th June, where cell counts reached 1,528,134 cells/L. Domoic acid levels in shellfish did not exceed the regulatory limit of 20 mg/kg during the year.

During 2019 *Pseudo-nitzschia* spp. cells were present in 1,212 (92.4%) of the samples analysed. *Pseudo-nitzschia* counts at or above the trigger level (set at 50,000 cells/L for Scotland) were recorded in 70 samples (5.3%), with 10.6% of the samples analysed in August exceeding this level.

The densest *Pseudo-nitzschia* bloom of 2019 was recorded in Loch Glencoul (Highland: Sutherland) on 6th August, where cell counts reached 508,124 cells/L. Domoic acid levels in shellfish did not exceed the regulatory limit of 20 mg/kg during the year.

Alexandrium spp and PSTs

During 2017 *Alexandrium* cells were present in 28.42% of the total samples analysed. They were reported at or above the trigger level (set at 40 cells/L) in 19.25% of all samples, mostly between June and July. Blooms were detected in areas around Argyll & Bute and in the Highland region during spring (March and April), but blooms were infrequently recorded in all other regions during this time, and indeed around the Shetland Islands throughout the whole of 2017. PSP toxicity was associated with *Alexandrium* spp. recorded at sites on the west coast and western isles all in June and early July. The highest values comes from Loch Stockinish on 14th June 2017 at 4450 ug STX eq/kg.

During 2018 *Alexandrium* cells were detected in 436 (33.5%) of samples analysed and above the trigger level (set at 40 cells/L) in 322 samples (24.7%). There were no closures of shellfish harvesting areas due to levels of PSTs exceeding regulatory thresholds of 800 ug STX eq/kg.

During 2019 were detected in 337 (25.7%) of the samples analysed during 2019. They were reported at or above the trigger level (set at 40 cells/L) in 204 samples (15.6%). Levels of PSTs only exceeded regulatory thresholds once in 2019 at Loch Laxford on 4th June 2019; 1436 μg STXeq/kg.

Dinophysiales and DSTs

During 2017 *Dinophysis* spp. and *Phalacroma rotundatum*, were present in 37.82% of the samples analysed during 2017. Cells were observed at or above threshold level (set at 100 cells/L) in 13.77% of the samples analysed .The majority of *Dinophysis* spp. blooms occurred around the Scottish coast in June, July and August. Closures of shellfish harvesting areas due to levels of DSTs > 160 OA eq μg/kg were also enforced during this time. The highest concentration of DSTs was recorded in shellfish from Loch Laxford; 1054 ug OA eq/kg. Blooms were also recorded around the Shetland Islands, mainly between June and August. Only three harvesting sites in Shetland had levels of DSTs > 160 OA eq μg/kg.

During 2018 *Dinophysis* spp. and *Phalacroma rotundatum*, were present in 627 (48.2%) of samples analysed. They were observed at or above trigger level (set at 100 cells/L) in 290 samples (22.3%) between April and October with the majority of blooms observed in June and July. *Dinophysis* spp. blooms were widespread around most of the Highland region between May and July, with cell counts at Loch Laxford (Highland: Sutherland) reaching 167,625 cells/L on 10th July. Blooms were also reported around the Shetland Islands at the same time, The total percentage of *Dinophysis* spp. at or exceeding trigger level during the current reporting period (22.3%) was the highest since 2013 (27.5%) and frequently resulted in DSP toxins above regulatory level, particularly in common mussels.

During 2019 *Dinophysis* and *Phalacroma*, were present in 552 (42.1%) of the samples analysed and were observed at or above trigger level (set at 100 cells/L) in 208 samples (15.8%). *Dinophysis* blooms were widespread around most of the Highland region, Loch Fyne and Shetland and were associated with shellfish closures.

Other species

2017: The dinoflagellates *Protoceratium reticulatum* and *Lingulodinium polyedra* were not particularly abundant. The potentially problematic dinoflagellate *Karenia mikimotoi* was not observed in densities likely to negatively impact aquaculture during 2017. Cell counts were low in 2017, with a maximum density of 1,940 cells/L recorded in Loch Torridon (Ross & Cromarty) on 18th July.

2018: The dinoflagellates *Protoceratium reticulatum* and *Lingulodinium polyedra* were not particularly abundant. Cell counts of *Karenia mikimotoi* in 2018, with a maximum density of 1,240 cells/L recorded at Kyle of Tongue (Highland: Sutherland) on 27th June.

2019: The dinoflagellates *Protoceratium reticulatum* and *Lingulodinium polyedra* were not particularly abundant. Cell counts of *Karenia mikimotoi* were higher than in 2018, with a maximum density of 2,574,796 cells/L recorded at Arisaig (Highland: Lochaber) on 27th August. Bloom densities of 807,089 cells/L were observed in Loch Kanaird (Highland: Ross & Cromarty) on 4th September, and 181,081 cells/L at Traigh Mhor (Uist & Barra) on 26th August.

England

Adam Lewis, CEFAS, UK

Pseudo-nitzschia and ASTs

During 2017 *Pseudo-nitzschia* species were recorded in 590 samples from 50 production areas. The trigger level (set at 150,000 cells/L) was exceeded on 12 occasions from 6 production areas. The highest cell density was recorded in a sample from Lantivet Bay: Sandheap Point collected on 15 August (893,000 cells/L). Domoic acid levels in shellfish did not exceed the regulatory limit of 20 mg/kg during the year.

During 2018 *Pseudo-nitzschia* species were recorded in 452 samples from 46 production areas. The trigger level was exceeded on 7 occasions from 6 production areas. Domoic acid levels in shellfish did not exceed the regulatory limit of 20 mg/kg during the year.

During 2019 *Pseudo-nitzschia* spp. cells were recorded in 532 samples from 46 production areas. The trigger level was exceeded on 16 occasions from 9 production areas. Domoic acid levels in shellfish did not exceed the regulatory limit of 20 mg/kg during the year.

Alexandrium and DSTs

During 2017 *Alexandrium* spp. cells were recorded in 50 samples from 22 production areas. The Salcombe production area recorded two results above the regulatory limit between 09/08/2017 and 22/08/2017. The Fowey production area recorded one result above the regulatory limit (1590 µg/kg) on 01/08/2017.

During 2018 *Alexandrium* species were recorded in 46 samples from 19 production areas. There were no closures due to PSTs exceeding the regulatory threshold.

During 2019 Alexandrium species were recorded in 20 samples from 9 production areas. Recorded maximum cell density was greater than last year, with a density of 1,240 cells/L recorded from Fowey: Pont Pill on 12 August. Mussel samples from Fowey contained PSTs above the regulatory limit. The maximum PSP toxin level was 4,766 μg [STX di-HCl eq.]/kg recorded in a sample collected on 19/08/2019.

Dinophyceae and DSTs

During 2017 members of Dinophyceae were recorded in 75 samples from 28 production areas. The trigger level (set at 100 cells/L) was exceeded by 21 samples from 12 production areas. Samples from Lyme Bay contained DSTs above the regulatory limit on the 12/07/2017 and 01/08/2017. The highest concentration during this event was recorded in a sample collected on 12/07/2017 (236 μg/kg).

During 2018 Dinophysiaceae were recorded in 158 samples from 24 production areas. The trigger level (set at 100 cells/L) was exceeded by 78 samples from 21 production areas. Lipophillic toxins were recorded above the regulatory threshold during the months of May to October 2018. All results exceeding the regulatory threshold were recorded in the South West with all but one sample collected from Cornwall. The highest levels of DSTs were recorded in mussels from Sandheap point on the 28/08/2018, 4199 μg/kg.

During 2019 Dinophysiaceae (lipophilic toxins producers) were recorded in 85 samples from 29 production areas. The trigger level (set at 100 cells/L) was exceeded by 33 samples from 16 production areas. Samples from three sites in the south west of England DSTs above the regulatory limit from the end of May to early June 2019. The maximum level recorded was 499 μg/kg from Ropehaven outer. Six cases of illness of DSP was reported during the summer of 2019. This case is described in Young *et al.*, (2019).

Other species

The dinoflagellates *Protoceratium reticulatum* and *Lingulodinium polyedra* were infrequently observed throughout the reporting period.

Reference

Young, N., Robin, C., Kwiatkowska, R., Beck, C., Mellon, D., Edwards, P., Turner, J., Nicholls, P., Fearby, G., Lewis, D. and Hallett, D., 2019. Outbreak of diarrhetic shellfish poisoning associated with consumption of mussels, United Kingdom, May to June 2019. *Eurosurveillance*, *24*(35), p.1900513.

Northern Ireland

April McKinney, AFBI, UK

Pseudo-nitzschia and ASTs

During 2017 *Pseudo-nitzschia* were present in all 7 monitored areas and in 286 samples. There were no closures due to ASTs exceeding the regulatory threshold of 20 mg/kg during the year.

During 2018 Pseudo-nitzschia cells were present in all 7 monitored areas and in 260 samples (42.1%). The trigger level of ≥150,000 cells L^{-1} was breached twice. There were no closures due to ASTs exceeding the regulatory threshold of 20 mg/kg during the year.

During 2019 cells from the *Pseudo-nitzschia* genus were present in all 7 monitored areas and in 412 samples. A maximum abundance of 648,400 cells L^{-1} was recorded in Dundrum Bay. There were no closures due to ASTs exceeding the regulatory threshold of 20 mg/kg during the year.

Alexandrium and PSTs

During 2017 *Alexandrium* spp. cells were recorded in 5 of the 7 areas monitored and were present in 4% of samples analysed. There were no closures of shellfish harvesting areas due to levels of PSTs exceeding regulatory thresholds of 800 ug STX eq/kg.

During 2018 *Alexandrium* spp. cells were recorded in 5 of the 7 areas monitored and were present in 3.1 % of samples analysed. There were no closures of shellfish harvesting areas due to levels of PSTs exceeding regulatory thresholds of 800 ug STX eq/kg.

During 2019 *Alexandrium* spp. cells were recorded in 4 of the 7 areas monitored and were present in 2.4 % of samples analysed. The trigger level for *Alexandrium* spp. (≥ 40 cells L^{-1}) was breached on only 2 occasions during the year with a maximum cell abundance of 120 cells $L^{-1.}$ There were no closures of shellfish harvesting areas due to levels of PSTs exceeding regulatory thresholds of 800 ug STX eq/kg.

