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Report of the ICES – IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD)

25–28 April 2017

Helsinki, Finland

ICES CIEM
International Council for the Exploration of the Sea
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Executive summary

The ICES - IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) held three annual meetings in 2015–2017.

The WGHABD Members presented annual reports on the status of harmful algal blooms (HABs); (ToR a) throughout the reporting cycle. HABs continue to cause problems within the ICES area with some showing a regional distribution e.g. cyanobacteria in the Baltic, neurotoxic shellfish poisoning (NSP) in the Gulf of Mexico, azaspiracids (AZA) in Ireland and the UK. Issues associated with paralytic shellfish poisoning (PSP) and diarrhetic shellfish poisoning (DSP) were more widespread. Highlights from the three years reporting include increased problems with DSP and amnesic shellfish poisoning (ASP) in the USA, first records of Tetrodotoxin (TTX) in shellfish from the Netherlands, concentrations of AZA in *Mytilus edulis* above the closure limit for the first time from English waters, and continued issues with ciguatera fish poisoning in Europe.

Three ToRs contribute to the work of the Intergovernmental Oceanographic Commission of UNESCO Intergovernmental Panel on Harmful Algal Blooms (IOC IPHAB). The manuscript on fish killing algae (ToR b) will feed into the IP HAB task team on fish killing algae. WGHABD have updated and quality controlled data in the IOC-ICES-PICES Harmful Algal Event Database (HAE-DAT). These data will be used to produce a Harmful Algal Event status report for the ICES area. This report will be the first overview of harmful algal events in the ICES area and will provide a useful resource to scientists, policy makers and regulators working in the area of HABs (ToRs c and f). The status report will be finalised during the WGHABD 2018 meeting and will be the ICES contribution to the Global HAB Status Report currently in production by the IOC.

A dynamic range of new findings (ToR e) were presented each year with summaries included in each annual report. These presentations encompassed studies performed with the latest technologies or approaches e.g. the use of new technologies such as the imaging flow cytobot to examine HABs in the USA and Sweden, citizen science in France, the use of sediment cores to reconstruct the history of toxic *Nodularia spumigena* blooms in the Baltic Sea and Oslofjorden, development of early warning systems in the UK, social unrest in Chile as a result of HABs.

WGHABD reviewed the OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition (ToR g and l). WGHABD has addressed the relationship between HABs and eutrophication in previous years and contributed their expert view to this document. Subsequently WGHABD participated in the subsequent advisory drafting group ADGJAMP.

WGHABD contributed to the organization of the ICES-PICES-IOC scientific symposium on climate change and harmful algal blooms held 19–22 May 2015, Gothenburg, Sweden (ToR h). More than 60 scientists from across the globe participated. A major output of this symposium is the peer reviewed publication, Wells, M.L. *et al.*, (2015). Harmful algal blooms and climate change: Learning from the past and present to forecast the future. Harmful Algae, 49:68–93.

A review of molecular methodologies (ToR i) in the study of HABs took place in 2015 with reviews of the use of molecular probes, qPCR methods targeting toxin producing

genes and metabarcoding presented. Members from WGHABD will contribute to the symposium coordinated by WG Phytoplankton and Microbial Ecology (WG PME) and WG Integrated Morphological and Molecular Methods (WG IMT) in October 2017.

ToR j reviewed the existing knowledge and latest findings on BMAA, the amino compound ß-methylamino alanine during year 1 of the reporting cycle and provided clarification on methodological issues.
ToR k reviewed the dynamics of *Gymnodinium catenatum* in the Iberian Peninsula, *Alexandrium minutum* in the Bay of Brest and *A. ostenfeldii* and cyanobacteria in the Baltic.

The methodology used for the collection of phytoplankton samples in harmful phytoplankton monitoring programmes and the abundances used as threshold levels is currently being reviewed by the EU National Reference Laboratory for Biotoxins Working Group on Monitoring Toxic Phytoplankton. WGHABD delegates participating in this working group are providing updates on developments in this area (ToR d).

1 Administrative details

Working Group name

Working Group on Harmful Algal Bloom Dynamics (WGHABD)

Year of Appointment within current cycle

2015

Reporting year within current cycle (1, 2 or 3)

3

Chair(s)

Eileen Bresnan, UK

Meeting venues and dates

13–18 April 2015; Lisbon, Portugal (20 participants)

19–22 April 2016; Brest, France (15 participants)

25–28 April 2017; Helsinki, Finland (20 participants)

2 Terms of Reference a) – z)

a) Deliver National Reports on harmful algal events and bloom dynamics for the years 2014, 2015, 2016;

b) Finalise a review document quantifying the scale, nature and extent of the problems associated with fish killing algae in the ICES region;

c) A one day Harmful Algal Event Data Workshop as part of the 2015 WGHABD Meeting (with intercessional work performed by delegates prior to WG meeting);

d) Review the methodology used for the collection of phytoplankton samples in harmful phytoplankton monitoring programmes and the abundances used as threshold levels in harmful phytoplankton monitoring programmes;

e) Report on new findings in the area of harmful algal bloom dynamics;

f) Identify HAB datasets that could be used to investigate climate related changes in HAB species phenology; present the assessment of representative datasets to describe HAB initiation and temporal trends and spatial variability; review outputs using the standard WGZE and WGPME result formatting;

g) Evaluate use of harmful/nuisance algae as an indicator of 'Good Ecological Status' for the Marine Strategy Framework Directive Descriptor 5 (Eutrophication). Review draft OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition;

h) Review progress and advice the scientific steering committee for the planned joint ICES-PICES-IOC scientific symposium on Climate change and harmful algal blooms. The symposium is planned to be arranged in 2015;

i) Review progress in development and application of molecular genetic technologies for taxonomic identification, phylogenetic reconstruction, biodiversity, toxin detection and population dynamic studies of HABs;

j) Review the existing knowledge and latest findings on BMAA, the amino compound ß-methylamino alanine;

k) Review how physical and biological interactions control of the dynamics of relevant harmful micro-algal blooms;

l) Review of draft OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition ICES is requested to advise OSPAR on the revision of the OSPAR JAMP Eutrophication Guidelines which will be revised by experts from Germany, The Netherlands and Sweden. WGHABD is asked to address the identification of harmful algae species and blooms in line with MSFD Descriptor 5 and relevant monitoring and measurement techniques as mentioned in the background information.

3 Summary of Work plan

Year 1	All of the ToRs were addressed during year 1 with ToR g, j and l completed. A one day workshop on the ICES-PICES-IOC HAE-DAT database was held during the WG meeting. ToR k focused on *Gymnodinium catenatum.*
Year 2	During year 2 the remaining ToRs were addressed. Initial discussions the previous year were to complete a HAB status report in a similar style to the WG Zooplankton Ecology and WG Phytoplankton and Microbial Ecology. During year two it was decided to use data in the HAE-DAT database to form the basis of the status report. This will form the ICES contribution to the Global HAB status report that is currently being produced by the IOC. ToR k focussed on *Alexandrium minutum.*
Year 3	During year 3, the remaining ToRs were addressed. WG members worked updating and QCing data in the HAE-DAT database. Outputs from this database showing the distribution of harmful algal events in the ICES area are included in this report. ToR K focussed on *Alexandrium ostenfeldii* and cyanobacteria.
Year 1–3	Work on Global HAB report, update the Harmful Algal Event Database, report new findings, physical-biological interactions – selected HAB genera

4 Summary of Achievements of the WG during 3-year term

HAE-DAT: Considerable progress has been made with the IOC-ICES-PICES Harmful Algal Event (HAE-DAT) database during the reporting period. This database holds data about harmful algal events across the globe. ICES-IOC WGHABD delegates enter data from the countries on an annual basis. During the last three years, missing data has been entered into HAE-DAT and historic data has been quality controlled. The first ICES Harmful Algal event status report to be produced during 2018 will be based on the HAE-DAT data. This report will form the ICES contribution to the IOC Global HAB Status Report that is currently in preparation. Maps showing the regional occurrence of HABs

during this reporting period (2014, 2015, 2016) have been created using data from HAE-DAT. These can be seen in Annex 6.

Two presentations were made using data from the ICES area contained in HAE-DAT during the reporting period:

Oral Presentation: Bresnan, E., K. Davidson, A. McKinney, S. Milligan, C. Belin, and H. Enevoldsen. (2016). The use of the IOC-ICES-PICES Harmful Algal Event Database (HAE-DAT) to detect spatial and temporal trends in harmful algal bloom events in UK waters. *ICES CM* N: 382., Riga, Latvia 2016

Poster presentation: Bresnan, E., K. Davidson, A. McKinney, S. Milligan, C. Belin, and H. Enevoldsen. (2015). The use of the IOC-ICES-PICES Harmful Algal Event Database (HAE-DAT) to detect spatial and temporal trends in harmful algal bloom events in UK waters. ICES-PICES-IOC Symposium on Climate Change and HABs, Gothenburg, Sweden May 2015.

National reports: National reports continue to be presented by delegates summarising the HAB events in their countries during the year and are available as annexes in each annual report with a three year summary in the final WGHABD report for the reporting period. These reports present the current status of harmful algal blooms in the ICES area and act as a resource to the HAB community.

Mini reviews: The group has presented mini reviews focused on the harmful organisms in the region of the host institute. These include *Gymnodinium catenatum* (2015), *Alexandrium minutum* (2016), cyanobacteria (2017) and *Alexandrium ostenfeldii* (2017). Summaries of these reviews are available in the annual reports or peer review literature.

New findings: New findings are presented by delegates and summaries are included in each annual report. These cover a variety of topics related to harmful algal blooms ranging from new records of toxins in shellfish e.g. Tetrodotoxin in shellfish from the Netherlands, the use of the imaging flow cytobot to examine HABs in the USA and Sweden, citizen science in France, the use of sediment cores to reconstruct the history of toxic *Nodularia spumigena* blooms in the Baltic Sea and Oslofjorden, development of early warning systems in the UK, social unrest in Chile as a result of HABs.

Advisory: ICES-IOC WGHABD was asked by OSPAR to review the OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition. The WG reviewed the document during the 2015 meeting in Lisbon. The WG chair then participated in an advisory drafting group (ADGJAMP) at ICES in Copenhagen during June 2015. The review document can be found at

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/Special_Requests/OSPAR_JAMP_advice.pdf.

ICES-PICES-IOC symposium on Climate Change and HABs: This symposium within the framework of GEOHAB was held 19–22 May 2015, Gothenburg, Sweden. More than 60 scientists from across the globe participated. A major output of this symposium is the peer reviewed publication Wells, M.L., Trainer, V.L., Smayda, T.J., Karlson, B.S.O., Trick, C.G., Kudela, R.M., Ishikawa, A., Bernard, S., Wulff, A., Anderson, D.M., Cochlan, W.P. 2015. Harmful algal blooms and climate change: Learning from the past and present to forecast the future. Harmful Algae, 49:68–93 which to date has been cited 23 times.

ICES Annual Science Conference: ICES-IOC WGHABD (co)chaired theme sessions at two ICES ASCs. During the 2014 meeting in Spain a theme session *'HABs in aquaculture and fisheries ecosystems'* attracted 27 presentations. At the 2016 meeting in Latvia, ICES-IOC WGHABD co-chaired a theme session with WG Phytoplankton and Microbial Ecology.' *Long-term phytoplankton trends in the ICES area: regional distribution, bloom dynamics and response to environmental drivers'.*

5 Final report on ToRs, workplan and Science Implementation Plan

ToR a: Deliver National Reports on harmful algal events and bloom dynamics for the years 2014, 2015, 2016

National reports were delivered every year and are available in the individual annual reports. A three year summary covering the reporting period is also given in Annex 5. HABs continue to cause problems across the ICES area. Highlights of interest during the three year period include continued problems with ciguatera fish poisoning (CFP) in Europe; the first reports of Tetrodotoxin in shellfish from the Netherlands, concentrations AZA toxins above the closure limit in *Mytilus edulis* from English waters; increased problems from diarrhetic shellfish toxins and domoic acid in the USA.

ToR b: Finalise a review document quantifying the scale, nature and extent of the problems associated with fish killing algae in the ICES region

This manuscript remains near completion. Progress has stalled due to the retirement of the lead author. During the 2017 meeting it was decided that the manuscript will feed into the IOC Intergovernmental Panel for Harmful Algal Blooms (IPHAB) task team on fish killing algae which has a number of actions for the coming years (http://hab.ioc-unesco.org/index.php?option=com_content&view=article&id=10&Itemid=0).

ToR C: A one day Harmful Algal Event Data Workshop as part of the 2015 WGHABD Meeting (with intercessional work performed by delegates prior to WG meeting) & ToR f: Identify HAB datasets that could be used to investigate climate related changes in HAB species phenology; present the assessment of representative datasets to describe HAB initiation and temporal trends and spatial variability; review outputs using the standard WGZE and WGPME result formatting

Considerable progress was made against these ToRs during the three year period. Delegates made a lot effort to enter missing data and quality control historic data within the HAE-DAT database. Delegates are beginning to interrogate their data and a presentation on the use of HAE-DAT data to investigate changes in shellfish toxins Scottish shellfish was made at the ICES ASC in Riga, 2017. Increased computer programmer capacity at the IOC centre in Oostende, Belgium has improved product output from HAE-DAT. Maps using HAE-DAT data showing the regional distribution of harmful algal events in two different formats are presented in Annex 6.Maps i-viii show the number of harmful algal events in each HAE-DAT region during the reporting period (2014, 2015, 2016) while maps ix - xvi report the number of years in the reporting period where harmful algal events have been recorded. In some areas, monitoring effort is low and there are no records to enter (e.g. Northern Canada, Greenland). Countries bordered by a pink line represent areas where data is still to be entered. These maps highlight the regional dis-

tribution of harmful algal events e.g.; cyanobacteria issues restricted to the Baltic, azaspiracids in Ireland and the UK, PSP and DSP relatively widespread, the latter more so in Europe.

During the 2016 meeting there was in depth discussion about the production of a Harmful Algal Event status report. Initial thoughts were to follow the format used in the ICES Phytoplankton and Microbial, and Zooplankton status reports; however it was felt that data from HAE-DAT should be used. This report will form the ICES contribution to the Global HAB Status Report (GSHR) that is currently being produced by the IOC. An update on the status of the GSHR was presented (see Annex 6 for more detail). The HAE-DAT status report will be finalised during the 2018 WGHABD meeting.

ToR d: Review the methodology used for the collection of phytoplankton samples in harmful phytoplankton monitoring programmes and the abundances used as threshold levels in harmful phytoplankton monitoring programmes

An update was given on the progress on the EU working group on Monitoring of Toxic Phytoplankton (WG MTP). This work is behind schedule. During the last year the group focussed on requirements for and functionality of monitoring in accordance to EU legislation, and the potential of the existing monitoring programmes to analyse population trends and population dynamics. This discussion resulted in a lack of consensus on the potential requirements.

It could be concluded that no extra sampling is necessary to obtain information on population trends; integrated sampling at control stations covers all the aspects of toxic phytoplankton monitoring in the legislation. The group also agreed that observing population trends requires discrete sampling with vertical resolution in the water column; integrated sampling at control stations only produces information on the presence of toxic phytoplankton. This information does not allow insight into phytoplankton population dynamics without additional detailed information. The WGMTP continues without resolving the discussion on requirements on population trends and dynamics.

The agenda for WGMTP in the next phase will focus on a document containing the following subjects; Sampling, Water column sampling (done), Sampling frequency (done), Spatial extent and Resolution of sampling stations, Sample preservation and storage, Species identification, counting protocols and calculations, Data handling and storage, Data interpretation, thresholds and triggers, Ancillary data.

WGHABD supports the discussion on requirements on population trends from the EC perspective. It needs clarification what the ambitions of the EC are in accordance to the legal framework.

WGHABD further advises to continue the discussion and documentation on phytoplankton trigger levels. Although no consensus will be apparent at the final stage, a description of options, and potential trigger actions would help member states to improve (and accommodate) the monitoring program in the member state in accordance to the guideline.

WGHABD further addresses the need for more detailed selection criteria or guidelines/procedures for sampling stations, distribution and locations, especially in relation to local hydrographical conditions. WGHABD welcomes a methodological guidelines, however this should be complementary to existing guidelines (such as IOC and ISO) and

will keep a watching brief on developments in the coming reporting period. As the work from WGMTP continues, WGHABD has put ToR to address this topic into the reporting cycle for the coming year.

ToR e: Report on new findings in the area of harmful algal bloom dynamics

During the 2017 meeting, ten new findings covering a wide range of topics relating to HAB dynamics were made. These included a reconstruction of the history of toxic *Nodularia spumigena* blooms in the Baltic Sea and Oslofjorden, a description of major HAB events and social disruption in Chile during 2016, further reports of Tetrodotoxin in shellfish from the Netherlands, two presentations on assessing risk from HABs in the UK, an introduction to the EuroCigua project: Risk characterization of ciguatera food poisoning in Europe, spatio-temporal variation of phytoplankton along the Basque coast: study of toxicity and quality as a food resource for bivalves, HABs and the MSFD. Summaries of these presentations are given in Annex 7. In addition reports were presented on community composition of microbial eukaryotes in arctic and subarctic fjords as well as the Tagesund-Jerico 2016 project where the imaging flow cytobot along with molecular methods and passive sampling techniques were used to study the dynamics of a *Lingulodinium polyedrum* in Sweden.

ToR g: Evaluate use of harmful/nuisance algae as an indicator of 'Good Ecological Status' for the Marine Strategy Framework Directive Descriptor 5 (Eutrophication). Review draft OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition and ToR l: Review of draft OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition ICES is requested to advise OSPAR on the revision of the OSPAR JAMP Eutrophication Guidelines which will be revised by experts from Germany, The Netherlands and Sweden. WGHABD is asked to address the identification of harmful algae species and blooms in line with MSFD Descriptor 5 and relevant monitoring and measurement techniques as mentioned in the background information

The WG addressed both of these ToRs. The WG felt it had already addressed the issue of HABs and eutrophication during previous reporting periods and there was already sufficient information in the peer review literature about the complex nature of the relationship between HABs and eutrophication. The WG used this expertise to review the draft OSPAR JAMP eutrophication guidelines which they contributed into the advisory ADG-JAMP which met in June 2015 in Copenhagen. The report from this meeting can be found at:
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/Special_Requests/OSPAR_JAMP_advice.pdf.