Dinophyceae and DSTs

During 2017 target species belonging to the family Dinophysiaceae were recorded in 5 monitored areas. Dinophysis spp. were present in 12% of samples with the trigger level of ≥ 100 cells L^{-1} being breached on 17 occasions. There were no closures due to DSTs exceeding the regulatory threshold.

During 2018 Target species belonging to the order Dinophysiales were recorded in all seven monitored areas and in 13% of samples analysed. The trigger level of ≥ 100 cells L^{-1} was breached on 26 occasions. Lipophilic toxins were detected above the regulatory level in shellfish samples from areas where *Dinophysis acuta* was detected above the trigger level in Dundrum Bay. The maximum recorded value of okadaic acid in mussels was 1165 µg/kg (29th August) for oysters the maximum recorded was 579 µg/kg (3rd September).

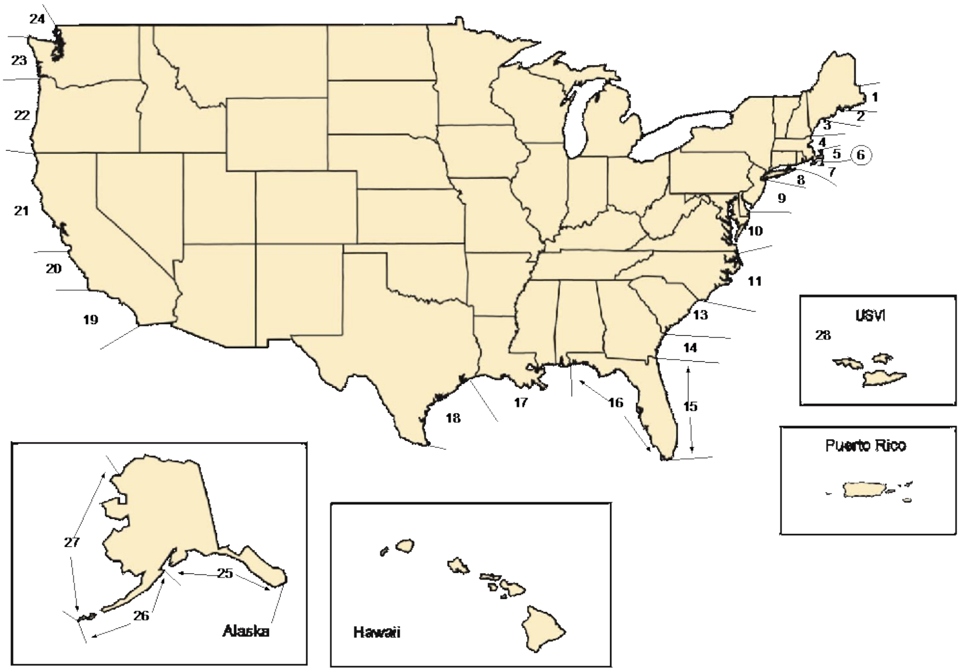
During 2019 target species belonging to the Order Dinophysiales were recorded in all the monitored areas and were present in 21.7% of samples analysed. Two beds in Dundrum Bay were closed in August until early September. Both were mussel beds with maximum toxicity recorded at 261 and 170 µg/kg respectively.

Other species

The dinoflagellates *Protoceratium reticulatum* and *Karenia mikimotoi* were infrequently observed throughout the reporting period.

USA: National Report 2017–2019

Don Anderson, Woods Hole Oceanographic Institution



New England (Regions 1-7)

PSP

2017. In Maine shellfish closures due to PSP occurred along the coastline at various times from early May through July 23rd with saxitoxin concentrations up to 3776 µg/100g. PSP toxicity in New Hampshire was more short-lived beginning on June 2nd and terminating on July 21st with a maximum toxicity of 1571 µg/100g shellfish.

For the 1st time since 2014, shellfish beds on the north shore of Massachusetts were briefly closed from June 22nd through July 18th when PSP test results on blue mussels rose to 115 µg/100g shellfish. Harvest was also banned in the Nauset Marsh from May 3rd – June 10th, with a small portion remaining closed until June 27th.

2018. A mandatory closure from April – October for mussels, European oysters and carnivorous snails has been implemented in Maine, however, additional closures were needed in regions 1 and 2 for surf, razor, soft-shell, and quahog clams which exceed quarantine concentrations of saxitoxin. The maximum *Alexandrium catenella* cell density recorded was 13,080 cells/L.

In Massachusetts, saxitoxin was detected at Nauset Estuary for the second year in a row, peaking at 523µg/100g. This resulted in a closure for all shellfish from April 4th to June 15th, to the detriment of commercial and recreational shellfisheries.

2019. PSP: A widespread and prolonged bloom of *Alexandrium catenella* extending from the Canadian border to the south shore of Massachusetts was responsible for shellfish closures at various intervals from April through August. This was the 1st time since 2007 that both the north and south shores of Massachusetts required a closure due to PSP (June 19th – July 19th) with saxitoxin concentrations reaching 388µg/100g shellfish. In Maine, there is a mandatory closure from April – October for mussels, European oysters and carnivorous snails, however, additional closures were needed in Regions 1, 2 and 3 for differing times and different species of clams including surf, razor, soft shell and quahogs.

New Hampshire also has a mandatory closure in the Hampton Harbor area from May 31st until November 1st, however, PST levels exceeding quarantine were recorded on May 9th in this section of the shoreline. Star Island, which is 7 miles off the NH coast was closed for shellfishing from 5/8/19 until 8/9/19 due to PSP. In Little Bay, where PST is rare, quarantine levels were almost reached at 70µg/100g in June resulting in 2 precautionary closures based on Scotia Rapid Assays. These closures were suspended once assay results were confirmed by mouse bioassay to be below action levels.

Also, in Massachusetts, PSP was detected in shellfish from the Nauset Estuary for the third year in a row, peaking at 289µg/100g. This resulted in a shellfishing ban from April 25th to June 6th.

One low measurement of saxitoxin in shellfish of 41 µg/100g was returned from samples collected in Palmer Cove, Groton Connecticut on June 13th. Subsequent measurements of shellfish were negative. This is now 16 consecutive years that Connecticut has not experienced any shellfish closures due to HABs.

Conclusion 2017–2019. In all three years, PSP resulting from *Alexandrium catenella* blooms in the Maine, New Hampshire and Massachusetts had a significant impact on shellfish resources at various times from April through December.

ASP

2017. As was the case in 2016, shellfish quarantines were required in Maine and Rhode Island due to domoic acid (DA) concentrations exceeding the regulatory limit of 20 ppm brought on by *Pseudo-nitzschia* spp. blooms. In Maine, DA was detected on September 10th and persisted until December 26th with concentrations reaching 60.4 ppm. The rapid accumulation of toxin by blue mussels prompted an immediate recall of this shellfish species following the quarantine order. As a result of this recall, along with one in 2016, state regulators adopted a new guideline for shellfishery closures. Beginning in April 2018, when domoic acid is found in plankton (water samples), the harvesting of shellfish will be provisionally banned in that region.

From March 1st through March 24th, southern Narragansett Bay, Rhode Island, shellfishing was banned as domoic acid concentrations as high as 32 ppm were found in northern quahogs (*Mercenaria mercenaria*). While no ASP-related shellfish closures were required in Massachusetts, high densities of *Pseudo-nitzschia* spp. which typically do not produce high DA concentrations were documented. However, *P. australis*, which is highly toxic, was identified in Massachusetts waters for the 1st time.

2018. Implementing new regulations, Maine officials closed the waters between the southern tip of Petit Manan and the southern tip of Pond Point on Great Wass Island on September 7th as a result of elevated concentrations of domoic acid found in the plankton coincident with a *Pseudo-*

nitzschia bloom. During this closure, domoic acid toxin concentrations in shellfish peaked at 42 ppm on 9/18 and the area was reopened on 11/30.

Rhode Island experienced a brief *Pseudo-nitzschia* bloom in Narragansett Bay in June, with a peak of 60,000 cells/L and domoic acid present in the water, but shellfish tests all had values less than 1ppm so no closures were instated.

2019. Domoic acid levels in shellfish ranging from 0.81 to 22.24µg/g impacted the coast of Maine from August to December 2019. The highest *Pseudo-nitzschia* cell densities were observed from September through December with a maximum concentration of 63,750 cells/L, which prompted the provisional shellfish bed closures.

In Rhode Island, short-lived blooms of *Pseudo-nitzschia* were experienced from late May to early June and also in early August with maximum cell densities of 250,000 cells/L. Scotia rapid tests on plankton detected domoic acid but LC-MS/MS analyses of shellfish were well below threshold limits of 20ppm and no closures were implemented.

Conclusion: High density blooms of domoic acid producing *Pseudo-nitzschia* spp, have resulted in shellfish closures in Maine and Rhode Island suggest that domoic acid toxicity is now a significant additional threat to New England's shellfishery.

DSP

2017. No DSP toxicity was reported in New England.

2018. Maine was the only state in the region to register a closure of shellfish beds due to DSP from 6/7/2018 – 8/9/18. The closure was a result of a long-lasting *Dinophysis norvegica* bloom during the months of May through August where cell concentrations reached 130,000 per liter and toxicity ranged from 0.06 to 0.196 ppm. This was an unusual case where tests with the PP2A assay were positive, but LC/MS tests for OA, DTX1, and DTX2 were negative. These conflicting findings were confirmed by several laboratories. Further analysis confirmed the presence of a new toxin – dihydro-dinophysistoxin 1 - that is being further characterized.

2019. Low levels of DSP toxins, 7µg/100g were measured in Maine shellfish on July 8th which was below the regulatory limit of 16µg/100g shellfish even though high concentrations of *Dinophysis* were documented from May through August. In Massachusetts, a precautionary closure was implemented in the Nauset Estuary, from 7/10 – 7/19 due to the very high densities of *Dinophysis acuminata* found in water samples but the ban on shellfish harvesting was curtailed when low toxicity shellfish measurements were obtained from the FDA.

New York (Long Island; Region 8)

PSP

2017. Three shellfish closures occurred in James Creek, Shinnecock Bay, and for the first time in Deep Hole Creek. Maximum *Alexandrium catenella* cell densities of 90,000, 19,000 and 1,000 cells/L respectively, were recorded during the April to June timeframe when the blooms occurred.

2018. *Alexandrium catenella* returned to the Long Island coastline in 2018 from April 9 through May 29, at concentrations up to 8,778 cells/L. This resulted in shellfish toxin concentrations above

80μg/100g triggering closures in several north shore locations including, western Shinnecock Bay, Northport Harbor, and Huntington Harbor. Estuaries along the south coast - Great South Bay, Moriches Bay, Quantuck Bay, Shinnecock Bay, and East Hampton as well as Flanders Bay, Peconic Bay, and the Peconic River, all had elevated *Alexandrium* cell concentrations reaching 5,040 cells/L but no shellfish beds were impacted by elevated PSP concentrations.

2019. *Alexandrium catenella* was present in water samples collected from the North shore of Long Island (Cold Spring Harbor, Northport Harbor, Port Jefferson Harbor), the Peconic Estuary (Flanders Bay, Peconic Bay, Peconic River), as well as the South shore (Great South Bay, Moriches Bay, Quantuck Bay, Shinnecock Bay and East Hampton) from early April to late May. Of those sites where *Alexandrium* populations were found, PSP toxicity exceeding regulatory limits of 80μg/100g occurred in Northport Harbor, Steers Canal, Terry Canal and Meetinghouse Creek during the month of May.

Conclusion: For 3 consecutive years, shellfish beds were closed due to PSP concentrations exceeding quarantine levels. In the nine years prior to 2017, there have been only 2 years, 2014 and 2016, where shellfish beds have not been closed, thus, PSP can be considered to be an annual threat to Long Island coastal waters.

DSP

2017. There were no New York Department of Environmental Conservation closures due to DSP toxins.

2018. *Dinophysis acuminata* was detected on both the north and south shores of Long Island from April 9 through June 25 with maximum cell densities of 3,612 cells/L that gave rise to okadaic acid concentrations in SPATT collectors ranging from 65-185 μg/kg. On the north shore, Cold Spring Harbor, Northport Harbor, Port Jefferson Harbor, Flanders Bay as well as the Peconic Bay system, 73-198 μg/kg DSP toxins collected with SPATTs were measured using the okadaic phosphatase assay with *Dinophysis* concentrations reaching 50,400 cells/L.

2019. A brief shellfish bed closure due to DSP toxicity occurred in Old Fort Pond from July 11 to July 18 resulting from high densities of *Dinophysis acuminata*. Blooms of *D. acuminata* were also were found during the months of April through July in multiple coastal locations including Great South Bay, Moriches Bay, Quantuck Bay, Shinnecock Bay and East Hampton with cell concentrations exceeding 10,000 cell/L.

Conclusions. Blooms of *Dinophysis acuminata* occur in a number of Long Island embayments and occasionally they are accompanied by DSP toxicity as measured in shellfish and SPATT samples.

Brown tide

2017. From May 5th through October 31st, brown tide affected over 100km of shoreline within multiple estuaries including: Great South, South Oyster, Quantuck, Moriches, Shinnecock, Moneybogue and Hewlett Bays. This marks the 11th consecutive year that *Aureococcus* cell densities have exceeded 1.5 billion cells/L in this region.

2018. Brown tides affected fish and benthic life on the New York coastline this year from May 7th to July 23rd, reappearing at some sites at the end of October. 100km of coastline were impacted. *Aureococcus anophagefferens* was present at 622 million cells/L, marking the first time in 12 years that the concentrations did not exceed 1.5 billion cells/L. *Synechococcus* spp., however, was present in excess of 3 billion cells/L.

2019. This was the 2nd consecutive year in 13 years that cell concentrations of the brown tide organism, *Aureococcus anophagefferens,* did not exceed 1.5 billion cells/L, but like last year, *Synechococcus* spp., was present in excess of 3 billion cells. Impacted waterways include: Great South Bay, South Oyster Bay, Quantuck Bay, Moriches Bay, Shinnecock Bay and Moneybogue Bay where the blooms began as early as May 22 and persisted into mid-late July and then reappeared at various sites at lower concentrations during the end of October.

Conclusions. Concentrations of brown tide were less pronounced in 2018 and 2019, as compared to the previous 11 years where cell concentrations exceeded 1.5 billion cells/L.

Margalefidinium

2017. *Margalefidinium polykrikodies* has bloomed annually on Long Island since 2004 causing water discoloration and unexplained toxicity in shellfish (*Argopecten irradians*) and fish (*Menidia menidia*) as a result of very high cell densities exceeding 7,000,000/L. This year, Shinnecock Bay, Peconic Bay, Shag Harbor, and Three Mile Harbor waters were impacted from June through September.

2018. Cells were first detected as early as May in most locations along the south shore (Shinnecock Bay, Sag Harbor, Great South Bay, and East Hampton) but as late as August in others, the bloom persisted until mid-September at all sites and covered more than 100km of shoreline at its peak. Cell densities at Conscience Bay on the north shore of Long Island reached 4,530,000 cells/L.

2019. Specific areas affected this past year include: Shinnecock Bay, Sag Harbor Bay, Great South Bay, and East Hampton. The 2019 blooms began in July and dissipated by early September with maximum cell concentrations of 25,000,000 cell/L which were significantly higher than those witnessed in 2018 where cell concentrations reached ~4,500,000 cells/L.

Conclusions. Since 2004, significant water discoloration and shellfish mortalities have resulted from dense blooms of *Margalefidinium polykrikodies* in various locations throughout Long Island.

New Jersey and Delaware (Region 9)

Chatonella

2017. Low oxygen conditions resulted from a very localized *Chatonella* spp. bloom (400,000,000 cells/L) which were suspected of promoting avian botulism and the poisoning of ducks. Abraxis kit test results for neurotoxic shellfish poisoning were also conducted and were negative.

ASP

2017. *Pseudo-nitzschia* spp. concentrations of greater than 10,000 cells/L were found in the Sandy Hook/Raritan Bay area during the month of September. Abraxis domoic acid test kit results were negative on all shellfish samples.

2018. The New Jersey coastline experienced a *Pseudo-nitzschia* spp. event from December 2017 to April 2018, with a peak of 240,000 cells/L in Barnegat Bay. The bloom originated in open Atlantic waters but moved into the coastal bays and concentrated there. Water testing showed low concentrations of domoic acid, but shellfish tissue did not. No human health issues were reported.

2019. There were no *Pseudo-nitzschia* concerns in 2019.

Conclusions. Like other regions within US, New Jersey managers will have to remain vigilant on the potential threat of *Pseudo-nitzschia* populations to contaminate shellfish in their local waters.

Maryland, Virginia and North Carolina (Regions 10 & 11)

In 2018 and 2019, no significant algal blooms were reported within the waterways of Virginia. Even the *Margalefidinium polykrikodies* bloom that is often widespread and dense in most years was absent or greatly reduced in magnitude. Listed below are the various bloom events that have caused problems and concerns primarily within the Chesapeake Bay. While loss of habitat as a result of brown tide events is a considerable concern, to date, toxins including NSP, PSP, ASP and DSP that could be associated with other bloom organisms including *Karenia papilionacea and Karlodinium veneficum* and those mentioned below, have only been detected at very low concentrations. Resource officials remain hopeful that this trend continues.

North Carolina representatives once again reported that no HABs impacted their coastal waters from 2017 – 2019, and this has been a similar result for a number of years.

Brown tide

2017. Chincoteague Bay has suffered major losses of seagrass beds due to persistent annual blooms of *Aureococcus anaphagefferens* with cell concentration of more than 100,000,000/L reported.

PSP

2017. While PSP toxicity has not been documented in the Chesapeake Bay, high concentrations of cells in the *Alexandrium minutum* complex (>25,000,000/L), first detected in 2015, were recorded throughout the mid-bay area (Patuxent, Potomac, Eastern Bay, main bay).

2019. An *Alexandrium minutum* bloom located along the northern Maryland Atlantic coastal region within the St Martin River Bishopville Prong waters occurred in late May through early June. PSP toxicity results of shellfish samples were negative.

ASP

2017. High densities of *Pseudo-nitzschia* spp. exceeding 800,000 cells/L were found in water samples collected in the Isle of Wight Bay. Elisa test kit results for domoic acid were negative.

DSP

2018. *Dinophysis* spp. was reported in a small canal in Delaware Bay, peaking in mid-May at 1,560,000 cells/L. No toxicity information are available.

2019. From 6/6 to 8/5/19 a *Dinophysis acuminata* bloom located near the Ocean City inlet was documented but shellfish samples from the affected area were negative for DSP.

Levanderina fissa

2019. A dense bloom of *Levanderina fissa* (formerly *Gymnodinium instriatum*) leading to a fish and crab mortality event in the Potomac River was documented from July 24th to August 14th. The bloom stretched from Colonial Beach, VA to Ragged Point Beach, VA with the mortality epicenter due to hypoxia occurring in the region of Westmoreland, VA.

General Conclusions. HAB organisms responsible for PSP, DSP and ASP are often found in the regional waters at high concentrations and warrant monitoring when bloom conditions exist. Thankfully, toxins associated have with the blooms have remained low and have not triggered an event closure.

South Carolina and Georgia (Regions 13 & 14)

In 2017 no report was submitted, and in 2018 and 2019, no significant HAB blooms were reported.

Florida (Regions 15 & 16)

NSP

2017. Two significant, and persistent *Karenia brevis* blooms were documented in 2017 affecting the southwest coastal waters. The first began in September of 2016 and continued until mid-June of 2017 with cell densities exceeding 12,000,000/L. The second bloom, with cell concentrations greater than 6,000,000/L arose on October 2nd and continued through 2018. During both of these blooms, which were extensive but patchy, there were reports of multiple fish kills, wildlife mortalities and respiratory irritation. Shellfish harvest is banned when cell concentrations exceed 5,000/L, but nonetheless, in March recreationally harvested gastropods (likely conch or whelk) resulted in documented human illnesses. Unfortunately, no meal remnants remained for testing. When cell concentrations drop below 5,000/L, and toxin levels are less than 20MU/100g shellfish, areas are reopened for harvest.