ToR h: Review progress and advice the scientific steering committee for the planned joint ICES-PICES-IOC scientific symposium on climate change and harmful algal blooms. The symposium is planned to be arranged in 2015

This symposium was held 19–22 May 2015, Gothenburg, Sweden. More than 60 scientists from across the globe participated. A major output of this symposium is the peer reviewed publication Wells, M.L., Trainer, V.L., Smayda, T.J., Karlson, B.S.O., Trick, C.G., Kudela, R.M., Ishikawa, A., Bernard, S., Wulff, A., Anderson, D.M., Cochlan, W.P. 2015.

Harmful algal blooms and climate change: Learning from the past and present to forecast the future. Harmful Algae, 49:68–93.

ToR i: Review progress in development and application of molecular genetic technologies for taxonomic identification, phylogenetic reconstruction, biodiversity, toxin detection and population dynamic studies of HABs

New molecular and imaging technologies are being rapidly developed and trialled and tested in monitoring programmes. A review of emerging molecular technologies was presented by Allan Cembella (Germany) and Raffaele Siano (France) during the 2015 meeting. Methods reviewed included the use of molecular probes, qPCR methods for toxin producing genes (STX) and metabarcoding. Summaries of these presentations can be found in the WGHABD 2015 report.

WGHABD discussed overlap with initiatives currently underway with WG Phytoplankton and Microbial Ecology (WG PME) and WG Integrated Molecular and Morphological Taxonomy (WG IMT). WG PME and WG IMT are holding a symposium 'High throughput methods for application in marine biodiversity time series: Addressing their challenges to fulfil their promises' which focuses new automated imaging and next generation sequencing technologies in Hannover, Germany in October 2017. Representatives of WGHABD have been invited. While advancing technologies are contributing to large scale investigations such as the Tara Oceans survey, WGHABD felt that there is still a need for a focus on more established molecular tools such as FISH probes and qPCR methods, targeting a small suite of organisms (e.g. HABs) which are more practical to implement in routine monitoring programmes from a cost and validation perspective.

WGHABD felt a workshop on these techniques was also important as many countries consider these methods as standard and many delegates within WGHABD have more than 20+ years of experience to date in routine monitoring of HABs using molecular methods. Allan Cembella, Germany and Raffaele Siano, France have been in discussion about a venue to host such as workshop, and also the relevant expertise to bring to such a session. Other countries are being approached to host such an initiative. A ToR to address these molecular methods has been included in the ToRs for the next reporting session however it was suggested that the main focus of activity would occur during years 2 &3 to allow the HAE-DAT status report to be completed during year 1.

ToR j: Review the existing knowledge and latest findings on BMAA, the amino compound ß-methylamino alanine

This ToR was addressed during year 1 of the reporting cycle. ß-N-methylamino –L-alanine (BMAA) is a small non-proteogenic amino acid. It was originally found in the seeds of cycad (*Cycas micronesica*) growing on the Pacific Island of Guam. Since the work published by Cox *et al*. (2003), the production of this compound by symbiotic and free-living cyanobacteria has been associated with the elevated frequency of neurodegenerative diseases among people exposed to the toxin. Recently, BMAA has also been detected in axenic strains of diatoms as well as filter feeders such as mussels and oysters. Although the presence of BMAA in aquatic organisms and food products was documented in several countries (e.g. Sweden, France, USA, China), so far, a direct link with the incidents of disease has not been proven. Methodological problems have been identified which led to high variations in the reported concentrations of BMAA. When HPLC with

fluorescence detector was used, the BMAA concentrations were overestimated or even false positive results were obtained (Christensen *et al.* 2012). Currently, LC-MS/MS for the derivatized or underivetaized BMAA is recommended as the most reliable detection technique which minimizes the risk of misidentification. However, the analytical procedure should always be validated, and effects such as ion suppression or the presence of BMAA structural isomers should be considered. A more detailed review including key references on this topic can be found in Annex 8 of the 2015 ICES-IOC WGHABD report.

ToR k: Review how physical and biological interactions control of the dynamics of relevant harmful micro-algal blooms

This ToR has addressed the status of four different harmful algal species/groups during the reporting period. Reviews of *Gymnodinium catenatum* (2015), *Alexandrium minutum* (2016), *Alexandrium ostenfeldii* (2017), Cyanobacterial blooms (2017) were presented. These reviews encompassed data gleaned from many different methods, advanced molecular technologies, sediment cores, environmental studies, cyst surveys and model predictions. These reviews provided useful updates on the dynamics of these species including data from latest investigations.

6 Cooperation

During last three year reporting period the WGHABD chair represented the working group at:

IOC UNESCO Intergovernmental Panel on Harmful Algal Blooms (IPHAB), France (May 2015). This panel was formed by recommendation of the IOC Assembly in 1991 to address issues with HABs across the globe. The WG chair presented a summary of the work performed by ICES-IOC WGHABD during the preceding two years. IPHAB is the mechanism for the IOC to review WGHABD and propose or advice of WGHABD ToRs.

IOC-SCOR GlobalHAB International Scientific Steering Committee for the study of Harmful Algal Blooms (Scotland, March 2016, Italy (via correspondence), March 2017)

Publications arising from ICES representation at GlobalHAB include:

Peer review publication: Berdalet, E., R. Kudela, E. Urban, H. Enevoldsen, N.S. Banas, E. Bresnan, M. Burford, K. Davidson, C.J. Gobler, B. Karlson, P.T. Lim, L. Mackenzie, M. Montresor, V.L. Trainer, G. Usup, and K. Yin. 2017. GlobalHAB: A new program to promote international research, observations, and modelling of harmful algal blooms in aquatic systems. Oceanography 30(1):70–81, https://doi.org/10.5670/oceanog.2017.111.

Poster presentation: Berdalet E., Banas N., Bresnan E., Burford M., Davidson K., Enevoldsen H., Gobler C., Karlson B., Kudela R., Lim P.T., Mackenzie L., Montresor M., Trainer V., Urban E., Usup G. and Yin K. (2016) GlobalHAB: the international SCOR-IOC program for the study of Harmful Algal Blooms, International Conference on Harmful Algae, Florianopolis, Brazil, 9–14 October 2016

7 Summary of Working Group evaluation and conclusions

WGHABD has completed a set of ToRs during the reporting period which covers a wide range of topics relevant to the ICES Science Plan. These include; reporting data on a global scale (HAE-DAT), provision of advice (ADGJAMP), annual national reports about the status of HABs in ICES countries, new findings, investigations into new technologies, reviews of key harmful taxa in the ICES area. These ToRs address a number of priorities and sub priorities in the ICES Science Plan (see Annex 4). These include priority 1, 3, 4, and 9 within 'Ecosystem Processes and Dynamics'; priority 10 and 17 within 'Ecosystem Pressures and Impacts', priority 20 within 'Integrated Ecosystem Assessments' and priority 29 within 'Integrated Observation Monitoring Programmes'.

Achievements, provision of advice and external work performed by WGHABD during the three year reporting period are detailed in sections 4, 5 and 6.

Decreasing staff resource in some countries with experienced delegates retiring, a shift in obligations or moving positions has led to some breaks in representation. In some instances monitoring programmes have been stopped due to resource issues and contributions from these long term time series have ended. Difficulties in getting some countries to enter data in to HAE-DAT have been encountered but much progress with the database has been achieved by intensified communication and renewed commitment.

ICES-IOC WGHABD feels a continuation is required and has proposed a dynamic programme of work for the next three years (see Annex 3 for future ToRs). Reasons behind this decision include:

- HABs and their impacts continue to cause problems in the ICES area: impacting on the ecosystem, as well as goods and services.
- HABs are a global problem. ICES-IOC WGHABD is co-sponsored by the IOC UNESCO and the work of this group feeds into a number of global intergovernmental initiatives relating to HABs (IPHAB, HAE-DAT, GlobalHAB).
- The role of HABs in the EU Marine Strategy Framework Directive has yet to be addressed.
- An ICES-IOC HAB status report is currently in production. This will form the contribution from the ICES region to the IOC Global HAB Status report that is currently in production.
- Developing technologies are revolutionising the ability to monitor and understand the dynamics of HABs. How these technologies are harnessed to improved prediction will need to be performed on a regional sea scale.
- Environmental pressures such as climate change, ocean acidification, have the potential to impact the frequency and diversity of HABs.
- Work of ICES-IOC WGHABD addresses many points in the ICES Science and Strategy Plans.
- WGHABD continues to serve as a North Atlantic cradle for new collaborations and development of project ideas which are followed-up upon and implement by WGHABD members and beyond.

Annex 1: List of participants

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Annex 2: Recommendations

RECOMMENDATION	ADRESSED TO
1. Shipping can be a vector in the transfer of HAB organisms and presents an emerging concern in the Arctic region as the levels of shipping increase. WGHABD ask to be kept updated on the outcome of discussions and assessments within WGBOSVand WGITMO and on the role of shipping as a vector for the introduction of HAB organisms in this region.	WGBOSV, WGITMO

Annex 3: WGHABD resolution 2018–2020

The **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			Interim report by DATE	
Year 2020			Final report by DATE	

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	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.		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.		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	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.		Year 1,2,3	Outputs on request and as described in ToR D

	Ecosystem reviews that can be updated annually or as required.			
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.	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.	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.	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.	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 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.	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.	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	None.
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 4: WGHABD self-evaluation

1) Working Group name. ICES-IOC WGHABD

2) Year of appointment: 2015

3) Current Chairs. Eileen Bresnan, Marine Scotland, UK

4) Venues, dates and number of participants per meeting.

13 – 18 April 2015	Lisbon, Portugal	20 participants
19 – 22 April 2016	Brest, France	15 participants
25 – 28 April 2017	Helsinki, Finland	20 participants

WG Evaluation

5) If applicable, please indicate the research priorities (and sub priorities) of the Science Plan to which the WG make a significant contribution.

The table below lists the research priorities (and sub priorities) to which ICES-IOC has contributed via its ToRs to during its three year reporting period 2014, 2015, 2016.

Ecosystem Processes and Dynamics

Science plan objective: Describe and quantify the state of the North Atlantic Ocean regional systems

Science priority area: 1**.** Assess the physical, chemical and biological state of regional seas and investigate the predominant climatic, hydrological and biological features and processes that characterise regional ecosystems.

(ToR, A, C, E, K)

Science plan objective: Understand and forecast the impact of climate variability and change on marine ecosystems

Science priority area: 3. Quantify the different effects of climate change on regional ecosystems and develop species and habitat vulnerability assessments for key species

(ToR, A, C, E, H, K)

Science priority area: 4. Understand the influence of climate impacts across a range of temporal and spatial scales, from local to global and from seasonal to multidecadal and identify indicators of climate driven biotic responses and forecast trajectories of change

(ToR, A, C, E, H, K)

Science plan objective: Quantify the relationship between habitat condition, ecological processes and the provision of ecosystem goods and services

Science priority area: 9. Identify indicators of ecosystem state and function for use in the assessment and management of ecosystem goods and services

(ToR, A, C, F, K)

Ecosystems Pressures and Impacts

Science plan objective: Estimate long term trends of human impacts on marine ecosystems

Science priority area: 10. Develop historic baseline of population and community structure and production to be used as a basis for population and system level reference points.

(ToR, A, C,F)

Science plan objective: Provide evidence in support of the sustainable management of ecosystem goods and services

Science priority area: 17. Develop science in support of advisory needs in marine aquaculture systems, minimizing environmental impacts and integrating other marine sectors.

(ToR, A, B, C,D, E, F, G, H, I)

Integrated Ecosystem Assessments

Science plan objective: Develop a scoping process to identify objectives to guide IEA's in ICES regional Seas

Science priority area: 20. Provide priorities and specifications for data collection frameworks supporting IEAs.

(ToR C)

Integrated Observation and Monitoring Programme

Science plan objective: Develop further the methodology for the observation and monitoring of marine ecosystems in the ICES area.

Science priority area: 29. Promote new technologies and opportunities for observation and monitoring and assess their capabilities in the ICES context.

(ToR I)

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6) In bullet form, list the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc. *

Outcomes and achievements of ICES-IOC WGHABD during the three year reporting period include;

HAE-DAT: Much progress has been made with the IOC-ICES-PICES Harmful Algal Event (HAE-DAT) database during the reporting period. This database holds data about harmful algal events across the globe. ICES-IOC WGHABD delegates enter data from the countries on an annual basis. The first ICES HAB status report to be produced during 2018 will be based on the HAE-DAT data. This report will form the ICES contribution to the IOC Global HAB Status Report that is currently in preparation.

Two presentations were made using data from the ICES area contained in HAE-DAT during the reporting period:

Oral Presentation: Bresnan, E., K. Davidson, A. McKinney, S. Milligan, C. Belin, and H. Enevoldsen. (2016). The use of the IOC-ICES-PICES Harmful Algal Event Database (HAE-DAT) to detect spatial and temporal trends in harmful algal bloom events in UK waters. *ICES CM* N: 382., Riga, Latvia 2016

Poster presentation: Bresnan, E., K. Davidson, A. McKinney, S. Milligan, C. Belin, and H. Enevoldsen. (2015). The use of the IOC-ICES-PICES Harmful Algal Event Database (HAE-DAT) to detect spatial and temporal trends in harmful algal bloom events in UK waters. ICES-PICES-IOC Symposium on Climate Change and HABs, Gothenburg, Sweden May 2015.

National reports: National reports continue to be presented by delegates summarising the HAB events in their countries during the year and are available as annexes in the annual report.

Mini reviews: The group has presented mini reviews focused on the harmful organisms in the region of the host institute. These include *Gymnodinium catenatum* (2015), *Alexandrium minutum* (2016), cyanobacteria (2017) and *Alexandrium ostenfeldii* (2017). Summarys of these reviews are available in the annual reports.

New findings: New findings are summarised in the annual reports and include the first record of Tetrodotoxin in the Netherlands, problems with *Pseudo-nitzschia* and domoic acid in the USA, an early warning system to forecast *Dinophysis* and DSP events in Scottish waters.

Advisory: ICES-IOC WGHABD were asked by OSPAR to review the OSPAR JAMP Eutrophication Guidelines on phytoplankton species composition. The WG reviewed the document during the 2015 meeting in Lisbon. The WG chair then participated in an advisory drafting group (ADGJAMP) at ICES in Copenhagen during June 2015. The review document can be found at

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/Special_Requests/OSPAR_JAMP_advice.pdf.

ICES-PICES-IOC symposium on Climate Change and HABs: This symposium was held 19 – 22nd May 2015, Gothenburg, Sweden. More than 60 scientists from across the globe participated.. A major output of this symposium is the peer reviewed publication Wells, M.L., Trainer, V.L., Smayda, T.J., Karlson, B.S.O., Trick, C.G., Kudela, R.M., Ishikawa, A., Bernard, S., Wulff, A., Anderson, D.M., Cochlan, W.P. 2015. Harmful algal blooms and climate change: Learning from the past and present to forecast the future. Harmful Algae, 49:68–93 which to date has been cited 23 times.

ICES Annual Science Confernce: ICES-IOC WGHABD (co)chaired theme sessions at two ICES ASCs. During the 2014 meeting in Spain a theme session *'HABs in aquaculture and fisheries ecosystems'* attracted 27 presentations. At the 2016 meeting in Latvia, ICES-IOC WGHABD co chaired a theme session with WG Phytoplankton and Microbial Ecology.' *Long-term phytoplankton trends in the ICES area: regional distribution, bloom dynamics and response to environmental drivers'.*

7) Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.

ICES-IOC WGHABD responded to the request from OSPAR to review the OSPAR JAMP Eutrophication Guidelines on Phytoplankton Species Composition. The WG commented on the document, referring back to previous indepth work performed by the group flagging the complex nature of the relationship between eutrophication and phytoplankton species composition, lack of indicator species, influence of local hydrodynamics etc. This advice was fed back to ICES and the WGHABD chair participated in the advisory drafting group in Copenhagen in June 2015. Documentation produced can be found at:

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/Special_Requests/OSPAR_JAMP_advice.pdf.

8) Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.

During last three year reporting period the WGHABD chair represented the working group at:

UNESCO-IOC Intergovernmental Panel on Harmful Algal Blooms (IP-HAB),France (May 2015). This panel was formed by recommendation of the IOC Assembley in 1991 to address issues with HABs across the globe. The WG

chair presented a summary of the work performed by ICES-IOC WGHABD during the preceeding two years.

IOC/SCOR GlobalHAB International Scientific Steering Committee for the study of Harmful Algal Blooms (Scotland, March 2016, Italy (via correspondence), March 2017)

Publications arising from ICES representation at GlobalHAB include:

Peer review publication: Berdalet, E., R. Kudela, E. Urban, H. Enevoldsen, N.S. Banas, E. Bresnan, M. Burford, K. Davidson, C.J. Gobler, B. Karlson, P.T. Lim, L. Mackenzie, M. Montresor, V.L. Trainer, G. Usup, and K. Yin. 2017. GlobalHAB: A new program to promote international research, observations, and modeling of harmful algal blooms in aquatic systems. Oceanography 30(1):70–81, https://doi.org/10.5670/oceanog.2017.111.

Poster presentation: Berdalet E., Banas N., Bresnan E., Burford M., Davidson K., Enevoldsen H., Gobler C., Karlson B., Kudela R., Lim P.T., Mackenzie L., Montresor M., Trainer V., Urban E., Usup G. and Yin K. (2016) GlobalHAB: the international SCOR-IOC program for the study of Harmful Algal Blooms, International Conference on Harmful Algae, Florianopolis, Brazil, 9–14 October 2016

9) Please indicate what difficulties, if any, have been encountered in achieving the work plan.

Decreasing staff resource in some countries with experienced delegates retiring, having other obligations or moving positions has lead to some breaks in representation. In some instances monitoring programmes have been stopped due to resource issues and contributions from these long term time series have ended. Difficulties in getting some countries to enter data in to HAE-DAT has been encountered but much progress with the database has been achieved by intensified communication and renewed commitment..