2018. The persistent *Karenia brevis* bloom which began in October of 2017 persisted through all of 2018 in Southwest Florida with multiple reports of extensive fish kills, wildlife mortality (birds and marine mammals), and human respiratory irritation as a result of cell densities as high as 90,000,000 per liter. The bloom was extensive but patchy and occurred in inland, coastal and offshore locations causing major losses to the all-important tourist industry. ELISA analysis of brevetoxin concentrations in *Mercenaria* and *Crasseotrea* were measured at 24 and 73.7 ppm respectively, however, all shellfish harvest was banned when cell concentrations exceed 5,000/L which varied by location.

The high concentrations of *K. brevis* were transported from the Gulf through the Florida Keys and up the east coast including Brevard, Indian River, St. Lucie, Martin, Palm Beach, Broward, and Miami-Dade counties from 9/29/18 – 11/18/18. Cell concentrations as high as 11,000,000/L caused widespread fish mortalities and human respiratory irritation.

In Northwest Florida, including the panhandle area, *Karenia brevis* populations with cell densities as high as 1,536,120/L were recorded. Shellfish quarantines were enacted from 9/4/18 – 11/29/18 as a result of the bloom, and, as was the case in the southwestern and eastern shores of the state, cases of fish mortalities and human respiratory irritation were recorded.

2019.

This year, two blooms of *Karenia brevis* impacted the southwest Florida coast that were patchy and extensive. They occurred in inland, coastal, and offshore areas, including Lower Tampa Bay, Sarasota Bay, Charlotte Harbor, Florida Bay and along and offshore of the adjoining coastal areas. The 1st bloom was a continuation of the pervasive and devastating bloom that began in October of 2017 and finally terminated on July 4th 2019. During this bloom there were multiple reports of extensive fish kills, wildlife mortality (birds and marine mammals), and human respiratory irritation as a result of cell densities as high as 90,000,000 per liter. The 2nd bloom began on September 30th and lasted until December 7th, 2019 although some areas were still closed to shellfishing at the close of the year as a result of NSP concentrations of 88ppm as detected with ELISA, and 50 mouse units per 100 grams shellfish confirmed by mouse bioassay.

Conclusions. *Karenia brevis* blooms have been a persistent problem along the Florida coast causing shellfish closures, multiple fish kills, marine mammal, bird and turtle deaths, human respiratory irritation and significant economic losses related to the cleanup of beaches and waterways as well as decreased revenues to waterfront merchants due to reduced traffic and tourism flow.

PSP

2017. In the Indian River Lagoon, on the East Coast of Florida, high cell densities of *Pyrodinium bahamense*, 17,643,865 cells/L, caused water discoloration and closures of shellfish beds based on these high cell densities. PSP toxin values of up to 51 µgSTX equivalents per 100g shellfish were also recorded. As was the case last year, shellfisheries were closed from May to October and no human illnesses were reported.

2018. Tampa Bay experienced concentrations greater than 5,000,000 cell per liter of *Pyrodinium bahamense* during the height of the bloom which occurred from April through late September. Shellfishing was already banned in this area thus precluding the necessity of PSP testing.

High concentrations (>6,000,000 cells/L) of *Pyrodinium bahamense* were also measured in the Indian River Lagoon from 8/9/18 to 11/19/18. Once again, no shellfish closures were enacted as the area was closed due to a sewage spill.

2019. Pine Island Sound in southwest Florida experienced a *Pyrodinium bahamense* bloom from June 11th through August 12th. The area was seasonally closed so testing for PSTs was not conducted until prior to reopening. For this, hard shell clams were tested using the Neogen Reveal 2.0 assay and no toxins were detected.

In the Indian River Lagoon, *Pyrodinium bahamense* was found in very high cell concentrations from mid-May – mid-October with maximum cell densities of 1,557,768 cells/L giving rise to saxitoxin concentration in shellfish of up to 7,900µg/100grams. The area was reopened to shellfishing on 10/10/19 when bloom conditions had improved.

Conclusions. In Florida, PSP has been responsible for shellfish bed closures as a result of annual localized *Pyrodinium bahmense* blooms on both east and west coasts.

Brown tide

2017. High densities of the brown tide organism *Aureoumbra lagunensis* were once again seen in the Indian River Lagoon.

2018. A patchy but often times dense bloom of *Aureoumbra lagunensis* with cell concentrations exceeding 100,000,000/L was found in the northern and central Indian River Lagoon from mid-September and persisted through the New Year.

2019. A dense bloom of *Aureoumbra lagunensis* with cell concentrations exceeding 200,000,000/L, has been a persistent concern in the central and northern India River Lagoon since late 2015. Finally, in mid-September of 2019 cell concentrations dropped below the Florida Fish and Wildlife operational threshold of 200,000,000/L but cells were still present.

Conclusions. *Aureoumbra lagunensis* brown tide events are common in the Indian River Lagoon with patchy, high density blooms that are occasionally associated with fish kills.

ASP

2017. A commercial shellfish closure in Saint Joseph Bay on the Florida west coast due to domoic acid concentrations of up to 32 ppm shellfish tissue occurred from late July through late September. This area routinely has high concentrations of *Pseudo-nitzschia* spp. exceeding 1,000,000 cells/L.

2018. No ASP toxicity was reported in Florida waters in 2018.

2019. No ASP toxicity was reported in Florida waters in 2019.

Conclusions. The shellfish bed closure in 2017 was the 2nd incident of ASP in Florida with the 1st occurring in 2013. For now, these appear to be random closures, but high densities of *Pseudo-nitzschia* are commonly found in these waters so toxic blooms could become more pervasive.

Central Gulf Coast (Region 17)

NSP

2017. There were no reported HAB events in region 17 this past year. *Karenia brevis* and associated NSP impacts including shellfish bed and beach closures, as well as fish and marine mammal mortalities, periodically impact the central Gulf of Mexico waters.

2018. *Karenia brevis* was present along the Alabama coastline from Florida Point to Fort Morgan during the month of November with cell densities up to 250,000 cells/L. The bloom was characterized by water discoloration, high cell concentrations, and impacts on fish and shellfish. A shellfish closure from November 5th – December 3rd was issued due to cell densities exceeding 5000 cells/L, however, brevetoxin was only detected at low concentrations (<1.8ppm, ELISA assay) in local oysters tested during the bloom.

2019. Alabama did not experience any *Karenia* blooms in 2019.

Conclusions. It should be noted that Mississippi and Louisiana did not contribute to the survey during this time period. Nonetheless, periodic shellfish bed and beach closures along with fish and marine mammal mortalities resulting from *Karenia brevis* blooms periodically impact the central Gulf of Mexico waters.

Cyanobacteria

2019. A large, and long-lasting cyanobacteria bloom plagued the Mississippi coastal beaches beginning on June 22nd and extending through October 8th. This was a result of high-volume discharges from the Mississippi River through the Bonnet Carre spillway that carried the blue-green and nutrient laden waters into the coastal waters sufficiently lowering the salinity and increasing nutrient levels to promote the blooms along 21 Mississippi beaches. This resulted in fish and marine mammal deaths and created economic hardship in communities surrounding the waterways.

Texas (Region 18)

NSP

2017. There were no reported HAB events in region 18 in 2017, however, over the course of the past six years, *Karenia brevis* blooms have caused fish kills, shellfish bed closures and human respiratory irritation.

2018. A significant bloom of *Karenia brevis* occurred along Texas Gulf Coast this year just as it has for six of the last ten years. This, impacted resident fish populations and humans. Low cell concentrations were recorded from Galveston to the Rio Grande, while the highest *Karenia* concentrations coincided with a fish kill near Corpus Christi, at concentrations of 340,000 cells/L. The localized bloom was initially characterized by a fish mortality event of gizzard shad, gulf menhaden, and mullet with reports of respiratory irritation on September 12 in Packery Bay, Nueces County. Respiratory irritation was also reported at Mustang Island State Park in the same time frame. *Karenia* was recorded at low concentrations at the Houston Ship Channel, Matagorda Bay, Port O'Connor, Mustang Island State Park, and Packery Channel through October 8, with no further reports of fish kills or human respiratory distress.

2019. No *K. brevis* bloom events were noted in 2019.

Conclusions. Similar to the Florida Gulf Coast, near annual blooms of *Karenia brevis* are responsible for fish kills, shellfish bed closures and respiratory irritation.

DSP

2017. At the beginning of March, IFCB data showed increasing abundances of *Dinophysis ovum* and a closure of shellfish beds was issued. The closure was extended to Matagorda and Corpus Christi Bays and lasted over one month.

2018. No shellfish closures related to DSP toxins were reported.

2019. No shellfish closures related to DSP toxins were reported.

Conclusions. Periodic episodes of elevated concentrations of *Dinophysis ovum* and DSP occur in the Corpus Christi region.

Brown Tide

2017. No brown tide event was reported.

2018. The Laugna Madre experienced a significant *Aureoumbra lagunensis* brown tide bloom during the month of April.

2019. No brown tide event was reported.

Conclusions. In frequent blooms of *Aureoumbra lagunensis* are witnessed in Laugna Madre.

California (Regions 19, 20, 21)

PSP

2017. Monterey Bay experienced two separate PSP events in 2017. The first began in January and lasted almost two months, and another started at the end of August and terminated early in October. Sonoma County also experienced a brief PSP event in October. California mussels and giant rock scallop were the main fisheries species affected, with maximum toxin concentrations of 1812 and 507 µg/100g shellfish respectively. The median toxin level for all mussels above the alert level was 162 µg/100g shellfish. PSP is somewhat common along the entire California coast, and similar events have occurred in years past.

2018. *Alexandrium* spp. blooms occur every year along the California coastline at levels of varying severity. In 2018, there was one major PSP event, beginning simultaneously in January in San Luis Obispo and Monterey counties. While it was once rare for *Alexandrium* blooms to be found north of the Bay, by March the bloom had spread into Marin, Sonoma, the Bay Area, including the peninsula. In April, the bloom was found as far south as Santa Barbara and Ventura counties, while remaining as far north as Sonoma. The bloom was over by May, but elevated PSP was found in rock scallops as late as August in Monterey. California mussels were affected along the entire coastline from January through early May, registering levels from 206 µg/100g shellfish in Southern California to 4760µg/100g in Northern California, although that particular spike was an outlier from a seasonal average of 341µg/100g in the area. Rock scallops in Northern California registered PSP levels as high as 946µg/100g from January through August. Other species of note included cultured Pacific oysters (544µg/100g), gaper clams (588µg/100g), Washington clams (110µg/100g), and bay mussels (216µg/100g).

One human intoxication was reported from the recreational harvest in Northern California.

2019. Paralytic Shellfish Poisoning as a result of *Alexandrium catenella* blooms is common along entire California coast. On June 3rd and extending until June 30th the Central California coast, including San Luis Obispo and Santa Barbara Counties, Region 20, experienced a brief shellfish quarantine as a result of toxicity in Pacific Oysters and California Mussels which had concentrations of 172 and 451µg/100g shellfish respectively.

In region 21, Northern California, specifically, Sonoma, Santa Cruz and Marin Counties, 3 PSP events requiring closures were documented in 2019. The first was in Santa Cruz and lasted from April 24 until May 5, the second event in Sonoma and Marin Counties, had the highest concentration of PSTs with these findings: Pacific Oyster (*Crassostrea gigas*) 82µg/100g; California Mussels (*Mytilus californicus*) 734µg/100g; Gaper Clam (*Tresus nuttallii*) 192µg/100g; Washington Clam 133µg/100g. A 3rd quarantine was implemented in Sonoma County when mussel PST values exceeded regulatory limits of 80µg/100g shellfish from August 8 – September 20.

Conclusions. PSP related shellfish bed closures are common along the California coast, however, there are occasional years where saxitoxin concentrations do not reach quarantine levels.

ASP

2017. For the third year in a row, domoic acid (DA) was found along the California coastline at various times of year. Contaminated shellfish and arthropods necessitated fisheries closures, and marine mammal health was affected. *Pseudo-nitzschia* blooms are common in Santa Barbara, the Northern Channel Island region, and Monterey Bay. However, these events are historically more rare north of San Francisco, making mussel contamination in Del Notre County this year notable. Mussel contamination along the coastline occurred in the spring through late June. Bay mussels and razor clam registered particularly high toxicities, with maximums of 350 and 390 ppm respectively. Razor clams tested positive for toxin year-round, and domoic acid was found to be more highly concentrated in the muscle tissue than the viscera.

Spiny lobster near Santa Cruz and North Coast Dungeness crab reached quarantine levels in late September and continued into December, with maximum toxin levels of 730 and 150 ppm respectively. Rock crabs in Santa Barbara channel were found to have elevated toxin levels on April 19th. In the Northern and Central California region, rock crabs had elevated toxin levels on January 16th, June 2nd and August 8th.

2018. Domoic acid from *Pseudo-nitzschia* blooms was detected for the fourth year in a row off the coast of California in 2018. Razor clam harvest remains closed, as it has been since April 2016 due to slow deputation of domoic acid by this species of clam. Levels of DA had dropped during summer, but they returned to the range of 330 ppm later in the year. The Dungeness crab season was significantly delayed from late September until December due to domoic acid levels up to 110 ppm, causing major economic upheaval in the commercial crabbing industry. Rock crab also experienced several partial closures in 2018 that carried over from 2017, some lifting as issued as early as January 16 while some remained in place until April 20th. The California Spiny Lobster was subject to two closures in 2018, the first one from January 1 through 25 and the second from October 17 through November 16. Domoic acid levels ranged from 6.3 to 210 ppm with an average of 78.3 ppm. Domoic acid was also detected in California mussels from late August to late October, at levels up to 87 ppm.

There were 73 marine mammal strandings mainly in Mendocino-San Luis Obispo Counties with symptoms fitting ASP in 2018. These peaked in June with 29 California Sea Lions exhibiting signs of domoic acid toxicity. DA levels in animal body fluids that were tested ranged from below the detectable limits to 6228.9 mg/mL.

2019. In 2019, domoic acid concentrations ranging from below detectable limits to 110mg/mL were found in urine, feces or stomach contents of stranded marine mammals. Up to 100 California sea lion strandings due to suspected DA toxicosis were documented in May to July with another significant incident from August to November where up to 20 animals were involved.

In consumable seafood products, the action limit for domoic acid is 20ppm. This level was exceeded for a significant period of time in the Northern California counties of Mendocino, Del Norte and Humboldt, Region 21, from 3/18/19 – 10/14/19 for razor clams where concentrations of ASP toxins up to 450ppm were detected. This resulted in year-long harvest restrictions for razor clams in Northern California waters. California mussels in this same area were also tainted with domoic acid with concentrations ranging between 23 and 31ppm during the month of October.

Conclusions. California seafood and marine life are deeply impacted by domoic acid toxicity produced by *Pseudo-nitzschia* blooms.

Oregon (Region 22)

PSP

2017. In 2016 there were no closures due to PSP, however, in 2017, there were multiple areas on the mid and north Oregon Coast where shellfish harvesting was banned with concentrations as high as 149 µg/100g saxitoxin during the month of October.

2018. There were no PSP closures in Oregon in 2018, in contrast to multiple site closures in 2017.

2019. PSP concentrations as high as 291µg/100g in California mussels along the south coast were detected toward the end of the year as a result of an *A. catenella* bloom which began in September and terminated in December.

Conclusions. Similar to California, Oregon is typically impacted by saxitoxin related closures in most years, and within those years, the severity and breadth of the quarantine can be highly variable.

ASP

2017. There are areas of the Oregon coast that have been closed due to DA toxicity in razor clams for several consecutive years. This year, approximately half of Oregon Coast was closed for domoic acid in razor clams, and an ASP evisceration order was put in place for commercial Dungeness crab landed in the south. Levels peaked in April on the South Jetty of Columbia river at 120 ppm. A secondary bloom presumed to originate in the southern Oregon Coast peaked in December at Gold Beach with concentrations reaching 270 ppm, and at this time, levels as high as 62 ppm were detected in Dungeness crab viscera from the same area. DA toxicity caused significant and costly disruptions to the Oregon Dungeness crab fishery.

2018. As they have been for the past three years, razor clam harvest remains closed on the Oregon coast due to domoic acid levels up to 230 ppm. Coupled to this, *Pseudo-nitzschia* blooms severely impacted the Dungeness crab fisheries with DA levels up to 99 ppm measured in crab viscera. Dungeness crab is the most economically important fishery in Oregon, but domoic acid toxicity once again closed recreational crab fishing and delayed the start of the commercial season leading to a drop in market confidence due to the delays and closures.

2019. Domoic acid as high as 73 ppm was found in Dungeness crab viscera in January 2019. The crab was harvested from regions bordering California which also had quite high DA levels around that time. It is speculated that razor clams in that same area were also tarnished by DA, which has been true for several years, but officials were having difficulty collecting clams for testing as their abundance has become much reduced along the south coast so no results were available.

The domoic acid in the crab viscera resulted in a recall having to be issued for crab harvested from the affected area. The recalled crab could only be sold if eviscerated by licensed processors. No sales of whole or live crab from the quarantined area was permitted for approximately two months.

Conclusions. For 6 consecutive years, the commercial and recreational seafood industries were adversely affected by domoic acid toxicity.

DSP

No closures due to DSP were reported in 2017 and 2018, as was the case in 2015 and 2016.

Washington (Regions 23-24)

The Washington State coastal waterways which encompass regions 23 and 24 are plagued by annual HAB events caused by *Alexandrium catenella*, *Dinophysis* spp. and *Pseudo-nitzschia* spp. In 2019, the Straits of Juan de Fuca experienced closures due to DSP, ASP and PSP. It is the first time all three toxins were found in concentrations above action limits one growing area.

PSP

2017. This year saw a continuation in the annual PSP events that began in Puget Sound in 2012 with *Alexandrium catenella* being the causative species. The central section of Puget Sound experienced closures for over six months, from July 2017 into February 2018. Contaminated species included blue mussels, butter clams, geoduck clams, littleneck clams, manila clams and pacific oysters. Toxin levels were measured by mouse bioassays, reaching levels as high as 2535 µg/100g shellfish for blue mussels. Northern Puget Sound experienced saxitoxin contamination from June until the end of November. Mouse bioassays indicated contamination levels of up to 763 and 309 µg/100g shellfish in blue mussels and pink scallops respectively. Southern Puget Sound experienced a briefer PSP season, with closures from September until October. PSP closures along coastal beaches extended from June through November. In the Strait of Juan de Fuca, shellfishery closures due to PSP risk occurred from April 2017 though January 2018. Species registering high saxitoxin levels included blue mussels, littleneck clams, and geoduck clams, measuring up to 518, 163, and 447 µg/100g shellfish respectively.

2018. PSP closures continued to occur throughout Puget Sound and the Strait of Juan de Fuca in 2018 in response to *Alexandrium catenella* blooms, as they have since 2012. The North Sound experienced two closures, from April to July and then again from September through January of 2019, focused on blue mussels, manila clams, Pacific oysters, and pink scallops. Mouse bioassay testing detected saxitoxin at levels from 134µg/100g (pink scallops) to 4567µg/100g shellfish (blue mussels). The Central Sound had one closure from August through November, targeting blue mussels, butter clams, geoduck clams, littleneck clams, manila clams, and Pacific oysters. Saxitoxin peaks ranged from 209µg/100g (Pacific oysters) to 5761µg/100g (blue mussels). The South Sound experienced a minor blue mussel closure from September to October with a saxitoxin peak at 123µg/100g. The Strait of Juan de Fuca was closed for blue mussels, butter clams, manila clams, and geoduck clams from September through December with saxitoxin levels of 83µg/100g (geoduck clams) to 370µg/100g (blue mussels).

This was an unusual year, with a dip in PSP levels in July and August, but strong blooms in the fall, resulting in closures throughout Puget Sound and the Strait of Juan de Fuca.

2019. The only zone that did not require closures due to elevated levels of PSTs was the Hood Canal. Working from north to south, the Strait of Juan de Fuca had closures due to PSP on the eastern and western straits shore from about 6/24/19 – 11/26/19 with PST concentrations in blue mussels of more than 6,000µg/100g. Concentrations in Manila clams, Pacific oysters and Geoduck were in the range of 335 - 446µg/100g shellfish. In the North Puget Sound, a closure that began in September 2018 terminated on January 14 but a new event was realized on June 2nd which lasted until October 24th with toxicity found in blue mussels (1158µg/100g), Pacific oysters (1557 µg/100g) and butter clams (199 µg/100g). There were closures in the Central Puget Sound as a result of PSP between 7/3/19 and 11/4/19 with blue mussels having the highest amount - 757 µg/100g. No PSP quarantines were necessary in the South Puget Sound or in the Hood Canal region but closures were required along the coastal beaches where 1276 µg/100g saxitoxin equivalents in blue mussels were found when shellfishing was prohibited from 7/29 – 10/30/19.