Future plans

10) Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons)

ICES-IOC WGHABD does think a continuation is required and has proposed a dynamic programme of work . The resons behind this include:

-HABs and their impacts continue to cause problems in the ICES area: impacting on the ecosystem, as well as goods and services.

-HABs are a global problem. ICES-IOC WGHABD is co-sponsored by the IOC UNESCO and the work of this group feeds into a number of global intergovernmental initatives relating to HABs (IP-HAB, HAE-DAT, GlobalHAB etc)

-The role of HABs in the EU Marine Strategy Framework Directive has yet to be addressed.

-An ICES-IOC HAB status report is currently in production. This will form the contribution from the ICES region to the IOC Global HAB Status report that is currently in production.

-Developing technologies are revolutionising the ability to monitor and understand the dynamics of HABs. How these technologies are harnessed to improved prediction will need to be performed on a regional sea scale.

-Environmental pressures such as climate change, ocean acidification, have the potential to impact the frequency and diversity of HABs.

-Work of ICES-IOC WGHABD address many points in the ICES Science and Strategy Plans

-WGHABD continues to serve as a North Atlantic cradle for new collaorations and development of project ideas which are followed-up upon and implement by WGHABD members and beyond.

11) If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.

(*If you answered YES to question 10 or 11, it is expected that a new Category 2 draft resolution will be submitted through the relevant SSG Chair or Secretariat*.)

12) What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?

Increased effort from some countries in entering data into HAE-DAT.

13) Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used? (please be specific)

Outputs from HAE-DAT have the potential to feed into ICES Ecosystem Review documents

Outputs from HAE-DAT have the potential to contribute to the description of 'prevailing oceanographic conditions' for the EU Marine Strategy Framework Directive.

National reports and HAE-DAT can form the basis of advice that can be provided to the Aquaculture industry.

Annex 5: ToR a) National Reports

Canada National Report (2014–2016)

Cynthia McKenzie, Canada

Atlantic Coast of Canada (ICES regions)

ASP: One location in Quebec (CA 01) in the Strait of Belle Isle, had levels of domoic acid above 20 ug/g (23 ug/g) and these levels fluctuated from July 22, 2015 to October 1, 2015. It is speculated that these levels are not a result of a bloom in 2015 but residual toxicity from a large toxic bloom in July 2013. *Placopecten megallanicus*, the test organism for these values, is known to require long periods of depuration and an indication of these residual values. The domoic acid values continued to be above the closure limit (23–29 ug/g) in scallops in 2016 as well.

One location in New Brunswick (CA 22) (western Bay of Fundy) had high levels of domoic acid from September 25 to December 5, 2014 with a maximum value in the *Placopectin magellanicus* of 320ug/g on October 1, 2014. In 2016 two sites (CA22 western Bay of Fundy: CA19 eastern Bay of Fundy) reported 20–33 ug/g toxin in clams in late September and early October and closed large areas to shellfish harvest.

DSP: A maximum value of 1.6 ug/g YTX was found in *Mytilus edulis* on the Atlantic Coast of Nova Scotia (CA 17) on November 3, 2014. Toxin was detected in mid- October (0.51 ug/g) and continued until 1 Dec 2014 (0.54 ug/g). Although there were not DSP closures on the Atlantic Coast in 2015, the previously noted location (CA17) reported elevated levels in of DSP in 2016. No DSP was reported in other areas of the Atlantic Coast in 2016.

PSP: Several HAB events leading to closures related to PSP were reported in this three year period. In 2014, the highest concentrations of *Alexandrium fundyense* was observed in the Bay of Fundy, southwest New Brunswick (CA 22) with highest shellfish toxicity detected in *Mytilus edulis* at 7977 μg 100 g STX equivalent on July 16, 2014. Also in the Bay of Fundy but in Nova Scotia (CA 19) 426 ug/100g STX equivalent was detected in the soft shell clam, *Mya arenaria*, also in July 2014. No species report was received from the St. Lawrence Estuary but shellfish harvesting areas were above PSP threshold levels and closed to harvesting for a portion of the spring/summer. In 2015, two locations in New Brunswick, the Bay of Fundy, were closed to soft shell clam harvest, *Mya arenaria*, July 10, 2015 due to values above 80 ug 100g STX equiv. It was reopened August 20, 2015. In 2016, several locations in the Bay of Fundy had closures due to PSP toxin levels ranging from 82–2200 ug/100g in clams and mussels in June and July and again (82–160 ug/100g) in late September to early October. PSP related HAB closures were also reported in the St. Lawrence Estuary (82–248 ug/100g in June –August) and in the Gulf of St. Lawrence (112–385 ug/100g in clams, August to late September).

There were not cultured or wild fish kills reported on the Atlantic Coast during this time period.

Pacific Coast of Canada (PICES regions)

ASP: The west coast of Canada experienced a massive *Pseudo-nitzschia australis* bloom in 2015. The bloom first appeared off the west coast of Vancouver Island in May 2015 (CA35, CA36) with closures for shellfish harvesting occurring along Vancouver Island north of Tahsis. The bloom continued and expanded along the entire coastline, appearing to peak around June 17, 2015 with toxin levels of 75 ug/g and a second bloom in August and into November with toxin levels 54ug/g (CA37). The entire west coast was closed throughout June. Levels were decreasing by June 29th. Domoic acid levels in mussels were 10X less than those reported in the U.S. in razor clams probably due to the rapid depurate rates in mussels (compared to razor clams used in the US), the standard test organism for CFIA in Canada. ASP data for 2014 was unavailable.

DSP: There were no reports of DSP in 2014 and 2015. There were two events in 2016 with found in OA in tested mussels. The first one, on west Vancouver Island in mussels (0.23–0.33 ug/g OA) in June and another in the southern Strait of Georgia, (0.20–0.26 ug/g OA) January through June.

PSP: Several areas of the Pacific Coast reported PSP levels above closure limits in 2016. Two locations were in the Strait of Georgia with 110ug/100g in Oysters in May and 130–210 ug/100g in mussels, clams and geoduck from May to September. Reported values further north along the coastline at Queen Charlotte Sound were PSP amounts in clams and geoduck at 94–140ug/10g in May to late November, with values 110–290 ug/100g late October to mid-November in the Hecate Strait. Information was unavailable for 2014.

<u>Salmon mortalities in fish culture operations</u>:

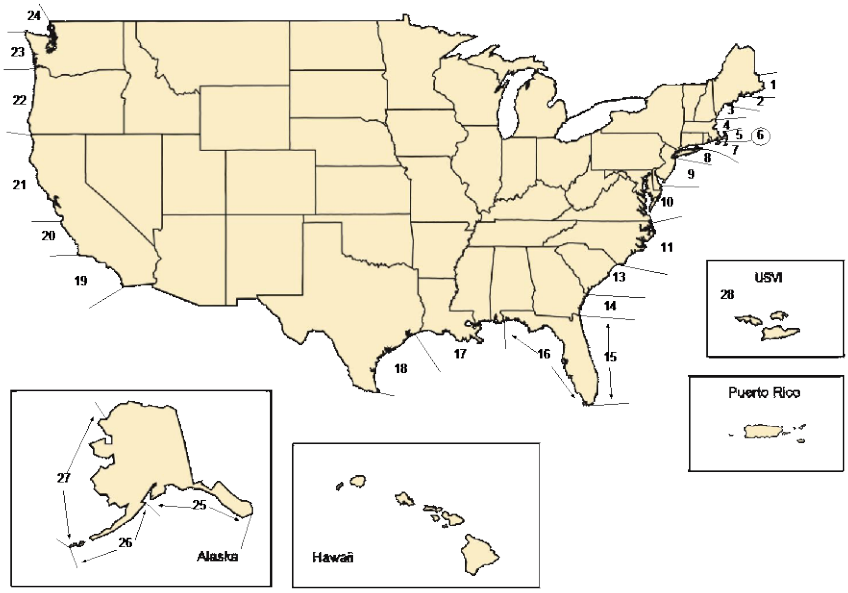
In 2014 *Chrysochromulina* sp. (provisionally identified as *C. ericina* and other *Chrysochromulina* species) was first detected May 24, 2014 in Knight Inlet (ICES CA38). The bloom lasted approximately 2 weeks and affected most of Knight Inlet. Farmed salmon mortalities were seen at mostly one farm site, although 3 were affected. Maximum cell numbers were 16 million cells•L^{-1} on May 26, 2014. In 2016 there was a *Chrysochromulina* sp. bloom (6 million cells/l) in Clayoquot Sound (CA36) with low but significant fish mortalities in May and again in December (600,000 c/l).

Heterosigma akashiwo was responsible for salmon mortalities in Queen Charlotte Strait (ICES code CA38) in late September 2014 when concentrations were 40 million cells•L^{-1}. *H. akashiwo* was detected in Broughton Archipelago and Queen Charlotte Strait on the west coast of Canada on September 2, 2014 prior to the mortalities. In 2015 there were mass fish mortalities at Clayoquot Sound (CA36) in late June with a bloom that lasted three weeks then another bloom in September and October that lasted 4 weeks. There was a *H. akashiwo* bloom at Broughton Archipelago (CA38) in mid-July with the bloom lasting 6 weeks and a bloom in Sechelt Inlett (CA37) in October that lasted two weeks.

Chaetoceros concavicornis blooms (16,000 c/l) in Johnstone Strait (CA38) in mid-July 2015 caused mass cultured finfish mortalities. *Chaetoceros convolutus* (465,000 c/l) and *C. concavicornis* caused mass cultured finfish mortalities in the Esperansa Inlet (CA35) in October 2016.

USA National Report (2014–2016)

Doon Anderson, USA



Map of USA HAB region codes

New England (Regions 1–7)

PSP: 2014. The region experienced moderate levels of toxicity and related closures extending from the Casco Bay area of western Maine through the north shore of Massachusetts. In addition, a small area of far eastern Maine experienced toxicity. The Nauset Marsh, which typically has shellfish quarantines resulting from PSP, remained open for the year.

2015. In Massachusetts the entire Nauset Marsh Estuary was closed from 5/8 – 6/11/15 as a result of one set of assays just above the quarantine limit of 80µg/100g shellfish. The eastern coastline of Maine had PSP closures from 6/22 – 8/1/15 with toxin concentrations as high as 484 µg/100g shellfish. Western Maine shellfish beds were closed from 5/20 – 6/30/15 with lower levels of toxin (186 µg/100g shellfish) and this closure extended along the New Hampshire coastline where102µg/100g shellfish was reported for Star Island, however, the rest of the New Hampshire coastline remained open.

2016. Once again, the Nauset Estuary was closed for shellfishing as a result of PSP beginning on 6 April and lasting through 27 May with saxitoxin concentrations exceeding 1200µg/100g shellfish meat. Shellfish beds in Maine were quarantined at various times and locations between 27 March and 19 September with maximum saxitoxin concentrations of 343µgSTX/100g shellfish reported. Once again in New Hampshire, only Star Island reached elevated toxicity levels with a maximum concentration of 225.7µg/100g shellfish on May 18th. Elevated PSP concentrations persisted in this region until June 8th.

Conclusion 2014–2016. PSP in the New England region was sporadic with relatively low toxicity although the Nauset Marsh had STX concentrations greater than 1200µg/100g shellfish in 2016 following 2 years of low (2015) and no toxicity (2014).

ASP: 2012–2015. Elevated domoic acid (DA) concentrations determined by Jellett Rapid Tests resulted in a closure in 2012 on Mount Desert Island, Maine but further analysis determined the DA concentration was below quarantine levels. There was no ASP in 2014, however, three regions along the Maine coastline were closed in 2015, but once again, DA concentrations were below the regulatory limit of 20ppm even though high *Pseudo-nitzschia* cell densities of over 375 000 cells/L were enumerated.

2016. In Maine, from Penobscot Bay to the Canadian border, shellfish beds were closed from 28 September until 31 October as a result of domoic acid toxicity with concentrations of up to 129ppm were measured in blue mussels by HPLC. *Pseudo-nitzschia* spp. cell densities of over 200 000 cells/L during the bloom were recorded. At about the same time, several areas within the New England region also had shellfish closures as a result of DA toxicity from late September through October. The affected areas included the waters south and west of Cape Cod, Massachusetts including the coastlines of Nantucket and Martha's Vineyard, Buzzards Bay as well as Narragansett Bay, Rhode Island.

The ASP closures in Narragansett Bay transpired between 7 and 29 October and in Massachusetts between October 7th and 31st. Maximum *Pseudo-nitzschia* cell densities of approximately 2 million cells/L were reported in Rhode Island waters while in Massachusetts, maximum cell concentrations were 760 000 cells/L. The highest concentrations of domoic acid in Quahogs from Rhode Island reached 6ppm, and in Massachusetts, values of 9.3ppm were measured by HPLC and Scotia Kits. Even though DA concentrations were below regulatory thresholds of 20ppm, pre-emptive closures were imparted in both states as a safety measure.

Conclusion: ASP appears to be a mounting problem in the waters of New England. State regulatory agencies are aware of this and will be developing improved protocols to monitor shellfish beds in the region.

DSP: 2014. No DSP toxicity was reported in New England.

2015. For the 1st time, a waterway in Massachusetts, Salt Pond on the northern flank of the Nauset Estuary, was closed due to DPS toxicity. Persistent high densities of *Dinophysis acuminata* (>1 million cells/L) were recorded for several months beginning in April and this was followed by shellfish toxicity on 6/30/15 until 8/20/15. DSP toxin levels of 9.0 to 19.0µg/100g shellfish were measured by the FDA. The regulatory threshold in Massachusetts is 16.0µg/100g shellfish. High densities of *D. acuminata* have been documented in many saltwater embayments in Massachusetts and the Northeast in the past, but due to the low levels of toxin produced by these cells, shellfish toxicity has not been found.

2016. In Maine, there was a bloom of *Dinophysis* spp. and initial results using the Abraxis PP2A test kit on shellfish extracts revealed scores over the closure level. These samples were reanalysed by independent laboratories using LCMS/MS and those results were all negative. Apparently, there is a yet unresolved matrix effect caused by Gulf of Maine shellfish or seawater affecting the results of the Abraxis kit that has not been realized in samples from other areas.

Conclusion: DSP could be a concern in the New England region when persistent high density blooms of *Dinophysis* are found as was the case in the Nauset Marsh in 2015.

New York (Long Island; Region 8)

PSP: 2014 For the first year since 2007, no closures were implemented due to presence of PSP toxins.

2015 Closure limits >80µg/100g shellfish were reported in Meetinghouse Creek, and Shinnecock Bay, and for the first time in James Creek where toxin concentrations of 350µg/100g shellfish were found. The highest PSP concentrations measured in blue mussels during the April through June bloom events was 540µg/100g shellfish with maximum *Alexandrium fundyense* cell densities of 47 000 cell/L recorded.

2016 No closures due to PSP were reported in New York during 2016.

Conclusion: After 7 consecutive years of having shellfish bed closures due to PSP, there was no reported toxicity in 2014 and 2016 in New York waters.

DSP: 2014 There were no New York Department of Environmental Conservation closures due to DSP toxins, however, a research program documented DSP toxin levels of 20 µg / 100g shellfish in blue mussels and soft shell clams in the Northport Bay and Cold Spring Harbor regions.

2015 Northport Bay, and Cold Spring Harbor both experienced high cell concentrations of *Dinophysis acuminata* of up to 10 000 cells/L but no DSP toxicity was detected.

2016 No shellfish closures were reported in New York during 2016.

Conclusions Even though there were no closures in New York during this timeframe, DSP has been documented in the recent past (2012), and as such, DSP could be a mounting threat to shellfish resources.

Brown tide

2014. This was the eighth year in a row with elevated *Aureococcus* concentrations (570 000 000 cells/L), following a decade of very low levels. Before that, there was a decade of high concentrations, beginning in 1987.

2015 For the ninth consecutive year high *Aureococcus anophagefferens* concentrations (maximum, 800 000 000 cells/L) were recorded from May through September in Great South Bay, Moriches Bay, Quantuck Bay and Shinnecock Bay.

2016 This is the tenth year in a row that high *Aureococcus anophagefferens* concentrations, 1.5 billion cells/L, have been recorded in this region including Moneybouge Bay, Quantuck Bay, and Shinnecock Bay. The affected area covers over 100km of lagoon that was impacted between June and July of 2016. A *Synechococcus* bloom with high concentrations of 3 billion cells/L succeeded the *A. anophagefferens* bloom. This bloom has been occurring on a near annual basis since the 1980s.

Conclusions For the past ten years, brown tide has plagued various embayments on Long Island just as it did from 1987–1997.

Cochlodinium

2014. Cochlodinium blooms were seen in eastern Long Island.

2015. The Peconic Bay Estuary, Shinnecock Bay, Weesuck Creek, Sag Harbor, Accabonic Harbor and Three Mile Harbor all experienced *Cochlodinium* blooms with cell densities up to 13 000 000 cells/L during the months of August and September.

2016. Blooms of *Cochlodinium polykrikoides* were observed in Shinnecock Bay, Peconic Bay, Sag Harbor and Three Mile Harbor from August through September with cell concentrations up to 20 000 000/L causing water discoloration. Although no toxins were measured, unexplained toxicity was witnessed during the bloom in shellfish (*Argopecten irradians*) and fish (*Menidia menidia*). 'Unexplained toxicity' is noted because the toxicant associated with *C. polykrikoides* is still somewhat debated in the literature and researchers can't necessarily distinguish between direct and indirect (i.e. low DO, poor food quality, etc.) causes associated with toxic effects from the bloom in field settings.

Conclusions: *Cochlodinium polykrikoides* is a persistent "red tide" former throughout the Long Island region. Coincident with these blooms, fish and shellfish mortalities have been noted.

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

<u>There was no HAB report from this region in 2014.</u>

Alexandrium monilatum

2015. Alexandrium *monilatum* bloomed in the Hampton Roads area and along Virginia Beach's Atlantic coastline during August. Maximum cell concentrations were 7.6 x 10^6 $cells^{-L}$. Although toxicity has been demonstrated in this species in laboratory bioassays, there were no environmental impacts in the lower Chesapeake Bay environments outside of discolored water and bioluminescence.