Conclusions. PSP continues to be a serious annual concern for the Washington State recreational and commercial shellfish interests.

ASP

2017. *Pseudo-nitzschia* blooms disrupted razor clam harvest along Washington State's coastal beaches. ASP closure events that began in Fall 2016 extended into April 2017. A second round of closure began in May and concluded in July and was followed by a third closure that started in November and continued until May of 2018. LC assays were used to measure domoic acid concentration, which reached a maximum of 53 ppm.

2018. As noted above, the razor clam ban that began in late 2017 continued to May 2018 with measured concentrations up to 21 ppm.

2019. 2019 was a relatively quiet year for ASP related closures with only one occurring in the Strait of Juan de Fuca from November 4th to December 2nd which was based on a single sample above the action limit (33ppm). The last closure due to ASP in the Puget Sound area occurred in 2005. Razor clams and Dungeness Crab from the coastal beach areas all tested below action levels so no restrictions we were imposed beyond normal mandatory closures.

Conclusions. ASP has been occurring along the Washington State coastline since 1991 and closures of shellfish and Dungeness Crab fisheries are of great concern to the local economy as well as to the health of the community.

DSP

2017. The entirety of Puget Sound experienced DSP closures due to *Dinophysis* blooms in 2017. In Southern Puget Sound, DSP closures began at the end of August and have continued into 2018. Blue mussels, rock scallops, and cockles have been most affected, with okadaic acid maximums of 250, 27 and 19 µg/100g shellfish respectively, measured by LC/MS assays. Central Puget Sound was closed from August through November, with blue mussels reaching toxin concentrations of 242 µg/100g shellfish. In Northern Puget Sound, closures began on July 7th and continued until August 15th. DSP also affected the Strait of Juan de Fuca from August through December, disrupting fisheries for blue mussels, manila clams, pacific oysters and rock scallop. The maximum toxin concentration recorded for blue mussel in Northern Puget Sound was 35 µg/100g.

2018. *Dinophysis* blooms caused closures in all of Puget Sound in 2018, as well as in the Strait of Juan de Fuca and off the coastal beaches of Washington State. North Puget Sound was closed for blue mussels from July to October, due to okadaic acid levels up to 44µg/100g shellfish as detected with a LC/MS assay. The central sound was also closed for blue mussels, with toxin concentrations of 44µg/100g, but the closure was longer, lasting from May until late November. The South Sound did not experience a late summer bloom, instead closing for blue mussels from January into February for toxin levels of 30µg/100g. The Strait of Juan de Fuca recorded higher toxin concentrations than the main body of Puget Sound, with a peak of 69µg/100g in blue mussels. This resulted in a closure from July through September. The coastal beaches recorded fairly low concentrations of okadaic acid in California mussels, at 16µg/100g, but this still resulted in a closure from November into December of 2018.

2019. Since 2012, DSP shellfish quarantines have been required in the Washington State coastal zone and 2019 was not an exception to this now annual event. Okadaic acid concentrations above the regulatory limit of 16µg/100g were found from May 5th – September 3rd in the Strait of Juan de Fuca while the North Puget Sound had to close briefly on two occasions - 1/10 – 1/24 and 8/1 – 8/20 as a result of DSP contamination. The Central Puget Sound had blue mussels with very high DSP levels (106µg/100g) during the 8/7/19 - 9/20/19 closure. In the South Puget Sound, the DSP event began on November 22nd and continues into 2020 with 85µg/100g in blue mussels and 46µg/100g in rock scallops. No DSP closures were required for Hood Canal or the coastal beaches.

Conclusions. Since the first toxicity and closures reported in 2011, DSP has become a serious and persistent problem for Washington state.

Alaska (Regions 25-27)

PSP

2017. Butter clams harvested from Sadie Cove, Kachemak Bay in August had some of the highest saxitoxin concentrations measured in this region of Alaska, 6624 µg/100g shellfish tissue. Around the same time, PSP levels of 575µg/100g were found in bivalves from St. George, a small island in the Bearing Sea that is part of the Pribilof Island chain. *Alexandrium* spp. was the causative organism in both situations. For the 2nd consecutive year, monitoring by the Southeast Alaskan Tribal Ocean Research (SEATOR) group identified additional PSP hot spots in the Alaskan panhandle (region 25) beginning in early June. This was earlier than normal, however, most of these locations reopened by mid-July.

In the Bering Straits region between mid-August and the end of September, 39 dead walrus have been identified with a suspected link to saxitoxin poisoning. Gut contents of one freshly harvested animal had saxitoxin levels exceeding 800 ng/g.

2018. On the whole, the Aleutian Islands reported cooler water temperatures and less severe PSP events for 2018 than in 2017. There was one major spike in the butter clam population in July at Sand Point, Alaska, where levels rose to 1250µg/100g shellfish; this was the highest recorded concentration since June of 2016. The Aleutian Pribilof Islands Association has begun testing fin fish species for PSP and found low, but detectable levels in the viscera and flesh of forage fish, multiple salmonid species, and halibut from Prince William Sound, Cook Inlet, and the Aleutian Islands.

In Kachemak Bay, PSP levels were also low with a maximum concentration of 33-35µg/100g shellfish during the summer season.

The Southeast Alaskan Tribal Ocean Research group (SEATOR) continues to monitor 38 sites for PSP and provide advisories when biotoxins are detected in butter clams, horse clams, blue mussels, and cockles at various sites. The highest recorded levels for this past year were in butter clams, peaking in October in Kake, Alaska, at 1712µg/100g.

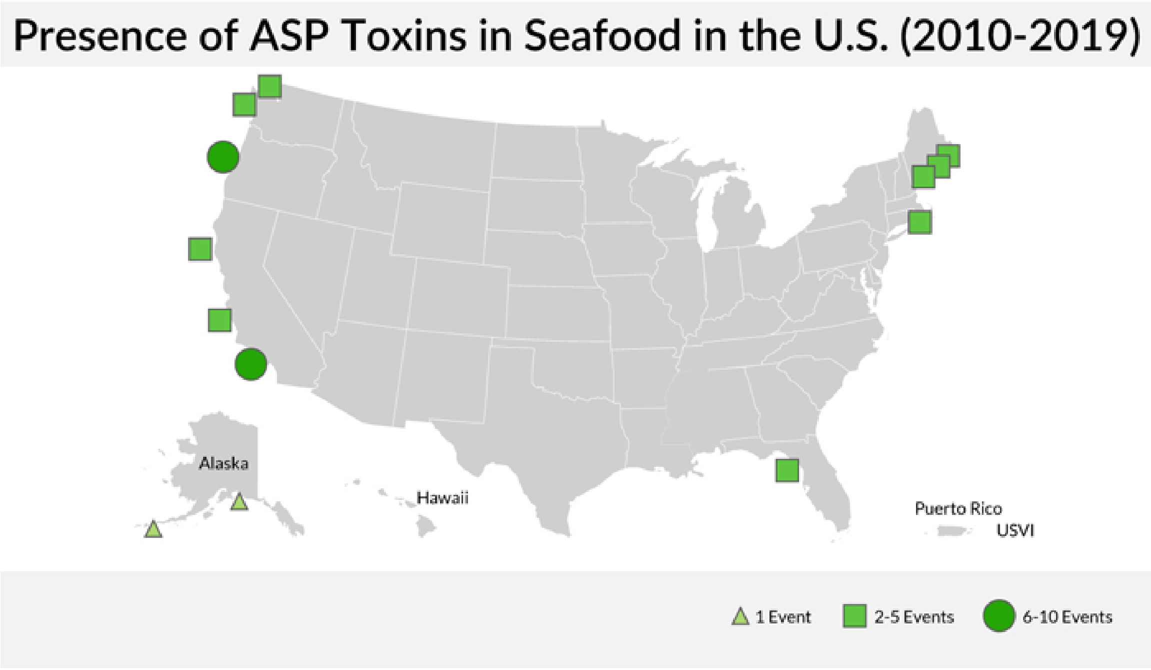
2019. Alaska (Regions 25-27)

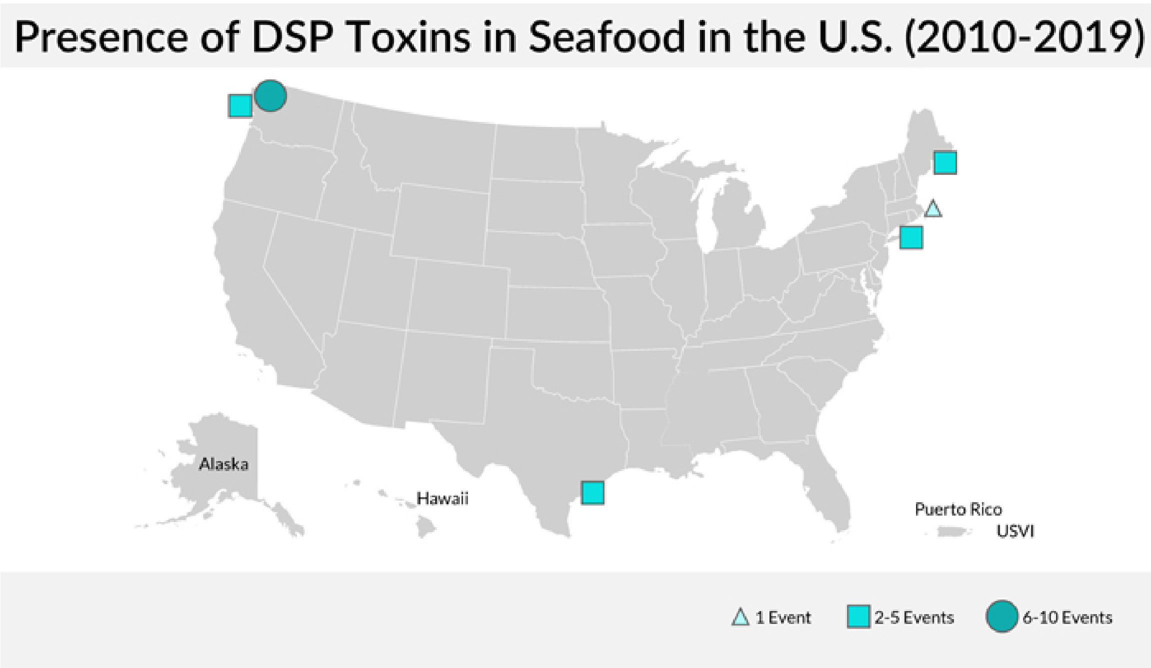
A long duration, high toxicity PSP event along the Alaskan Panhandle determined by SEATOR monitoring found saxitoxin concentrations over 4,000µg/100g in a blue mussel sample during the event which lasted from April 9 until October 15.