2016. An extensive *Alexandrium monilatum* bloom was exported from Chesapeake Bay and transported along the southern most shore of Virginia to the northern outer banks of North Carolina. The bloom covered approximately 67 km of shoreline and extended offshore 3–4 km. Bloom identity was confirmed using a species-specific molecular assay and bloom extent was determined using satellite. This species is known to be toxic to shellfish larvae, but no direct monitoring was being conducted during the bloom. Hence, whether it caused any mortalities in offshore shellfish is unknown.

Conclusions: High density blooms of *Alexandrium monilatum* were found in 2015 and 2016 but no associated toxicity or impacts to fish or shellfish resources were noted at those times.

PSP 2015 & 2016 PSP toxins have not been found in Chesapeake shellfish but *Alexandrium minutum* and *A. monilatum* blooms have been documented and these species are known to produce saxitoxin and its congeners, so continued vigilance is warranted.

ASP 2015 Domoic acid was not found in the Chesapeake Bay.

2016. In Chesapeake Bay, including Tangier and Pocomoke Sounds, *Pseudo-nitzschia* was found in densities of 2 884 000 cells/L between 17 March and 14 April. Domoic acid concentrations that were detected in both water samples and oyster tissue samples using ELISA remained below the 20ppm quarantine levels.

Conclusions: High *Pseudo-nitzschia* cell abundances in the Chesapeake Bay have been documented and low levels of domoic acid toxicity associated with these high cell densities were measured.

DSP

2015. From mid-April through mid-May, routine monitoring in the Saint Martin River, Assawoman Bay and its creek tributaries showed the presence of *Dinophysis* sp. Peak cell concentration were 2.4 x 10^4 cells/L and ribbed mussels tested using the PP2A inhibition assay were positive for okadaic acid, but at levels below regulatory limits.

2016. Concentrations of *Dinophysis* reached a maximum of 42 000 cells/L in Upper Chesapeake Bay, Maryland Coastal Bays, and the Maryland Atlantic coast from the Delaware-Maryland border to the Ocean City Inlet. This resulted in detectable levels of okadaic acid in water and shellfish samples, but below regulatory levels.

Conclusions Concentrations of DSP toxins lower than regulatory thresholds were measured during blooms of *Dinophysis*.

NSP

2015. No reports of NSP toxins were reported.

2016. Water samples from the Delaware Maryland border to the Ocean City Inlet showed no evidence of brevetoxins. However, *Karenia papilionacea,* a species that is known to produce NSP toxins was found in concentrations as high as 233,300 cells/L between July 19th and August 15th.

Conclusions: Due to the presence of high densities of *Karenia papilionacea,* NSP toxicity is a potential concern for the Chesapeake Bay region.

Karlotoxin

2015. Populations of *Karlodinium veneficum* were found throughout the Maryland coastal bays and the Chesapeake Bay during much of the year but no associated toxicity was noted.

2016. *Karlodinium veneficum* bloomed in the upper reaches of two Chesapeake tributaries, the Gunpowder and Bird Rivers where it has not been previously found (maximum cell densities = 4 284 000 cells/L). Higher than normal salinity levels in the rivers are suspected in promoting these blooms which caused fish kills as a result of Karlotoxin concentrations ranging between 25–168 ng/mL.

Conclusions Toxicity attributed to Karlotoxins resulted in fish kills in 2016 and blooms of *Karlodinium veneficum* were recorded in 2015 and 2015.

Brown tide

2015. Problems associated with brown tide were not noted in 2015.

2016. Chinoteague Bay has annual blooms of *Aureococcus anaphagefferens* which damage seagrass beds within the estuary as a result of persistent high cell densities resulting in reduced light levels in the euphotic zone (0.2 meter secchi disc readings). This year's bloom had cell densities up to 140 000 000 cells/L.

Conclusions: High concentrations of *Aureococcus anaphagefferens* are damaging seagrass beds due to drastic reduction of light levels in the euphotic zone.

Florida (Regions 15 & 16)

NSP

2014. Karenia *brevis* blooms occurred on the west coast of Florida as well as Cedar Key in the fall. Fish kills (multiple species) were attributed to both blooms but no respiratory problems in humans were reported at either location. The west coast bloom reached cell densities of > 5.5 million cells /L; the Cedar Key bloom reached 2.3 million cells/L.

2015. Patchy *Karenia brevis* blooms occurred on the west coast of Florida as well as in the northern Panhandle waters. Both blooms occurred in the fall through winter months resulting in fish kills (multiple species) and respiratory problems in humans associated with the bloom along the west coast. The west coast bloom reached cell densities of 41.9 million cells /L; the Pan Handle bloom reached 10.8 million cells/L. Shellfish toxin levels of 95 MU/100g shellfish were measured in the Pan Handle region, while on the west coast, toxicity values of up to 34 MU/100g shellfish were found.

2016 As was the case last year, spatially and temporally patchy *Karenia brevis* blooms occurred on the west coast of Florida as well as in the northern Panhandle waters. In the northwest gulf coast waters, the *Karenia* boom that began in September of 2015 terminated in late January 2016. Maximum cell densities of >10 000 000 cells/L were detected resulting shellfish bed quarantines as brevetoxin concentrations of up to 35 MU/100g shellfish were found in oysters. Further south, brevetoxin concentrations ranging from <20–156 MU/100g shellfish were measured in areas where up to 61 000 000 cells/L of *Karenia brevis* were detected. The patchy bloom extended from the mid-state area near Tampa to Cape Sable on the south-western tip of the mainland. This region experienced one episode that began in September of 2015 and persisted until May 2016. A second bloom was confirmed in September and is still present as of April, 2017. The southwest

coast bloom was responsible for shellfish bed closures, multiple fish kills, respiratory irritation and marine mammal deaths.

Conclusions Karenia *brevis* blooms have been a persistent problem along the Florida west coast causing shellfish closures, multiple fish kills, human respiratory irritation and marine mammal deaths

PSP

2014. *Pyrodinium bahamense* blooms occurred on the west coast (Tampa Bay) and in the Indian River Lagoon. The Tampa Bay bloom lasted approximately four months but did not reach the lower levels of the Bay where shellfish harvesting is permitted, thus no seafood testing was done. The maximum cell concentration was 1 153 000 cells/L. The Indian River Lagoon bloom (east coast) also lasted for approximately four months with a maximum cell count of 2 425 000 cells/L. A management closure was implemented because saxitoxins were found in hard clams (*Mercenaria mercenaria*) at 217 µg/100 g shellfish. No human illnesses were reported.

2015. *Pyrodinium bahamense* blooms of up to 6.5 million cells/L were present in Indian River Lagoon on the east Florida coast. The bloom lasted approximately five months and shellfish beds were closed from 1 July to 14 October 2015 as toxin concentrations of up to 137µg/100 g shellfish were found in hard shell clams (*Mercenaria mercenaria*). No human illnesses were reported.

2016. There were two separate *Pyrodinium bahamense* blooms in 2016, one in Pine Island Sound near Cape Coral in southwest Florida and the other in the Indian River Lagoon on Florida's east coast. The bloom in the Indian River Lagoon began in late May of 2016 and persisted until early October. During this time, cells densities of up to 3 700 000 cells/L were recorded however, the shellfish beds in these areas were already closed so additional bans resulting from the bloom were not required.

In Pine Island Sound, maximum cell densities of >940 000 cells/L resulted in the closure of shellfish beds in the area as PSP toxins up to 328 µgSTX equivalents per 100g shellfish were measured using mouse bioassay. The bloom was short-lived lasting from 22 July until 1 August. No human illnesses were reported in either bloom.

Conclusions in FloridaÆ PSP has been responsible for shellfish bed closures as a result of *Pyrodinium bahamense* blooms. These appear to be localized annual problems on both east and west Florida coasts. *Pyrodinium bahamense* has been a recurring issue in both Florida locations over the past decade, however, before then, PSP toxicity was not known to be a problem in Florida.

Brown tide

2014. No occurrences this year.

2015. Time series monitoring indicates that *Aureoumbra lagunensis* commonly occurs in Indian River Lagoon phytoplankton assemblages. Increased abundance of this organism was observed beginning in September and continued through December.

2016. Increased abundance of *Aureoumbra lagunensis* continued at the beginning of the New Year in the northern and central Indian River Lagoon. It became the dominant phytoplankton species in these waters through March with concentrations reaching >1 000 000 000 cells/L which is ten times the concentration witnessed in 2015. Coincident with the high cell concentrations in March, extensive fish kills were noted.

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

ASP

2014. A *Pseudo-nitzschia* bloom (maximum cell count of 6 783 333 cells/L) occurred in Saint Joseph Bay (west coast) in late fall. Domoic acid was detected in eastern oysters (*Crassostrea virginica*) at a low level – 2.2 mg/100 g shellfish tissue.

2015. No ASP toxicity was reported in Florida waters in 2015.

2016. No ASP toxicity was reported in Florida waters in 2016.

Conclusions For the first time, Florida experienced a closure due to domoic acid (76 µg DA/g shellfish) in 2013 resulting from a short-lived *Pseudo-nitzschia* bloom in the Florida panhandle. This was followed by a high density, low toxicity bloom in 2014. Given these incidents, toxic *Pseudo-nitzschia* blooms could become more pervasive in Florida waters.

Central Gulf Coast (Region 17)

NSP

2014. No HAB report was filed.

2015. An infrequent NSP event occurred along the north Gulf of Mexico coastline from the Florida Panhandle to Louisiana. In Alabama, high densities of *Karenia brevis* were detected on 16 November 2015 and persisted until early January 2016. Resulting from this was NSP toxicity causing shellfish closures from 11/16/2015 until 1/31/2016 with NSP toxin levels >20MU detected with mouse bioassay. Previous to this bloom, the last reported shellfish closure in Alabama waters was in 2007.

In Mississippi, cell concentrations of more than 1 million cells/L were recorded causing beach and shellfish closures from late November to early January 2016. Dead fish and dolphin mortalities have also resulted from the *Karenia* bloom.

The Louisiana Department of Health and Hospitals closed Oyster Beds east of the Mississippi River in December as a result of the extensive and high density *Karenia* bloom affecting the northern gulf shore.

2016. Concentrations of *Karenia brevis* that reached a maximum of 310 000 cells/L in Mobile Bay and Mississippi Sound were detected between 16 November 2015 and 18 February 2016. This resulted in shellfishery closures associated with NSP toxicity from 11/16/2015 until 1/31/2016.

Conclusions: 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.

Texas (Region 18)

NSP

2014. At Port Aransas, a *Karenia* bloom in early-mid-September reached peak concentrations > 10 000 cells /L by the end of September. No shellfish harvest closures were issued; the bloom receded in mid-October.

2015. Karenia *brevis* blooms from Freeport south to the US/ Mexico border were observed from 13 September to late November 2015. Cells densities up to 134 000 cells/L caused water discoloration, fish kills and shellfish toxicity in various locations and times. The greatest fish kill impact was along the southern gulf shores from San Jose Island to U.S./Mexico border.

2016. In early September fish kills and moderate levels of *Karenia brevis* were reported along the Padre Island National Seashore and the southern Texas coast. A high concentration of *K. brevis* and small fish kills, including trout, flounder, croaker, and pigfish were reported in the Rio Grande Valley Area throughout September and October. Respiratory and eye irritation were also reported during this time. Low concentrations of *K. brevis* and respiratory irritation were reported in Corpus Christi Bay in October. No shellfish or beach closures were needed.

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

DSP

2014. 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.

2015. No shellfish closures related to DSP toxins were reported.

2016. 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

2014. No brown tide event was reported.

2015. The Laguna Madre experienced a significant *Aureoumbra lagunensis* brown tide bloom during the month of April.

2016. No brown tide event was reported.

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

California (Regions 19, 20, 21)

PSP

2014. Alexandrium was observed at sites along most coastal counties during 2014 including Chimney Rock LBS (Marin County) where saxitoxin concentrations up to 2134µg/100g shellfish were measured. Measurable concentrations of PSP toxins were found in 222 shellfish samples from 11 coastal counties through the course of the year.

2015. There were no closures due to PSP toxicity in California in 2015.

2016. PSP toxins above the alert level were detected at Chimney Rock in Marin County with the highest concentration being 592µg STX/100g shellfish on May 10, however, these levels dropped below regulatory concentrations in June. During the 1st week of August, a mussel sample also collected at Chimney Rock had PSP concentrations of 236µg/100g, and on the 1st of September, elevated saxitoxin levels were detected at the Santa Cruz Pier (127µg/100g). In December, PSP was detected at both the Monterey Commercial Warf, and Morro Bay sampling sites with maximum concentrations of 913 and 165µg STX/100g shellfish respectively. A health advisory was listed in Monterey County on December 16th and in San Luis Obispo County on 22 December both of which lasted until 7 March 2017.

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

2014. California's Department of Public Health's volunteer phytoplankton observers detected significant increases in *Pseudo-nitzschia* at sites representing all coastal counties during 2014 with estimates of this diatom exceeding 90 percent at times. The magnitude of domoic acid toxicity in 2014 was similar to that observed in 2013, with moderate toxin levels occurring mainly in the spring.

2015. There were extensive ASP related closures along the California coastline as a result of a massive *Pseudo-nitzschia* bloom that first began on 3 April in the Monterey Bay area with closures first implemented on 29 April. About two weeks later, ASP toxicity extended northward along the entire California coastline to the Oregon border, where traditionally, ASP toxicity is less frequent. Examples of domoic acid concentrations in various types of seafood include: 180ppm in California Mussels; 1000ppm in rock crab viscera, razor clams, 340ppm; Dungeness crab viscera, 270ppm; anchovy viscera, 1298ppm; sardine viscera, 220ppm. Seabird and marine mammal illness and deaths were numerous.

2016. For the second year in a row domoic acid (DA) was found throughout California at various times which is noteworthy as north of San Francisco, toxicity is less common. In May, the health advisory for Dungeness crab was lifted for the entire coast although in November it was reinstated for northern portions of California waters until early January

2017 when the state ban was lifted once again. Offshore samples collected in Southern California had persistent DA levels above quarantine in rock crab samples from January through early June. Razor clams from Humbolt Beach had DA concentrations up to 380ppm and harvesting advisories on them were common throughout the year in numerous areas along the California coastline.

Conclusions California seafood and marine life were deeply impacted by domoic acid toxicity produced by *Pseudo-nitzschia* blooms the most extensive of which was documented in 2015. This bloom was associated with unusually warm ocean waters which persisted along the west coast from late 2013 until the middle of 2016.

Oregon (Region 22)

PSP

2014. PSP toxin levels reached 792 μg/100g shellfish in mussels, resulting in closures.

2015. Closures from the mid-north coast to a little north of the California border were implemented on 9 May with toxin levels reaching 428 μg/100g shellfish. This closure was extended to the Columbia River (north boundary of the state) on the 22nd of May. Harvesting of mussels began to be opened up on the 22nd of June from the mid-north coast, and by 17th of July for the remainder of the coast. Clams and oysters were not included in this ban as significant PSP concentrations were not detected in either species.

2016. No closures due to PSP were reported in Oregon during 2016.

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

ASP

2014. A domoic acid closure along the Oregon coast began in September and continued through the end of the year; levels reached 53ppm in razor clams.

2015. Closures resulting from ASP in one section of the Oregon coast from Tillamook Head (south of Seaside) to the California border began in September of 2014 and persisted through the end of 2015; levels climbed to 170ppm in razor clams whereas in 2014 the concentrations were 53ppm. There was a delay in the Dungeness crab season opening due to domoic acid levels up to 70ppm in their viscera. Normal season opening is December 1st; however, this was delayed until January 2016 resulting in a serious economic loss as crab were not available for sale during the holidays. The razor clam fishery was also negatively impacted with the harvest season closed for part of the year affecting the commercial and recreational fishery.

2016. Domoic acid has been measured in both razor clams and Dungeness crabs for the last two years. The 2016 Dungeness crab season was once again delayed and experienced partial closures during the season. Razor clamming was closed along the majority of the coast for most of the year. The closures and delays caused major economic losses in addition to a loss in market confidence.

Conclusions For 3 consecutive years, the commercial and recreational seafood industries were adversely affected by domoic acid toxicity.

Washington (Regions 23–24)

The Washington State coastal waterways which encompass regions 23 and 24 are plagued by HAB events caused by *Alexandrium fundyense*, *Dinophysis* spp. and *Pseudo-nitzschia* spp. and the situation became more pronounced as for the 1st time, PSP toxicity was detected in the Hood Canal growing area. A breakdown of the various events follows.

PSP

2014. Very high toxin levels were measured in blue mussels in Central Puget Sound – 12 688 µg/100g shellfish. This is the third year in a row with very high toxicity. Additionally, there were 26 sub-tidal geoduck clam tracts, 5 general growing areas as well as 18 recreation closures due to PSP including the Pacific coast, Sequim Bay and Puget Sound.

2015. For the 4th year in a row, the central Puget Sound experienced PSP toxicity with toxin concentrations ranging from 86 to 880 µg/100g in blue mussels, butter clams and geoduck clams. In the northern end of Puget Sound, higher PSP values ranging from 319–1581µg/100g shellfish were recorded. A long-lasting closure occurred throughout the Straits of Juan de Fuca where PSP up to 506 µg/100g shellfish was detected resulting from high densities of *A. fundyense*. Along the coastal beaches and estuaries, PSP toxicity (93–253µg/100g shellfish) was found. In the Hood Canal region, PSP toxicity expanded further south than previously recorded and shellfish beds in that region had to be closed. Coincident with the closure, toxin values ranged from 105 to1031µg/100g in a variety of shellfish including blue mussels, geoduck, manila, pacific and varnish clams.

2016. For the fifth consecutive year, Puget Sound experienced PSP toxicity, which caused fishery closures in the northern and central regions with toxin concentrations ranging from 104–2535µg/100g measured by mouse bioassays in blue mussels, butter clams, and geoduck clams. The northern section was closed with toxin concentrations ranging from 309–763µg/100g in blue mussels and pink scallops. The area encompassing the Strait of Juan de Fuca and the Olympic Peninsula also experienced closure due to PSP toxicity. Toxin concentrations in blue mussels, Manila clams, littleneck clams, Pacific oysters, and geoduck clams ranged from 98–518µg/100g. Coastal beaches and estuaries of Washington were closed to shellfishing with maximal PSP levels of 220µg/100g. Toxicity levels, caused by *Alexandrium fundyense*, as well as the duration of the closures increased from 2015 in Puget Sound, the Strait of Juan de Fuca, and the Olympic Peninsula.