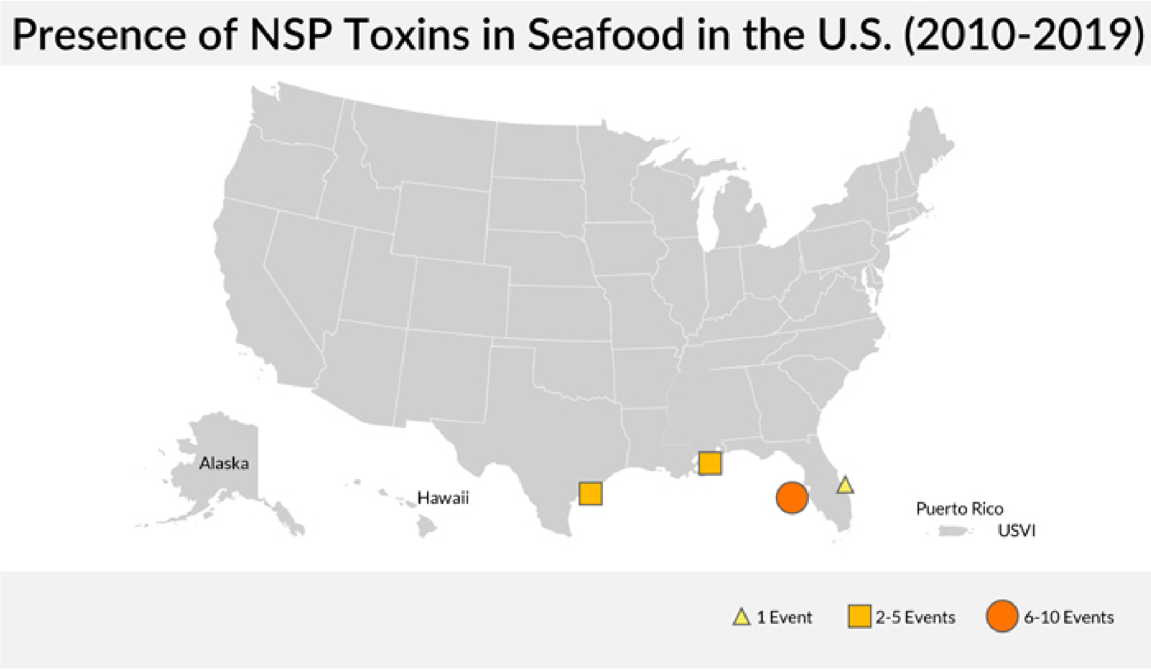
Recent research data from the Anderson Lab reveals high *Alexandrium catenella* cyst and cell concentrations in the Chukchi Sea/Arctic Ocean which helps to support a possible link between marine mammal and sea bird deaths in the Arctic and saxitoxin poisoning.

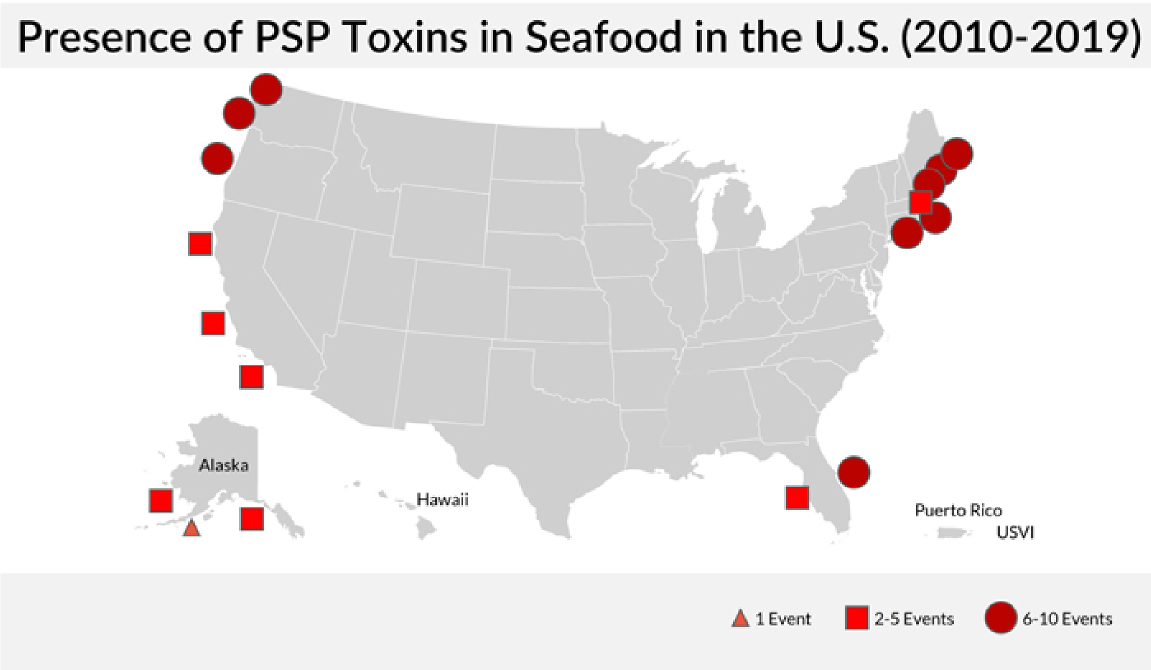
Conclusions. Alaska has persistent but variable annual PSP shellfish related toxicity. Given its extensive shoreline, the state does not conduct routine monitoring of these resources except for commercially harvested product. However, due to the effort of 16 Native Tribes in Southeast Alaska who have joined together to create the Southeast Alaskan Tribal Toxins network (SEATT) testing is now routinely conducted to safeguard harvesters in the Alaskan Panhandle.

Although this is a three-year summary, the United States decadal event maps for ASP, DSP, NSP and PSP are presented below.



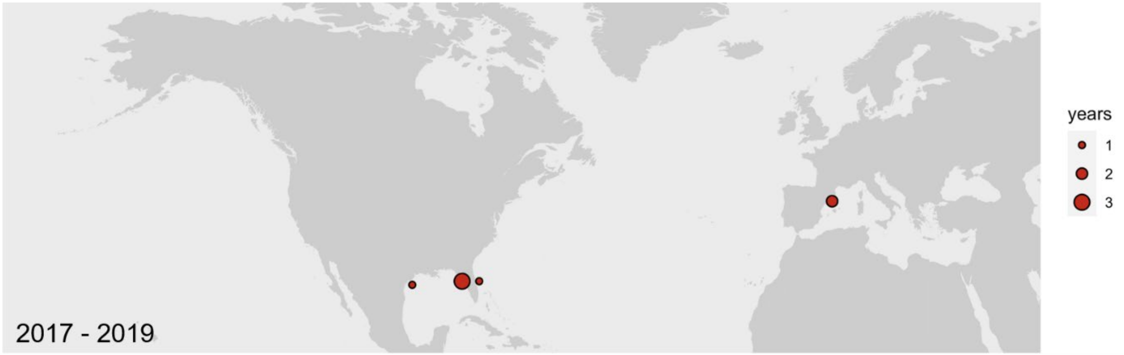



Presence of NSP Toxins in Seafood in the U.S. (2010-2019)
Alaska
Hawaii
Puerto Rico
USVI
1 Event
2-5 Events
6-10 Events

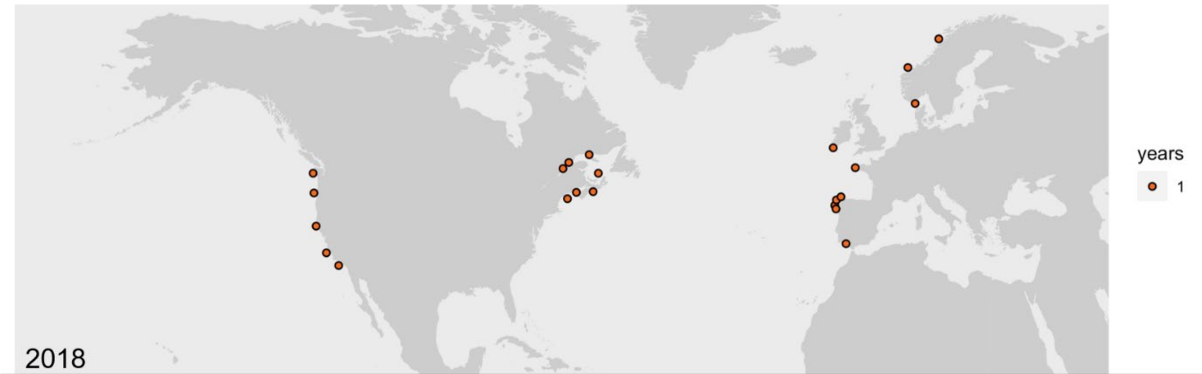

Presence of PSP Toxins in Seafood in the U.S. (2010-2019)
Alaska
Hawaii
Puerto Rico
USVI
1 Event
2-5 Events
6-10 Events

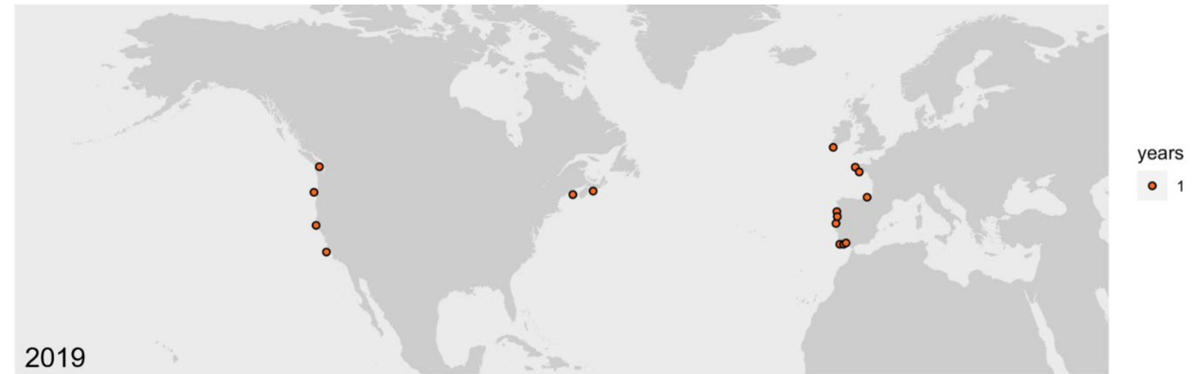
Annex 4: HAEDAT maps

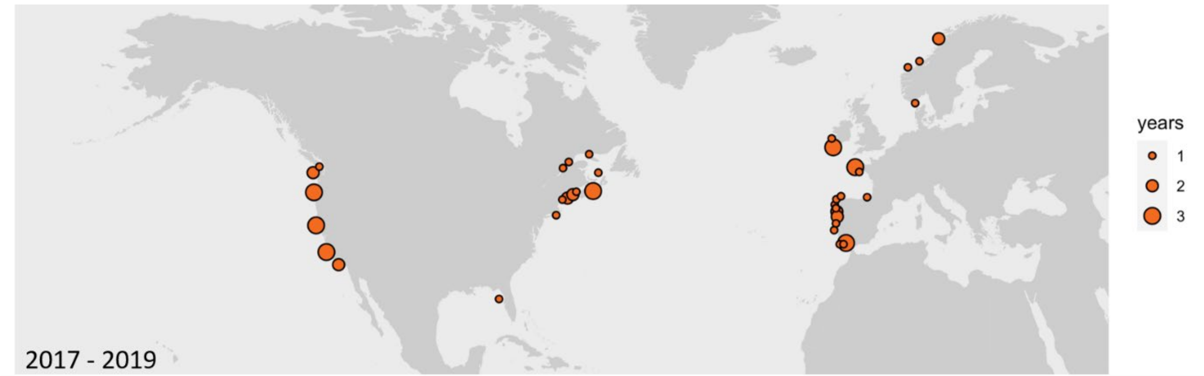
Aerosolised toxins



Amnesic shellfish toxin events






years
1
2
3
2017 - 2019

Azaspiracid toxin events

Ciguatera Poisoning Events

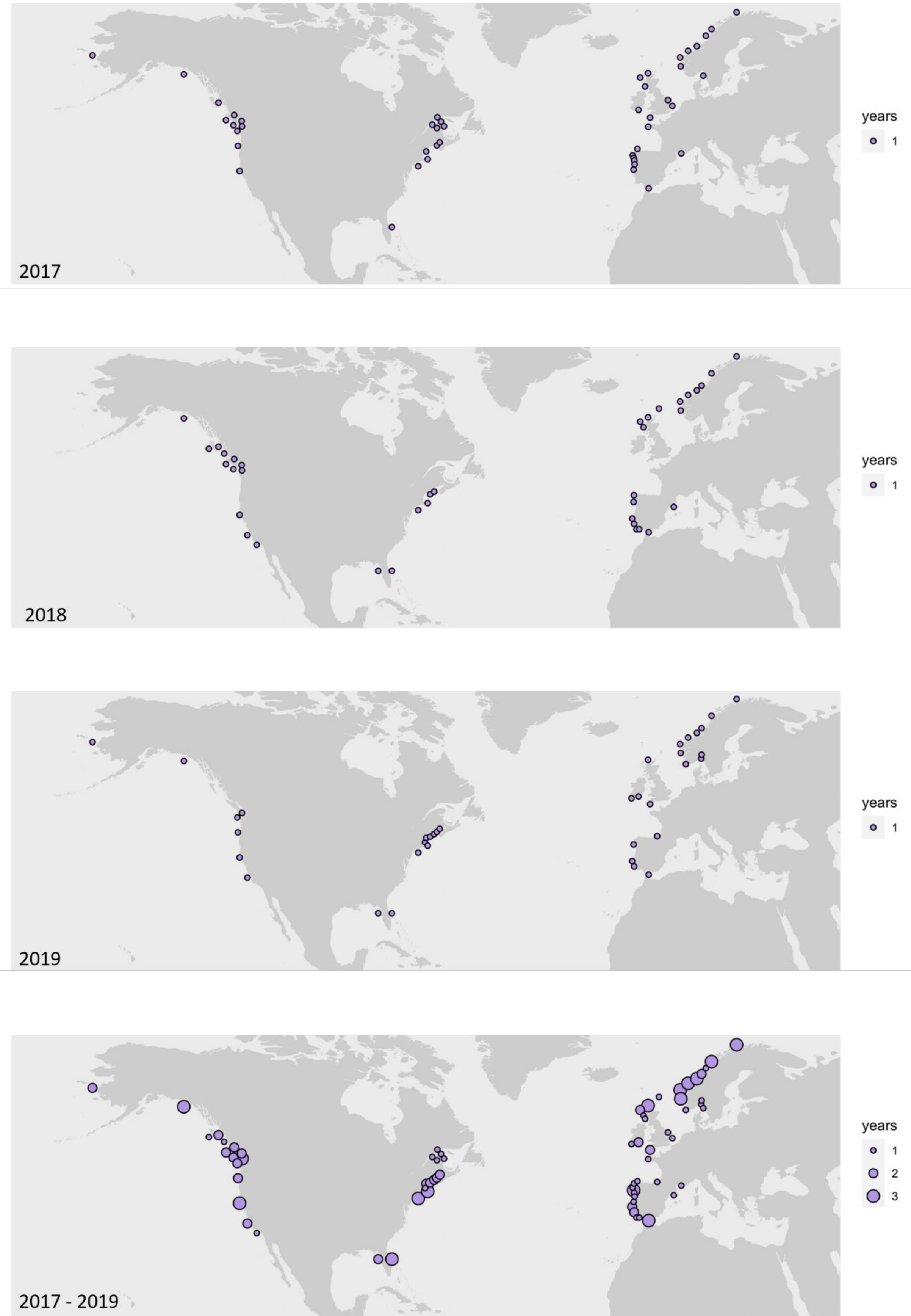
Cyanotoxin events

Diarrhetic Shellfish Toxin Events

Mass Mortalities

Neuro shellfish toxin events

Paralytic Shellfish Toxin Events



Annex 5: ICES Science Highlight

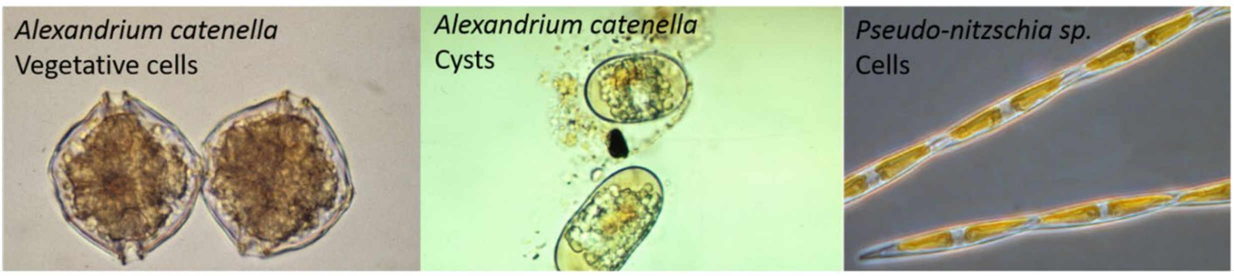
Harmful Algal Blooms and Non-Indigenous Species in the Arctic

Vectors for the introduction of marine species that are non-indigenous, harmful, or both, as well as their detection, are issues of concern and research across the ICES-Intergovernmental Oceanographic Commission of UNESCO (IOC) Working Group on Harmful Algal Bloom Dynamics (WGHABD), the Working Group on the Introduction and Transfer of Marine Organisms (WGITMO), and ICES-IOC-International Maritime Organization (IMO) Working Group on Ballast and Other Ship Vectors (WGBOSV).

Early detection is particularly important in vulnerable habitats—such as the Arctic—where climate change is having a dramatic impact on the environment, both in terms of the increased potential for shipping traffic to transport and introduce species in this sensitive area, as well as the biological impacts (an increased risk for the survival of new species).

In 2020, WGHABD, WGITMO, and WGBOSV met jointly for the first time. Members of all three expert groups exchanged their experiences using molecular methods and the measurement of algal toxins from the water to identify the presence of HAB species. Additionally, the results from studies on HABs and invasive, non-indigenous species present in Alaskan and Canadian Arctic areas were summarized.

One study focused on the distribution, community structure, and dynamics of *Alexandrium catenella* (which can cause paralytic shellfish poisoning) and *Pseudo-nitzschia* (which can cause amnesic shellfish poisoning) in the Northern Bering, Chukchi, and Beaufort Seas. High abundances of *A. catenella* cysts and cells were observed in waters previously thought to be too cold to initiate and sustain large blooms, and multiple toxic species of Pseudo-nitzschia were observed as well – all in a region with little experience with toxic HABs. Notably, a review of Canadian data revealed the widespread presence of more than a dozen potential toxin producing species throughout Canadian Arctic waters, the Beaufort Sea, Baffin Bay, North West Passages, well as Hudson Bay and the Labrador Sea. All three groups highlight similar issues with the use of molecular methods, including the need for standardization of methods among laboratories to allow data to be compared, concerns about primer bias, and the requirement for bioinformatics expertise and computing power. Future, innovative molecular technologies will benefit all three working groups.



Shellfish toxin producing species observed in the Chukchi sea

The Working Group on Introduction and Transfers of Marine Organisms deals with aquatic alien species that have an influence on and occur in the marine environment.

The Working Group on Ballast and Other Ship Vectors (WGBOSV) provides scientific support to the development of international measures aimed at reducing the risk of transporting non-native species via shipping activities.

The ICES- IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) looks at the dynamics of harmful algal blooms (HABs) and reviews and discusses HAB events, providing annual advice and updates on the state of HABs in the region.