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

ASP

2014. There were no commercial or recreational closures due to domoic acid in 2014.

2015. Commercial fishery closures resulting from ASP were a major problem not only for shellfish but also for the Dungeness crab seasons. ASP toxins ranging from 62 to 169ppm were measured resulting in razor clam and Dungeness crab closures. The Dungeness

crab season closed on 6/5/16 for the southern Washington coast and 8/3/15 for the northern Washington coast. Recreational Dungeness crab season reopened 9/25/15 and the commercial season did not reopen until 1/4/16. All told, this was a huge economic loss to the Washington State coastal community.

2016. The extensive *Pseudo-nitzschia* bloom that impacted the west coast of the US closed the razor clam fishery along the Washington coastal beach area beginning in the spring of 2015 lasting until the spring of 2016. A more recent bloom in September of 2016 resulted in the closure of razor clam harvest at two of Washington's southern beaches. One of the two beaches remains closed as of February 2017.

Conclusions Closures resulting from domoic acid toxicity beginning in 2015 and lasting into 2017 have had a pronounced economic impact on the Washington State fishery.

DSP

2014. Two commercial closures and nine recreational resulting from DSP occurred this year with the highest toxin level recorded being 180µg/100g shellfish in Sequim Bay.

2015. The north Puget Sound waters were closed to shellfishing due to DSP toxicity with maximum toxin concentrations of 19µg/100g shellfish measured by LC/MS. In the central Puget Sound area, DSP toxins up to 157µg/100g shellfish were measured resulting in bed closures. In the south Puget Sound waters, DSP concentrations of 43µg/100g were measured in blue mussels. DSP toxins were also found in the Straits of Juan de Fuca where shellfish measurements from 16 to 43µg/100g were reported.

2016. The entirety of the Puget Sound experienced closures due to DSP toxicity in 2016. Waters in northern Puget Sound were closed with toxins reaching a maximum level of 31µg/100g. Toxicity levels ranging from 21–242µg/100g in blue mussels closed the central Puget Sound, and in the southern Puget Sound, okadaic acid values of up to 250µg/100g shellfish were measured in blue mussels with lesser amounts in Pacific oysters and cockles. The ongoing shut-down incorporates two inlets that have not been included in prior closings that have occurred in the area since 2013. DSP toxins reaching a maximum of 35µg/100g in geoduck clams and blue mussels closed the region of the Straight of Juan de Fuca and the Olympic Peninsula while the Hood Canal was closed to shellfish harvest for a brief interval with maximum DSP toxin levels in blue mussels reaching 17µg/100g.

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

***Heterosigma* fish kills**

2014. A bloom of *Heterosigma akashiwo* in northern Puget Sound, including Port Angeles, the San Juan Islands, and Bellingham Bay caused mortalities of net penned salmon. Densities of *H. akashiwo* reached 5 000 000 cells/L. At least 345 adult summer chum salmon were killed the third week of September.

2015. There were no reported fish kills due to *Heterosigma*.

2016. There were no reported fish kills due to *Heterosigma*.

Conclusions: Heterosigma blooms and related fish kills are one of many HAB concerns confronting the Washington State waterways.

Alaska (Regions 25–27)

PSP

2014. In December of 2013, fish inspectors in China notified the U.S. Embassy that China was tentatively suspending imports of geoducks and other "double-shell aquatic animals" such as oysters, because they found high levels of PSP in a Nov. 21 shipment of geoducks. China closed its doors to all shellfish imports from an area that stretches from northern California to Alaska. The state of Washington reports losses of as much as $600 000 per week. The ban was instituted after finding two "bad" clams – one from Alaska with high PSP levels and one from Washington State with high inorganic arsenic levels. The ban was lifted after six months, but industry sectors and agencies are worried about current monitoring protocols and the potential for another export issue with China. Many believe that if there is a continued export ban by China due to PSTs in U.S. geoducks, it will be economically catastrophic to these fisheries, potentially eliminating the export fishery from the entire west coast. Ninety percent of the geoduck harvested in Washington is sold to China and Hong Kong.

2015. Mussels, butter clams, krill, sand lance, herring and Dungeness crab in region 25 all had measurable amounts of saxitoxin with the maximum concentration of 1135µg/100g shellfish determined by HPLC. In region 26, concentrations up to 6580µg/100g were found in various types of seafood including blue mussels, butter clams, sand lance and herring. One False Pass gull tested positive for PSP. PSP toxicity caused production value decreases in some areas as a result shellfish closures and a direct loss of subsistence and personal use of bivalve clams and Dungeness crab was also realized. In Kachemak Bay, for the first time in 10 years, a toxic HAB event was recorded as PSP was detected in 2 sub-bays in oysters and blue mussels.

2016. An *Alexandrium* bloom associated with PSP was detected in Kachemak Bay in 2016 with toxin concentrations over 80µg/100g. In St. George, PSP toxicity reached 1590µg/100g in July and then fell to 222µg/100g by October.

Conclusions: Alaska has persistent annual PSP shellfish related toxicity but the state does not conduct routine monitoring of these resources except for commercially harvested product. However, in 2013 in conjunction with NOAA, 14 Native Tribes in Southeast Alaska joined together to create the Southeast Alaskan Tribal Toxins network (SEATT). This organization provides testing for PSP and ASP for subsistence and recreational shellfishers to help safeguard harvesters.

ASP

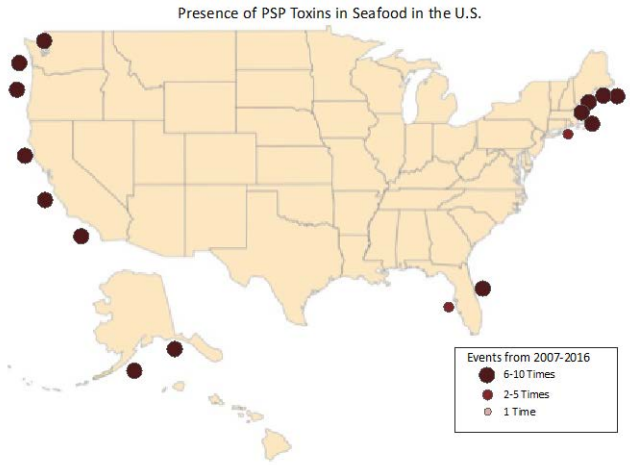
2014. No reports of ASP.

2015. Much warmer than normal water and air temperatures as a result of an unusually persistent high pressure ridge that first developed in 2013 on the USA and Canadian west coasts, along with the significant impact from the El Niño event continued to influ-

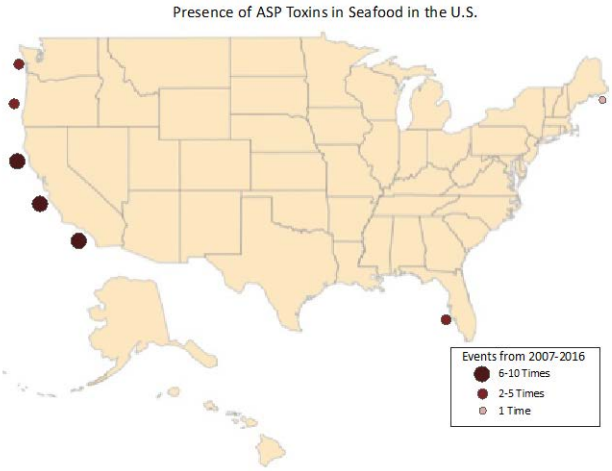
ence the Alaskan coastal areas during the spring and summer of 2015. Coincident with this was an extensive bloom of *Pseudo-nitzschia australis* extending along the entire continental shelf from Ketchikan to the Aleutian Islands. Toxicity testing of water samples from this bloom revealed very low DA concentrations, and ASP toxins in shellfish samples from May through September 2015 in region 25 were also low. Nonetheless, at least 45 whale strandings were reported in the Gulf of Alaska in 2015 with a possible link to domoic acid poisoning. Sand lance, herring and krill were being investigated as potential toxin vectors. Dead Sea otters, sea lions and birds were also found along Gulf of Alaska coastlines but the cause of death is unknown as of now.

2016. No reports of ASP.

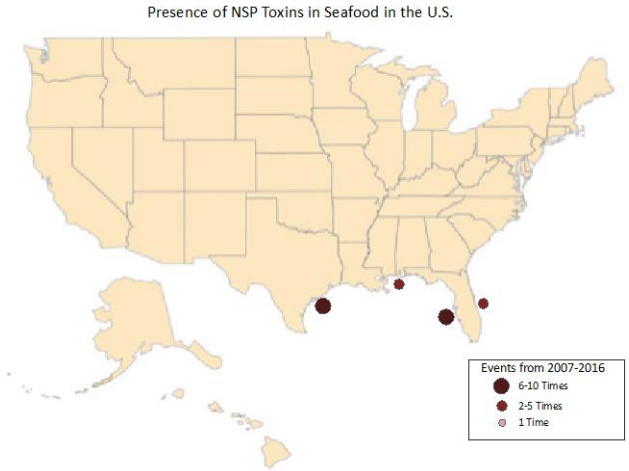
Conclusions: There appears to be a link between domoic acid and marine mammal deaths and strandings along the Alaskan coast and further investigation into this is needed.



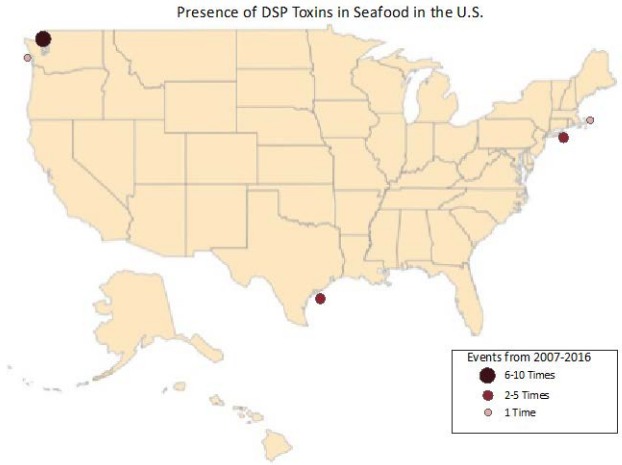
PRESENCE OF PSP TOXINS IN SEAFOOD IN THE U.S. – CHANGES DURING THIS PERIOD REFLECT A DECREASE IN FREQUENCY IN THE LONG ISLAND, NEW YORK AREA AND AN INCREASE IN THE FLORIDA WEST COAST WATERS.



PRESENCE OF ASP TOXINS IN SEAFOOD IN THE U.S. – CHANGES DURING THIS PERIOD REFLECT A SIGNIFICANT CLOSURE IN MAINE.



PRESENCE OF NSP TOXINS IN SEAFOOD IN THE U.S. – CHANGES DURING THIS PERIOD REFLECT AN INCREASE IN FREQUENCY IN CENTRAL GULF OF MEXICO REGION (ALABAMA, MISSISSIPPI, LOUISIANA).



PRESENCE OF DSP TOXINS IN SEAFOOD IN THE U.S. – CHANGES DURING THIS PERIOD REFLECT THE ADDITION OF SALT POND, NAUSET ESTUARY, MASSACHUSETTS.

Portugal National Report 2014–2016

A. Silva, M.A. Castelo-Branco, S. Rodrigues Portugal

The Portuguese Monitoring of HABs and phytotoxins, carried out by IPMA (Portuguese Institute for the Sea and Atmosphere, www.ipma.pt/), covers the whole coast of Portugal except Madeira and Açores archipelagos. The sampling grid covers 10 coastal areas (20 stations) and 26 estuaries+coastal lagoons (30 stations). The sampling is carried out on a weekly basis: 50 samples from shellfish harvesting areas and phytoplankton retention areas (90% of the stations are coincident for water and shellfish samples and 10% are sentinel stations for HABs initiation).

2014

During 2014, 15 events were reported in coastal areas and 14 in estuaries+coastal_lagoons. The events have lasted a minimum a month and a maximum of nine months, starting, in general, in April. From these events, 25 closures were by DSP associated toxins above the critical limit, *Dinophysis acuminata* recorded a maximum concentration of 76x103cells/L (850 µg OA equiv. Kg-1 in *Spisula solida*) in the NW coast in September (29/9/14) and 4 closures by ASP in Aveiro Ria, when 217x103cells/L of *Pseudo-nitzschia seriata* complex were observed (27 mg/Kg in *Cerastoderma edulis*) in June. The most problematic areas were the NW coast and Algarve. In these areas, events and bans are for longer periods, while for the SW coast events are normally shorter in time. The year of 2014 was warmer and rainy than 2013 and the number of events varied slightly, 29 in 2014 in relation to the 26 events in 2013 (9 DSP and 2 ASP events in coastal areas and 12 DSP and 3 ASP events in estuaries+lagoons). Compared to 2013, in 2014 events were detected earlier in the year:

- ASP events were detected in June instead of September, with a similar interval, around a month and half and mostly located at the NW coast.

- DSP events occurred in January, and again, from April until December, the longer and continuous ban recurrently observed in the NW and S coasts.

Regarding the presence of new species, *Karenia* genus, instead of single and sporadic detections, is becoming regular in monitoring water samples but in lower concentrations (<200 cells/L). *Gymnodinium aureolum* and *Takayama cladochromum* are also becoming regular presences in samples. No events were recorded for benthic *Prorocentrum* species or benthic HABs (e.g. O*streopsis*, *Coolia*) In October 2014; a single and occasional event of fish mortality (natural fish) was reported in Obidos lagoon, by locals that contacted IPMA. Water samples were collected and 250x103 cells/L of *Mesodium* spp. and 800 cells/L of *Kryptoperidinium foliaceum* were observed. These species were either absent or in very low concentrations in the monitoring water samples from the weeks prior and subsequent to this event.

2015

During 2015, 9 events were reported in coastal areas and 17 in estuaries and coastal lagoons. The events lasted a minimum of one month and a maximum of nine months, starting, in general, in April. From these events, 22 closures were by DSP associated toxins

above the critical limit, caused mostly by *Dinophysis acuminata* and 5 closures by ASP in particular due to *Pseudo-nitzschia seriata* complex.

In comparison with 2014, the year of 2015 was warmer and extremely drier and the number of events varied slightly, 26 in 2015 (in relation to the 25 events in 2014), 7 DSP and 2 ASP events in coastal areas and 15 DSP and 3 ASP events in estuaries and lagoons. In 2015 events were detected earlier in the year and last until December (usually is until September):

- ASP events were detected in April instead of June, and lasted for three months maximum.
- DSP events occurred later in the year, starting in April (instead of January as in 2014), until December

No events were recorded for benthic *Prorocentrum* species or benthic HABs (e.g. O*streopsis*, *Coolia*).

<u>ASP:</u> *Pseudo-nitzschia* species were regularly observed in water samples. Thresholds for early-warning (100x10^3 cells/L) and bloom initiation (200 x10^3 cells/L) are currently being evaluated because several harvesting closures occurred under lower cell concentrations in the water (<100x10^3 cells/L). Events were all on the NW coast, mostly associated with *P. seriata* complex proliferations;

i) PT-01, 116x10^3 cells/L (54 mg/Kg in *Mytilus galloprovincialis*) in 07/04/15
ii) PT-01/PT-02, 258 x10^3 cells/L (22 mg/Kg in *Mytilus galloprovincialis*) in 09/04/15
iii) PT-02, 165 x10^3 cells/L from *P. seriata* group (26 mg/Kg in *Mytilus galloprovincialis*) in 06/04/15 and 339 x10^3 cells/L from *delicatissima group,* also in April (28/04), with no shellfish toxicity (4 mg/Kg in *Venerupis corrugata*) but the area was closed for harvesting by the presence of *Pseudo-nitzschia* genus above 200x10^3 cells/L,
iv) PT-02, 93 x10^3 cells/L (23 mg/kg in *Cerastoderma edule*) in 04/08/15
v) PT-01/PT-02, 267 x10^3 cells/L in 18/8/15, the area was closed for harvesting by the presence of *Pseudo-nitzschia* genus above 200x10^3 cells/L.

<u>DSP:</u> *Dinophysis* species are a regular presence in water samples and responsible for most of the shellfish harvesting closures. *D. acuminata* was the dominant species, followed by *D. acuta, P. rotundata, D. caudata, D. ovum,* in decreasing order of concentration.

<u>*NW coast:*</u> Five events were reported along the NW coast, a short event (3 weeks) in January-February (cells below warning levels for cells in the water), and four others from April until December:

- PT-01, 5840x10^3cells/L, (>850 μg OA equiv. Kg^{-1} in *M. galloprovincialis*) in 21/04/15
- PT-02, 1840x10^3cells/L (>850 μg OA equiv. Kg^{-1} in *Venerupis corrugata*) in 11/05/15
- PT-01-PT-02, 3300x10^3cells/L (394 μg OA equiv. Kg^{-1} in M. *galloprovincialis*), in 12/05/15
- PT-03, 760 cells/L (118 μg OA equiv. Kg^{-1} in *Cerastoderma edule*) in 21/07/15

<u>*SW coast:*</u> Nine events were reported along the SW coast, from mid-April until the end of December. The highest concentrations were observed in:

- PT-05, 3500x10^{3}cells/L (96 µg OA equiv. Kg^{-1} in *Ensis siliqua*) in 01/09/15
- PT-04, 1520x10^{3}cells/L (370 µg OA equiv. Kg^{-1} in M. *galloprovincialis*) in 07/09/15
- PT-05, 3320 cells/L (>850 µg OA equiv. Kg^{-1} in M. *galloprovincialis*) in 14/09/15
- PT-04, 2340x10^{3}cells/L (>850 µg OA equiv. Kg^{-1} in M. *galloprovincialis*) in 26/10/15

S coast: Seven events were reported along the S coast, from mid-April until the end of December. The highest concentrations were observed in:

- PT-06, 3000x10^{3}cells/L (217 µg OA equiv. Kg^{-1} in *M. galloprovincialis*) in 14/04/15
- PT-07, 1300 cells/L (189 µg OA equiv. Kg^{-1} in *M. galloprovincialis*), in 08/06/15
- PT-07, 4920x10^{3}cells/L (143 µg OA equiv. Kg^{-1} in *M. galloprovincialis*) in 31/08/15
- PT-06, 4600x10^{3}cells/L (207 µg OA equiv. Kg^{-1} in *M. galloprovincialis*) in 08/09/15

No PSP outbreaks were recorded during 2015.

2016

During 2016, 24 HAB events were reported, 11 events in coastal areas and 13 in estuaries and coastal lagoons. The events have lasted a minimum a month and a maximum of ten months, starting, in general, in April. From these events, 21 closures were due to DSP associated toxins above the critical limit, caused mostly by Dinophysis acuminata, 1 closure due to ASP in particular due to Pseudo-nitzschia seriata complex and 2 due to PSP due to Gymnodinium catenatum. Details of the events are given in the table below.

Characterization of each toxic event in terms of cell concentration and dominant species in the water and toxin concentration in shellfish.

	Coast of Portugal	Production Areas	Areas code name	Maximum concentration (cells/L)	HAB SPECIES	ASP (mg/Kg)	PSP (µg STX equiv. Kg-1)	DSP (µg OA equiv. Kg-1)	Shellfish
2016	NW and Center	L2	PT-01	4240000	*Pseudo-nitzschia Seriata group*	421			*Spisula solida*
		RIAV	PT-02	4540	G.catenatum		4919		*Mytillus galloprovincialis*
		L2 and L3	PT-01, PT-02	23800	G.catenatum		957		*Mytillus galloprovincialis*
		L1,L2 and L3	PT-01, PT-02	no data	D.acuminata+D.ovum			256	*Mytillus galloprovincialis*
		L1	PT-01	4000	D.fortii			183	*Mytillus galloprovincialis*
		L2 and L3	PT-01, PT-02	4300	D.acuminata			275	*Mytillus galloprovincialis*
		ELM	PT-01	3200	D.acuminata			215	*Mytillus galloprovincialis*
		RIAV	PT-02	600	D.acuminata			791	*Mytillus galloprovincialis*
		L4	PT-03	no data	D.acuminata			> 850	*Mytillus galloprovincialis*
		EMN	PT-03	4456	P.cordatum			273	*Cerastoderma edule*
		LOB	PT-03	1080	D.acuminata			528	*Mytillus galloprovincialis*
	SW	L5	PT-04	900	D.acuminata			169	*Mytillus galloprovincialis*
		EMR	PT-05	800	D.acuminata			451	*Mytillus galloprovincialis*
		LAL	PT-04	520	D.acuminata			209	*Mytillus galloprovincialis*
		ETJ	PT-04	180	D.acuminata			340	*Mytillus galloprovincialis*
		L6 and L7a	PT-05	1st event- 2320; 2nd event- 800	D.acuminata			1st event- 468; 2nd event - 397	1st event- *Mytillus galloprovincialis* ; 2nd event- *Donax* sp.
	S	L7c, L8 and L9	PT-06, PT-07	3920	D.acuminata			443	*Mytillus galloprovincialis*
		LAG	PT-06	200	D.acuminata			231	*Mytillus galloprovincialis*
		POR2	PT-07	640	D.acuminata			41	*Mytillus galloprovincialis*
		OLH and FUZ	PT-07	3080	D.acuminata			351	*Mytillus galloprovincialis*
		TAV	PT-07	5120	D.acuminata			354	*Mytillus galloprovincialis*
		FAR1 and FAR2	PT-07	200	D.acuminata			417	*Cerastoderma edule*
		L9	PT-07	140	D.acuminata			189	*Donax sp.*

ASP: Pseudo-nitzschia species are regularly observed in water samples. Thresholds for early-warning (100x103 cells/L) and bloom initiation (200 x103 cells/L) are currently being evaluated. As in previous years blooms were reported only for the NW coast of Portugal and in 2016, there was only one event (5 in 2015) in the NW coast that started later in the

year (June instead of April) and bans were shorter in time (Table 1 and 2). The highest concentration recorded in the water was 424x104 cells/L.

DSP: Dinophysis species are a regular presence in water samples and responsible for most of the shellfish harvesting closures. D. acuminata was the dominant species, followed by D. acuta, D. caudata, D. ovum, P. rotundata, in decreasing order of concentration. On the NW coast there were more toxic events in 2016 but not all lasted until December like in 2015, while on the SW coast the number of toxic events decreased and started later in the year. The number of events on the S coast was similar to 2015 both in the period of occurrence and duration of the ban. The highest concentration was reported in the south coast, Algarve, 5120 cells/L.

PSP: These events were only reported in the NW coast, later in the year (December), caused by
severe blooms of Gymnodinium catenatum (not reported in 2015) that reached 23800 cells/L causing an extensive ban (December 2017 onwards).

Spanish National Report (2014–2016)

In Spain, the official control of toxic phytoplankton concerning classified production areas is under the competences of the different autonomous communities. At the national level, Jacumar is the institution in charge of the coordination, as for example it is in charge of compiling data from the different autonomous programs to submit the information to EU. The different representatives of each autonomous community are part of Jacumar. In order to contribute in a coordinated way to the EURLMB-Working Group on Phytoplankton control, the tree main institutions conducting official control of toxic phytoplankton in Spain (INTECMAR, IRTA and LCCRRPP) organized the Spanish Phytoplankton Group under the umbrella of Jacumar.

1. Andalusia (LCCRRPP, Junta de Andalucía)

ASP: ASP closures only in the Mediterranean (eastern coast) in 2014 off Cádiz and Málaga, due to a *Pseudo-nitzschia* cf. *australis* bloom in eastern Andalucía. This area registered also in Jul 2016 an increase of *P.* cf. *australis* in Algeciras Bay (Cádiz; máx. 75 258 cells L^{-1}) below regulatory limits (RL).

No ASP closures in the Atlantic (western coast); Domoic acid (DA) slightly increased its levels (always below RL) off Huelva from Mar-Jul in 2014 & 2016 due to (mid-Mar to end of Apr 2014 (max. 69,708 cells L^{-1}), Jun 2016 ("**AND 19**" max 26,400 cells L^{-1}) and Jul 2014 (máx. 164,261 cells L^{-1}).

DSP: DSP closures in the Mediterranean coast only in 2014: *D. acuminata* off Cádiz and Málaga from April till late Aug-Sep (max. 1,200 cells L^{-1}) responsible of scattered positive results.

DSP closures in the Atlantic coast each year (2014–2016) mainly off Huelva, associated with blooms of *D. acuminata*, excepting 2014 when the whole western coast was affected. An early bloom in 2014 led to positive values in all western zones followed by another major bloom in Apr (max 6,720 cells L^{-1}, late Apr), that declined in late May and peaked again until Sep (max. **¿?** cells L^{-1}). From late Jul-Aug 2014 a bloom of *D. acuta* (max. 3,240 cells L^{-1}) co-occurred with *D. acuminata* in the Guadiana River estuary (DSP positives from April to October throughout this region). From Oct-Dec 2014, low densities ($\leq$ 500 cells L^{-1}) of *D. acuminata* persisted but only one positive was recorded. In 2015, same situation off river mouths but due to *D. acuminata* blooms (3.6×10^3 cells L^{-1}) between Apr-Oct. Closures in these areas In Jan, Apr-Oct, and December.

In 2016 all closures off Huelva (excepting three positives in Málaga) by *D. acuminata*. In Huelva, positives started from Jan practically all along the coast due to remnant cells from 2015. Between Apr-Jul, new growth pulses (up to 4,360 cells L^{-1} in area "AND 19" (Huelva) during Apr) were detected, with DSP positives in mollusks between Apr-Aug in most production areas. From then to the end of the year, *D. acuminata* did not disappear from the water but kept low numbers (< 500 cells L^{-1}), and DSP closures were registered in few areas between Oct-Nov.

PSP: PSP closures in the Mediterranean coast only in 2014 and 2016, mainly in the second part of the year, always due to *G. catenatum.* In 2014 this species exhibited the same patterns throughout the whole Eastern Andalucía, with minor proliferations on Jan and late May and a major bloom in autumn with PSP closures off Cádiz (late Sep to Nov, max. 5,600 cells L^{-1}) and Málaga (6920 cells L^{-1}). Moderate blooms in a most northerly province (Almeria: <10^3 cells L^{-1}) with PSP positives only in Jan 2014. In 2016, PSP positives from Jun-Dec (Cádiz to Granada). The highest PSP toxin levels in mollusks in Dec, during population peaks (*G. catenatum*. max. 11,240 cells L^{-1} in area "AND 24–2" (Cádiz), around mid-December).

No PSP closures in the Atlantic coast. Some minor blooms of *G. catenatum* (max. 3,360 cells L^{-1}) off Huelva with PSP toxins below RL.

Other events: *Ostreopsis events in Almeria during* 2015 (J. Gilabert, pers. comm. at the end of June three Almería beaches were closed a few days due to occurrence of *Ostreopsis* and around 90 people were affected and had respiratory problems. Several newspapers covered this event at local and national scale (El País, 29 June: http://politica.elpais.com/politica/2015/06/29/actualidad/1435572178_691276.html).

2. Basque Country (AZTI (Pasaia) & University of the Basque Country (Leioa))

ASP, DSP, PSP

The Oka estuary (the only location where the authorities allow shellfish harvesting activity) did not suffer any ASP, DSP or PSP closures in this period. Toxins were always below quantification limits. Regarding ASP, cells identified as *Pseudo-nitzschia* spp. never exceeded 10^4 cells/L. Regarding lipophilic toxins, OA or Dinophysis spp. were never detected. Only potential YTX producers (*Gonyaulax spinifera*, 100 cells/L) were observed in spring 2015.

Pilot-scale farm (not commercial) located in open waters off the Basque coast. Regarding ASP, DA was not detected and occurrence of *Pseudo-nitzschia* spp. was only detailed in 2016, with frequent and occasionally abundant numbers (about 10^5 cells/L: *P. galaxiae, P. multistriata, P. americana/brasiliana*, together with non-identified species).

DSP toxins (OA) were above the allowed limits in mussels in 2 samplings (May 2014 and April 2015), whereas in 2016 these were detected in 5 samplings but lower quantities. DSP toxicity was not detected in oysters. Potentially toxic dinoflagellates (DSP) such as *Dinophysis acuminata*, *D. caudata*, *D. tripos* and *Phalacroma rotundatum* were observed in spring 2014/2015 and *D. acuminata* in 2016. Lipophilic toxins (YTX) were frequently detected (79% samplings) and paralytic toxins sporadically, during the 14 campaigns conducted in 2016. YTX correlated with the cell abundance of *Lingulodinium polyedrum*. It peaked in summer. Paralytic toxins were found only in 2 campaigns, during autumn.

Other events: *Alexandrium* sp. (*A. tamarense* complex) dominant organism in net samples of the seaward reaches of the Nervión estuary in late summer 2015 (4,220 cells/L). It was the first observation of a bloom of *Alexandrium* in this estuary during 15 years of monitoring.

3 .Catalonia

Catalonian beaches (during the summer): (Group of Litoral Processes from ICM-CSIC (national Project *OstreoRisk*) & ACA)

ASP: Detection of potentially toxic *Pseudo-nitzschia* spp. at densities above 10^5 cells L^{-1} in early July 2015 in several beaches and lower in 2016 (< 3 x 10^4 cells/L), only detected in two beaches. No reports in 2014.

DSP: Detection of potentially toxic species, *Dinophysis sacculus, D. caudata, Phalacroma rotundatum* and *Prorocentrum lima*, were scarce and their densities were very low in 2015 and 2016. No reports in 2014.

PSP: *Alexandrium taylori* blooms (>10^6 cells L^{-1}) were observed especially in 2015, its proliferations being registered in all Costa Brava beaches (max. densities Muga river: 2.7·x 10^6 cells L^{-1}). High densities (7.2 x 10^5 cells L^{-1}) were found for the first time further south (away from the common area of detection in Costa Brava), at the Arenal (Ampolla) beach, and again in 2016 (max. of 5 x 10^5 cells L^{-1}). Both in 2014 and 2016 concentrations were lower than usual (<10^6 cells L^{-1}), excepting two beaches (Estartit and Es Grau), in 2016.

Other events - *Ostreopsis.* In general, a positive trend has been observed in the last 3 years. In 2014 exceptionally high densities of *Ostreopsis* cf. *ovata* (>10^6 cells L^{-1}) were observed in mid-July in Sant Andreu de Llavaneras, a hot spot with recurrent and long lasting blooms for several months. Lower values in the water column from July to mid-August and by late July 2014, high densities detected in Sitges-Terramar (6.6x10^4 cells L^{-1}) and Ribes-Rojes (1.5x10^4 cells L^{-1}).

In 2015 again high densities in Sant Andreu de Llavaneras (peak of 6.8 x 10^4 cells L^{-1} in the water column and 1.1 x·10^6 cells g^{-1} wet weight macroalgae) from July to mid-August. A few cases (milder than usual) of local inhabitants affected by respiratory irritations. Similarly to 2014, high densities in mid-July in Sitges-Terramar (up to 2.3 x· 10^4 cells L^{-1}) and in this occasion also in Sant Feliu (up to 6.2 x· 10^4 cells L^{-1}).

In 2016, *Ostreopsis* blooms showed a first usual summer peak but also a second shorter one in autumn (early October). In July max. densities of 1–8 x10^4 cells L^{-1} in the water column, while in the benthos it reached values similar to 2015 (up to 1.3 x 10^6 cells g^{-1} fresh macroalgae). In mid-July, 17 people were affected with respiratory symptoms associated with *Ostreopsis* proliferations. Again, high densities (up to 4.2 x10^4 cells L^{-1}) of *Ostreopsis* were detected in Sitges-Terramar in August, followed by densities of up to 4 x 10^3 cells L^{-1} in other two beaches of the Costa Brava. The autumn peak exceeded 5x10^5 cells g^{-1} fresh macroalgae. Irritative respiratory tract symptoms at that time, from a group of volunteers, workers and residents from buildings nearby.

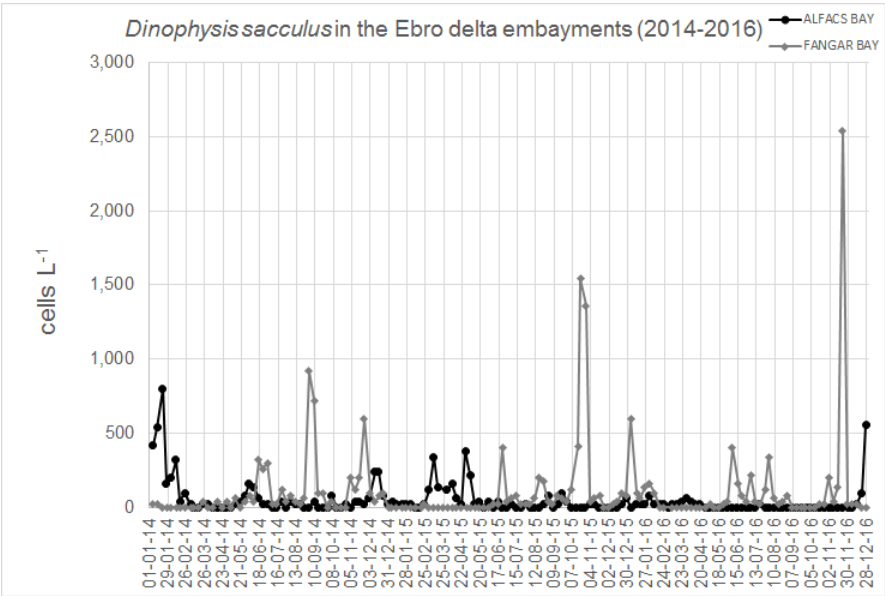
The results presented come from two projects: i) a contract for the "*Monitoring of toxic and harmful phytoplankton on the beaches of the Catalan coast*" (ACA, ICM-CSIC) and ii) National R+D+I project, RETOS Program, **OstreoRisk**: "*Noxious Proliferation of* Ostreopsis *in the NW Mediterranean: assessment of potential health risks*" (CTM2014–53818-R).

Catalonia coastal monitoring (IRTA, Sant Carles de la Rápita, Tarragona)**.**

In coastal embayments of the Ebro Delta abundances of toxic species during 2014–2016 were low in comparison with other years; alert levels were reached only occasionally. Along the open shore of Catalonia in the years 2014–2016, the abundance of toxic producing species was over alert levels during 22 weeks due to *Alexandrium minutum*, 5 weeks due to *Dinophysis sacculus* and 12 weeks due to *Pseudo-nitzschia* spp. These events along the open shore occur mainly in spring.

DSP/Lipophilic toxins

Closures were enforced in Arenys and Masnou in June-July 2014 after positive mouse bioassay results. During these events, the presence of yessotoxins under regulatory levels was confirmed by LC-MS/MS. The main species involved in DSP events in Catalonia; *Dinophysis sacculus*, *Dinophysis caudata* and *Prorocentrum lima* were present in low densities in shellfish growing areas. Maximal abundances detected for *Dinophysis sacculus* in the Ebro delta embayments were 8 x 10^2 cells L^{-1} in January 2014 in Alfacs Bay and 2.5 x 10^3 cells L^{-1} in November 2016 in Fangar Bay (Figure XX). *Dinophysis sacculus* reached high abundances in Masnou harbor (1.3 x 10^5 cells L^{-1}) in March 2015 and (3.5 x 10^5 cells L^{-1}) February 2016 as well as in port Ginesta (2.4 x 10^4 cells L^{-1}) in April 2015 and (2.3 x 10^4 cells L^{-1}) in October 2016. Yessotoxin producing species, *Protoceratium reticulatum*, *Lingulodinium polyedrum*, and *Gonyaulax spinifera*, were present in very low density. All shellfish samples tested for lipophilic toxins were below regulatory levels in 2015 and 2016.

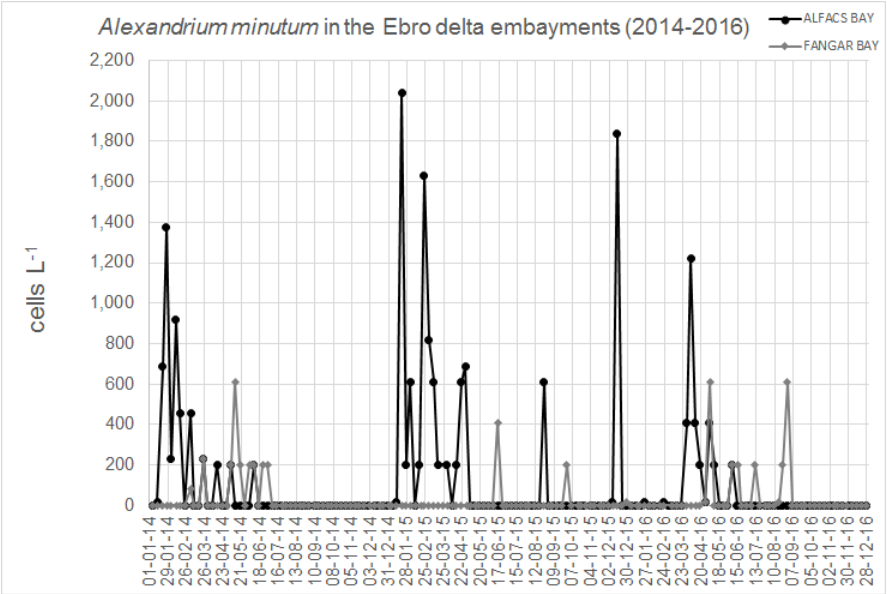


Abundance of *Dinophysis sacculus* in the Ebro delta embayments during the years 2014–2016.

PSP: Precautionary closures due to high levels of *Alexandrium minutum* (5 x 10^5 cells L^{-1}) inside several harbours) were enforced in Arenys from February to the end of April 2014, in Vilanova during April and June 2014 and in February and March 2016. During the years 2014–2016, *Alexandrium minutum* was present along the coast and reached a maximum of 2.4 x 10^6 cells L^{-1} in Arenys de Mar harbor in March 2015. It was also present in

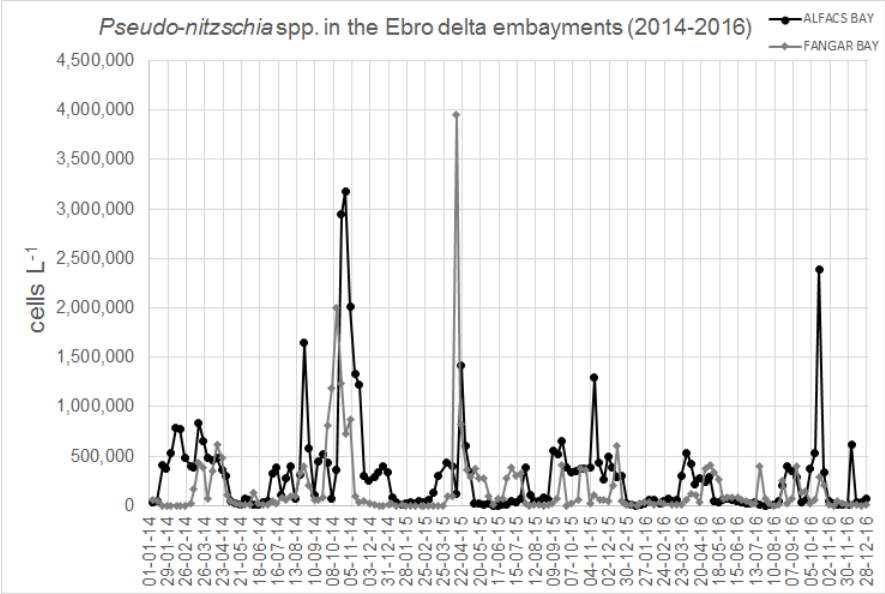
high densities in Vilanova (8.9 x 10^4 cells L-1) in April 2015 and (2.3 x 10^6 cellsL^{-1}) February 2016. In shellfish growing areas, *Alexandrium minutum* reached a maximum of 1 x 10^5 cells L^{-1} in March 2016 in Vilanova. In the Ebro delta embayments, *Alexandrium minutum* was present in low abundances, the maximum were 1.4 x 10^3 cells L^{-1} in January 2014, 2 x 10^6 cells L^{-1} in January 2015, 1.2 10^3 cellsL^{-1} in April 2016 (Figure XY). In 2015 there was an unusual presence of *Alexandrium catenella* in January in Tarragona harbor (where it usually blooms in late summer). This bloom reached a maximum density of 4 x 10^3 cells L^{-1}.

There were no PSP associated closures during 2015; all shellfish samples tested for PSP toxins were below regulatory levels during all three years (2014–2016).



Abundance of *Alexandrium minutum* in the Ebro delta embayments during the years 2014–2016.

ASP: Species of *Pseudo-nitzschia* reached high densities in the Ebro delta embayments: 3 x 10^6 cells L^{-1} and 2.4 x 10^6 cells L^{-1} in October 2014 and 2016 respectively in Alfacs Bay; in Fangar Bay the maximum abundances were 2 x 10^6 cells L^{-1} in October 2014 and 4 x 10^6 cells L^{-1} in April 2015 (Figure XZ). Abundances along the Catalan open coast were lower with maxima off Vilanova 1.3 x 10^6 cells L^{-1} in June 2015 and 2.5 x 10^5 cells L^{-1} off Masnou in March 2015. All shellfish samples tested for ASP were below regulatory levels.



Abundance of *Pseudo-nitzschia* spp. in the Ebro delta embayments during the years 2014–2016.

Benthic HABs: *Ostreopsis* cf. *56vate* was detected in the water column in high abundances (4 x 10^4 cells L^{-1}) in open waters off Vilanova at the end of July and beginning of August 2014. During the years 2015 and 2016 it was present below alert levels, maximum abundances were detected off Arenys de Mar (3.7 x 10^3 cells L-1) and Masnou (2.9 x 10^3 cells L^{-1}) in mid August 2015.

Other HABs: High densities of *Heterosigma akashiwo* found (7 x 10^5 cells L^{-1}) in August in Vilanova Harbor. *Karlodinium* was frequently present along the coast; maximum densities were detected in Alfacs Bay in February 2014 (3.3 x 10^4 cells L^{-1}). High biomass blooms were detected in confined waters: a bloom of *Gymnodinium impudicum* (6.3 x 10^5 cells L^{-1}) in Tarragona harbor in July 2015, and *Alexandrium taylorii* (10^7 cells L^{-1}) in Illa de Mar harbor in during the summer of the years 2015 and 2016.

4. Galicia (INTECMAR, Xunta de Galicia)

ASP: ASP closures in mussel rafts only in short periods during spring 2014 (May to June, Ría of Arousa) and 2015 (April). This year closures affected a larger geographical area, from Ría de Muros to Baiona estuary in Vigo. In turn, infaunal shellfish was affected every year. Rías of Vigo and Pontevedra experienced closures every year in spring, but also in summer 2016 (mostly in July). Northern sites were affected in spring 2015 (open coast, "Costa da Morte") and summer 2016 (Aug-Sep, in Cedeira and Camariñas). In 2015 Scallops (*Pecten maximus*) contained DA above RL, applying the restricted harvesting, with evisceration (According to Directive 2002/226/EC), the whole year round.

DSP: DSP closures in mussel rafts every year. Outbreaks in spring and summer in the Rías Baixas all three years round due to *D. acuminata* (max. 19 960 cell/L, 14 000 cell/L and 9520 cell/L in 2014, 2015 and 2016, respectively. In summer, maximum densities were observed in 2014–15 (81920 cell/L and 97000 cell/L, respectively), and considerably lower in 2016 (less than maximum values above mentioned in spring). Regarding YTX, they are

generally observed each year, but below RL. These values are typically observed in the northern Ría de Ares. Besides YTX it is always detected around 20% of 45OHYTX.

In addition to *D. acuminata*, in summer 2014 *D. caudata* was recorded in Pontevedra (1,960 cell/L). In summer-autumn 2015 harvesting closures due to *D. acuminata* and *D. acuta* affected during a longer period (until December= all production areas in Pontevedra, Muros and outer Ría de Vigo and Arousa (max 2.3 x 103 cells/L of *D. acuta* in Pontevedra). In 2016 *D. acuta* was also recorded but in low densities and its contribution to DSP toxicity was minor. Infaunal shellfish was specially affected by closures in 2016 (May-June in every Rías, and later in the year, Oct-Nov, in northern sites (Viveiro and Foz). Also in northern sites, Fisterra was affected all year round, and in autumn till the end of the year sporadic closures in the Rías Baixas (Vigo, Pontevedra and Arousa). Before that, DSP closures were only observed in spring to mid-summer 2014 and 2015, in the Rías Baixas and in open coast sites, respectively.

PSP: PSP closures in mussel rafts due to *G. catenatum* in November 2014 (880 cells/L) and December 2016 (1960 cells/L). This species did not affect infaunal shellfish.

Regarding *A. minutum* blooms affected infaunal shellfish every year, but mussel rafts only in 2015. The worst year was 2014, with closures of infaunal shellfish in northern sites from spring to autumn due to several outbreaks (Ares-Betanzos and Camariñas in spring, and Ares-Betanzos, Cedeira and Camariñas in summer, with max. of 76 426 cells/L in August, Ría de Camariñas). The latter site was the most severely affected, until November 2014, and in general during the 3-year period (2014–16).

In 2015 closures affected both mussel rafts (spring, with max. of 37 000 cells/L in Ares-Betanzos) and infaunal shellfish (summer, in Camariñas). Again, in 2016, Ares-Betanzos was a hot-spot for *A. minutum*, with infaunal closures in spring, summer and autumn (max. 59300 cells/L), also in Cedeira in that season.

5. Valencia (IRTA, Sant Carles de la Rápita, Tarragona)

Margarita Fernández Tejedor (IRTA) and Miguel Lull (Government of Valencia-Generalitat Valenciana)).

ASP: *Pseudo-nitzschia* was frequent and abundant along the three years 2014–2016, reaching maximal abundances (10^6 cells/L) in Sagunto at the end of August 2014, and over the alert level in Valencia(3 x 10^5 cells L^{-1}) in June 2015 and May 2016, and Alicante in January and June 2016. ASP toxins were detected in Valencia in May 2016 but below regulatory levels during the three years 2014–2016.

DSP/lipophilic toxins: *Dinophysis sacculus* and *Dinophysis caudata* were present in low abundances. *D. sacculus* reached alert levels at the end of June 2014 in Burriana, in Valencia during May 2016 (1.4 x 10^3 cellsL^{-1}) and during July 2016 in Altea (8 x 10^2 cellsL^{-1}). *Dinophysis sacculus* and *Dinophysis caudata* were present in low densities (max. 10^2 cells L^{-1}) in May and October 2015 respectively, in Alicante. *Prorocentrum lima* was over alert level in Altea during June 2016 (8 x 10^2 cellsL^{-1}).

The presence of 3 yessotoxin producing species (*Lingulodinium polyedrum*, *Gonyaulax spinifera*, and *Protoceratium reticulatum*) was frequent at very low abundances (10^2 cells L^{-1})

along all the three years 2014–2016 attaining maximum abundances during summer months.

There were two DSP closures in Valencia at the end of March-beginning of April 2014. Lipophilic shellfish toxins were below regulatory levels in 2015 and 2016. Shellfish samples during 2015 and 2016 were analyzed by the LC-MS/MS method (the mouse bioassay was the method applied before, until the end of the year 2015). Many closures enforced in past years in these areas may have been in fact due to false positives, because presence of yessotoxin producing species in these areas is frequently observed. Yessotoxins were detected below regulatory levels in Valencia in June 2016, and Sagunto in June and July 2016.

PSP: *Alexandrium minutum* was present in low abundances (10^2 cells L^{-1}), in Valencia in 2014 and Burriana in 2015. *Alexandrium catenella* was present in low abundances in Alicante in autumn 2014 and reached alert levels in October 2015 (10^3 cells L^{-1}) In the areas of Alicante and Santa Pola, a precautionary closure was enforced during one week at the end of January 2016 after detection of the presence of PSP toxins in shellfish under regulatory level. There was presence of *Alexandrium catenella* over alert level (10^3 cells/L) in the previous months inside the harbor of Alicante, but in the few samples taken in open waters *Alexandrium catenella* was below detection level (< 20 cells/L).

A closure was enforced during one week in Sant Pola (South of Alicante) due to detection of PSP toxins over regulatory levels in one sample of wild mussels in January 2016, PSP toxins in oysters from the same area were below regulatory level. A precautionary closure was enforced at the same time in the nearby area of Alicante although PSP toxins were below detection levels. There was no phytoplankton sampling in January 2016 in these areas. There was presence of *Alexandrium catenella* over alert level (10^3 cells/L) in the previous months inside the harbor of Alicante, but in the few samples taken in open waters *Alexandrium catenella* was below detection level (< 20 cells/L).

Benthic HABs: *Ostreopsis* reached (5×10^3 cells L^{-1}) in Villajoyosa in early July 2014; this concentration is over the warning level for palytoxins used in other European countries (4×10^3 cells L^{-1}). The maximal abundances detected in the years 2015 and 2016 were lower, 3.9×10^3 cells L^{-1} and 2.9×10^3 cells L^{-1} in July 2016, both in the harbor of Valencia.

Other HABs: In Alicante, a bloom of *Gymnodinium impudicum* (non toxic but producer of mucilage) lasted from June to September 2014. Maximal density (3×10^5 cells L^{-1}) found in early September 2014 was associated to fish kills in the area, in the year 2015 maximal abundances of this species were much lower (10^3 cells L^{-1}). In July 2016, *Gymnodinium impudicum* attained an abundance of 2×10^5 cells L^{-1} in Alicante, there were no reports of fish kills during the bloom.

In the harbor of Valencia harbor, *Karlodinium* was frequently present in low abundances (10^3 cells L^{-1}) along the years 2014–2016. *Prorocentrum cordatum* was present at abundances that reached 10^3cells L^{-1} in Sagunto, Valencia and Alicante during the months of April and May 2016.

6. Balearic Islands 2014–2016

(Margarita Fernández Tejedor (IRTA) and Jose Maria Valencia Cruz (Direcció General de Pesca i Medi Marí, Govern Illes Balears)).

http://www.caib.es/sites/estatszonesdeproducciomolluscs/es/presentacion-42244/?campa=yes

During the years 2014–2016, three closures were enforced due to lipophilic toxins in Menorca: two in Maó in October 2014 and April 2015, and one in the eastern open shore of Menorca in December 2014. The two closures in 2014 were impose after obtaining a positive result in the mouse bioassay for lipophilic toxins, the closure in April 2015 was enforced due to the presence of yessotoxins over regulatory levels in shellfish. The potential toxic phytoplankton species involved in these events were under detection level.

The species of the genus *Pseudio-nitzschia* reached high abundances 5.4 x 10^5 cells/L in April 2015, ASP was always below regulatory levels.

France National Report

Raffaele Siano and Catherine Belin

2014

Three types of toxic episodes were observed in France during the year 2014: DSP, PSP and ASP.

DSP. Several species of *Dinophysis* comprise the main DSP producing species in France. They were observed over a large part of the French coast, as in most years. In 2014, the highest concentrations were observed in Normandy (80 000 cells/L) Toxic episodes, with toxin results above the sanitary threshold of 160 µg/kg for the group of OA+DTXs+PTXs, took place on many sites along the Channel and Atlantic coast, affecting diverse shellfish as mussels, oysters, scallops, etc. The highest toxin concentration was observed in mussels (*Mytilus)* of the Seine bay (Normandy) with 4876 µg/kg.

PSP. *Alexandrium minutum* is the main PSP producing species along the coasts of Channel and Atlantic. *Alexandrium* was observed primarily along the Brittany coast. In 2014, the highest concentrations were observed in Jaudy river (North Brittany) with 708 000 cells/L, and in Brest bay (West Brittany) with 403 000 cells/L. Only one toxic episode followed these blooms, in Brest bay, affecting mussels (*Mytilus*) with a maximum of 3881 µg/kg (compared to the sanitary threshold of 800 µg/kg).

ASP. Several species of *Pseudo-nitzschia* are the ASP producing species in France. They were observed on the whole French coast at high concentrations during spring, as each year. In 2014, the highest concentrations were observed in the North of France (Cap Gris Nez and Somme bay) with a maximum of 4,780,00 cells/L. Toxic episodes, with toxin results above the sanitary threshold of 20mg/kg, took place in Normandy and West and South Brittany, affecting mainly scallops but also mussels and oysters in Brittany. The highest toxin concentration was observed in scallops (*Pecten maximus)* in Brest bay (West Brittany) with 860 mg/kg.

2015

Three types of toxic episodes were observed in France during the year 2015 : DSP, PSP and ASP.

DSP: As in previous years, *Dinophysis* cells (several species) were observed along a large part of the French coast. As usual, the highest concentrations were in Normandy, with 35 400 cells/L recorded north of the Seine estuary, and 12 400 cells/L south of Seine estuary. Toxic episodes, with toxin results above the sanitary threshold (160 µg/kg for the group of OA+DTXs+PTXs), were observed mainly along the Atlantic coast, affecting especially mussels, oysters and Donax. A few other sites were affected, in Channel (mussels and scallops), and in Mediterranean (mussels, oysters and Donax). The highest toxin concentrations were observed in mussels (*Mytilus galloprovincialis*) of the Salses-Leucate lagoon (Mediterranenan) with 3000 µg/kg, and in the mussels (*Mytilus edulis*) of Arcachon bay (2800 µg/kg). Concerning Azaspiracids and Yessotoxins, all results were below the European sanitary threshold.

PSP: *Alexandrium* was observed at three sites with concentrations above 100 000 cells per liter; Morlaix Bay and Brest Bay in Brittany with more than 200 000 cells per liter (*A. minutum*), and Thau lagoon in Mediterranean with 800 000 cells per liter (*A. tamarense* and *catenella*). Toxic episodes which followed these blooms, with toxin results above the sanitary threshold (800 µg/kg), affected oysters (*Crassostrea gigas*) in Morlaix bay with 1620 µg/kg, mussels (*Mytilus*) in Brest bay with 2430 µg/kg, mussels (*Mytilus galloprovincialis*) in Thau lagoon with 3,135 µg/kg.

ASP: Several species of *Pseudo-nitzschia* were observed on the whole French coast at high concentrations during spring, as each year. The highest concentrations were observed around the Loire estuary with a maximum of 6 500 00 cells/L. Toxic episodes, with toxin results above the sanitary threshold (20 mg/kg), were observed in Western and Southern Brittany, and between Loire and Gironde estuaries on the Atlantic coast, affecting mainly scallops. The highest toxin concentration was observed in scallops (*Pecten maximus*) in Brest bay with 285 mg/kg. In other sites the maxima stayed below 50 mg/kg.

Ostreopsis was observed in very low concentrations, below 1000 cells per liter, and no palytoxins analysis was performed on shellfish. The palytoxins searched in sea urchins showed an absence of these toxins.

2016

DSP caused the most problems for the French aquaculture industry with 15 events recorded in 2016 in the Harmful Algal Event data base (HAE-DAT). These events were reported from the Mediterranean, Atlantic and Channel coasts. In contrast only one closure for PSP was reported in the Mediterranean coast, and two HAE-DAT reports for closures due to ASP toxins in Northern France.

The Netherlands National Report

Marnix Poelman

2014

In 2014 the shellfish production areas; North Sea, Lake Grevelingen, Wadden Sea, Oosterschelde and Veerse Meer were monitored for the presence of toxic phytoplankton. This program is based on the National Shellfish Food Safety Program 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). In total 334 phytoplankton samples have been collected at a total of 13 sampling locations. As in many previous years, toxins have not been reported above regulatory limits. However, during the period of end of July till mid-October *D. acuminata* was reported present above threshold values (100 cells/litre). The main affected areas are the Wadden sea and Lake Grevelingen. In both cases *D. acuminata* counts up to 1.600 cells/litre were reported. The majority of the results were however reported at levels ranging from 100–800 cell/litre. Although no high toxin levels are found, back ground levels of lipophilic toxins (OA, DTX) are reported in ensis (5 samples, 10–18 µg OA-eq/kg), mussels (4 samples, 10–15 µg OA-eq/kg), and oysters (10–17.4 µg OA-eq/kg). Besides OA and derivatives, also Cyclic Iminines are found in 7 mussel samples (5–12.5 µg/kg 13-des Me SPX C, and 5–6.2 µg/kg GYM A), and oyster samples (5–26.5 µg/kg 13-des Me SPX C, and 5–6.6 µg/kg GYM A. The findings on GYM A are further investigated. RIKILT, Wageningen UR has been responsible for the toxin analysis.

2015

In 2015 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 based on the National Shellfish Food Safety Program and sampled monthly from November until April and weekly from May until October. The results are used as an early warning mechanism for potential presence of toxins in the shellfish (mussel, oyster, ensis and cockles). In total 324 phytoplankton samples have been collected at a total of 13 sampling locations. As in many previous years toxins have not been reported above regulatory limits. However, during the period of end of July till end of September *D. acuminata* was reported present above threshold values (100 cells/litre). The main affected areas is Lake Grevelingen. At Lake Grevelingen the presence of *D. acuminata* peaked on Lake Grevelingen with cell counts up to 8,600 cells / litre. The majority of the results in this period at levels ranging from 100–1.400 cell/litre. One sample in the Wadden sea was reported above threshold limits.

Although no high toxin levels are found, back ground levels of lipophilic toxins (OA, DTX) are reported in one sample of mussels at 63 µg OA-eq /kg. Two oyster samples were found to contain 10–12.3 µg OA-eq/kg. Besides OA and derivatives, also Cyclic Iminines are found in 2 mussel samples (Max 12.6 ug/kg 13-des Me SPX C). RIKILT, Wageningen UR has been responsible for the toxin analysis. IMARES, Wageningen UR is responsible for phytoplankton analyses. Besides the report on back ground levels of lipophilic toxins, the Netherlands reported TTX in oyster and mussel samples. The toxins were found in an additional research program, analysing all relevant samples for TTX. In

samples from July 2016 7 samples were reported to contain TTX above the LOQ. The maximum reported value is 124 µg TTX / kg. The causative organism is not yet confirmed. This report is further described in the new finding section. RIKILT is responsible for the analysis.

2016

In 2016 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 (mussel, oyster, ensis and cockle). In total 350 phytoplankton samples have been collected at a total of 13 sampling locations.

Alexandrium ostenfeldii was reported from the marine system in lake Grevelingen and the Eastern and Northern part of the Oosterschelde. These reports were perfromed in the beginning of September 2016, the cell counts were low with a maximum of <80 cells per liter.

Dinophysis acuminata occurred in most of the production areas. Abundance was highest, in September and beginning of October in the North Sea and Lake Grevelingen with levels up to 600 cells/litre and 850 cell/litre respectively. *D. acuminata* was recorded during the period from August through October in the Oosterschelde with maximum concetrations of 270 cells per litre. The threshold value for *Pseudo-nitzschia sp.* was reached in April with maximum values of 850.000 cells / litre, which was above the Dutch trigger limit of 500.000 cells / litre.

In 2016 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. RIKILT, Wageningen UR has been responsible for the toxin analysis. Wageningen Marine Research, Wageningen UR is responsible for phytoplankton analyses.

In 2015 Tetrodotoxins were first identified in Dutch shellfish, which was followed by the establishment of a regulatory limit, which in turn was implemented in 2016. In 2016 TTX was therefore monitored for in all Dutch shellfish production waters. A research program was established to provide management information, and insight in dynamics of TTX in shellfish and the environment.

The monitoring in 2016 resulted in absence of TTX during most of the year. However, mid-June the first detect of TTX showed up. TTX was found in oysters at values up to 253 µg / kg of shellfish flesh in Oysters and below 50 µg / kg in mussel flesh. The TTX epi-

sode lasted for 1 month until mid July 2016. The entire period resulted in closures of shellfish production areas. After this a small peak of TTX was detected in August. The detection of TTX is currently in the process of research to identify the potential source organism, and the relations with predators, and the microbiological community.

Germany National Report

Allan Cembella

Germany does not have an integrated national strategy for monitoring HAB events in German coastal waters; bloom information is provided from local environmental authorities and state-funded research institutes maintaining long plankton time-series. In 2014, the German coast of the Baltic Sea was subjected to typical annual cyanobacterial blooms (primarily of *Nodularia* sp.) causing beach fouling, although not to an unusual extent. At Helgoland (HAEDAT region DE-04), the potentially toxic HAB species *Dinophysis tripos* and *Pseudo-nitzschia multiseries* were identified and recorded for the first time in September 2014, but neither occurred at bloom concentrations. This toxigenic diatom may have been present before, but identity was not confirmed until now at the species level. During 2015 and 2016 no harmful algal events were reported.

Irish National Report (2014–2016)

Joe Silke, Ireland

HAB events in the three year period between 2014 and 2016 was limited to a series of biotoxin occurrences in Irish shellfish growing areas. There were no other harmful blooms that resulted in significant management actions other than small localised water discolouration due to *Noctiluca scintillans* and *Karenia mikimotoi*. No significant fish kills were attributed to algal blooms in this period. The biotoxin events in shellfish were due to the usual toxins that have been reported previously in Irish waters (DSP AZA ASP and PSP). In this three year cycle the occurrence was different in each year.

The Irish monitoring programme for biotoxins in shellfish is carried out by the Marine Institute (MI) as part of national official controls on seafood. It is carried out in cooperation with the Sea Fisheries Protection Authority (SFPA) and the Food Safety Authority of Ireland (FSAI). This programme includes biotoxin analysis and phytoplankton analysis carried out at the MI by the Shellfish Safety team at the Marine Environment and Food Safety Services (MEFSS) labs.

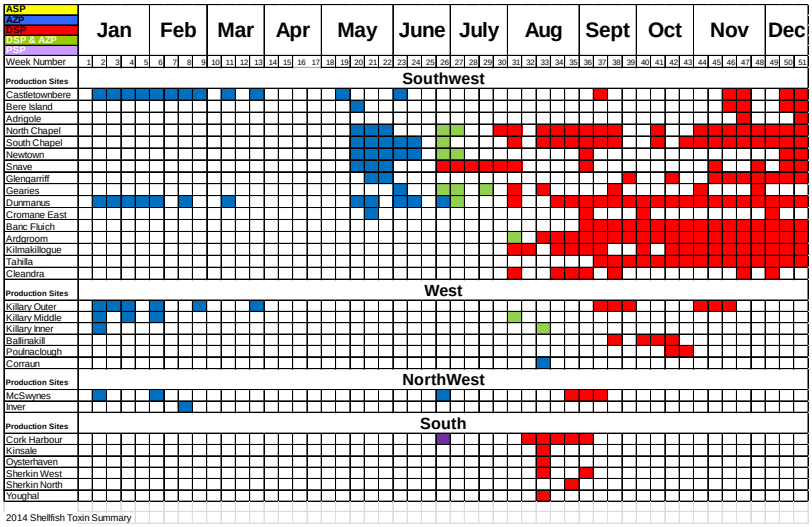
The main problematic species in Ireland are those resulting in Shellfish toxins, other blooming species that result in fish kills are rare, and red tide discolourations are also not often observed. In contrast to 2014 when the detection of an extensive and protracted series of biotoxin events led to the closure of many shellfish production areas from early summer through to year-end; 2015 showed more typical late summer/ autumnal toxicity characterised by DSP which was moderate and mainly limited to the South West. The

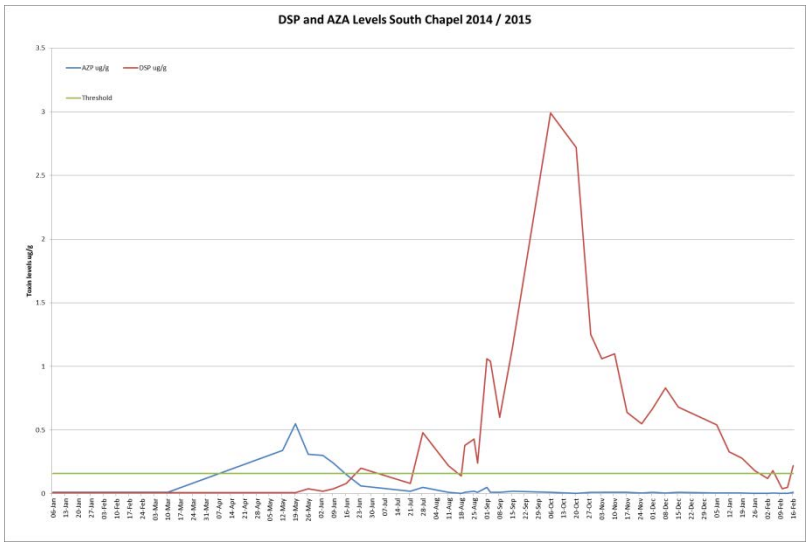
monitoring of shellfish toxins in Ireland is by chemistry analysis; supported by phytoplankton monitoring and molecular biological assays to detect the presence of both the toxin and causative organisms. Some 3111 samples shellfish samples were submitted in 2015, and a total of 11250 analytical tests were performed on these samples with 230 of these being positive for toxin content above regulatory levels which was less than half the positives recorded in 2014. The Marine Institute scheduled extra testing and additional monitoring to ensure that the re-opening of areas was permitted at the very earliest once safe to do so.

Ireland National HAB Report 2014

Summary

HAB events in Ireland in 2014 were limited to the occurrence of 3 shellfish poison types detected in the course of the national monitoring programme. Unusually, there were no detections of ASP in rope mussels in the spring/ early summer, and the usual late summer Azaspiracid event was much earlier in May / June followed by a protracted DSP event that lasted from July through to the end of the year. This event extended into 2015 and finally cleared during the month of February coinciding with the establishment of increased diatom presence in early spring. No other HAB events were reported (red-tides or fish killing blooms).





Pseudo-nitzschia and ASP Summary

Pseudo-nitzschia spp. cell counts were observed to remain at constant concentrations and distributions throughout Jan - Feb, increasing in March. The increases were observed to be predominatly in the *Pseudo-nitzschia delicatissma* group. Molecular analysis on phytoplankton samples during March from the SW was observed to contain the presence of the ASP toxin producing spieces *Pseudo-nitzschia australis*, and the non-toxic species *P. fraudalenta* & *P. delicatissma.* Typically all shellfish samples analysed (non scallops) were <LOD & <LOQ during this time frame, with some minor concentrations observed. ASP above the regulatory levels have been observed in the Gonad and remainder tissues in scallops from Bantry, Roaringwater, Dunmanus during Jan - Mar, highest concentrations observed are in the table below. ASP above the regulatory levels have been observed in the remainder tissues in scallops from Ballinakill, Mulroy, Kinsale & Valentia River.

Pseudo-nitzschia spp. cell counts and their distribution were observed to be increasing from April, in particular in the SW. The increases were observed to be predominately in the *Pseudo-nitzschia seriata* group. Molecular analysis on phytoplankton samples during March onwards from the SW was observed to contain the presence of the ASP toxin producing species *Pseudo-nitzschia australis*, and the non-toxic species *P. fraudalenta & P. delicatissma*. The other known ASP toxin producing species *Pseudo-nitzschia seriata* and *multiseries* were not detected during the ASP event in the SW.
During April - May the presence of *Pseudo-nitzschia australis* was observed to increase rapidly, the presence of ASP was detected in samples of M.edulis in Dunmanus, Bantry, Kenmare, Castlemaine Hbr. All ASP concentrations observed were below the regulatory level. From June, typically all shellfish samples analysed (non scallops) were <LOD & <LOQ during this time frame, with some minor concentrations observed. In addition to routine ASP analysis via HPLC, from June a semi-quantitative screen for analysing the presence of Domoic Acid via LCMS was introduced to run on all non scallop routine samples, where the majority of samples were observed to be N.D. (not detected)
ASP above the regulatory levels were observed in the remainder tissues in scallops from classified production areas Rosmuc, Blasket Islands, Castletownbere, Kenmare River,

Cahirciveen & Portmagee Channel, Broadwater North, Clew Bay South & North) from April – Aug. ASP above the regulatory levels have been observed in the gonad tissue from the offshore site OS-NQ-NQ (New Quay 33-E5) in Aug.

For August – September typically all shellfish samples analysed (non scallops) were <LOD & <LOQ during this time frame, with some minor concentrations observed. In addition to routine ASP analysis via HPLC, from June a semi-quantitative screen for analysing the presence of Domoic Acid via LCMS was introduced to run on all non-scallop routine samples, where the majority of samples were observed to be N.D. (not detected) ASP above the regulatory levels were observed in the remainder tissues in scallops from classified production areas Castletownbere, Portmagee Channel and Clew Bay North (highest concentrations observed in table above). ASP above the regulatory levels were also observed in the gonad tissue of scallops from Portmagee Channel.

Alexandrium and PSP Summary

Between Jan – Mar 2014, all samples analysed for PSP were typically Not Detected for PSP toxins, Alexandrium spp. have been sparodically observed in this time frame at very low population densities. *Alexandrium spp* cell counts and distribution was observed to increase nationally from June onwards, and increasing in particular in July & Aug in the West and NorthWest. Some sporadic high counts were also observed in the South & SouthWest during this time period. Quantifiable concentrations below the regulatory level were observed in samples of *C. gigas* from Cork Harbour, Kinsale & Oysterhaven. One sample of *M.edulis* was observed to be above the regulatory level during the last week of June from Cork Harbour. *Alexandrium spp* cell counts and distribution was observed to decrease nationally from September onwards, very low quantifiable concentrations below the regulatory level were observed in samples of *C. gigas* from Cork Harbour, Kinsale & Oysterhaven and in samples of *M.edulis* from Cork Harbour. These concentrations in shellfish were observed to be decreasing throughout August – September.

Dinophysis and DSP Summary

Quantifiable concentrations, below the regulatory level, were also observed throughout Jan – Mar 2014, mainly in the SW and Killary, in all other locations DSP concentrations were typically <LOD or <LOQ.

Dinophysis spp cell counts were observed to increase from June onwards, initially in the SouthWest, and increasing further during July and August in the South & SouthWest, with lower cell densities being observed in the West. *Dinophysis acuminata* was the predominant species observed in samples in June, where from the end of June onwards *Dinophysis acuta* was the predominant DSP causative organism present. DSP concentrations above the regulatory level were first observed in samples of *M.edulis* in June in Bantry & Dunmanus, followed by closures in Kenmare in July. DSP concentration were observed in increase throughout July, reaching a peak by the end of July in the majority of sites in SouthWest. During August, DSP concentrations above the regulatory level were observed in samples of *C.gigas* along the South Coast from Sherkin West, Kinsale, Oysterhaven and Youghal Bay, in samples of *M.edulis* from Cork Harbour, and also in the remainder tissues of *P. maximus* from Valentia River. Also in August, DSP concentrations

above the regulatory level were observed for a short period in samples of *M.edulis* from Killary

In the SouthWest, the cell no.'s of *Dinophysis acuta* (the predominant DSP causative organism present causing DTX-2 and hydrolysed DTX-2 in shellfish) was observed to continue to decrease in the SouthWest during October, with further decreases at the beginning of November. Subsequently, DSP concentrations increased to high levels in samples of *M.edulis* from Dunmanus, Bantry, Kenmare and Castlemaine Harbour, reaching a peak concentration in September / October before starting to decrease. DSP concentrations in samples of *C.edule* from Castlemaine were also above the regulatory level during October.

During September – October DSP concentrations were observed above the regulatory level in samples of scallops (remainder and gonad tissues) from Valentia River (Aug – Sept) and in the remainder tissues from Castletownbere (Oct). Also in September - October on the West Coast, DSP concentrations above the regulatory level were observed in samples of *M.edulis* from Killary, Ballinakill & Ballyvaughan.

Azadinium and AZA Summary

Toxicity from 2013 persisted above the regulatory level into 2014 in Castletownbere and Dunmanus and also in Killary, the toxicity was observed to decrease during Jan – Mar to below the regulatory level by the end of March A new AZA event occurred from May – Jun in the SW, where concentrations above the regulatory level were observed in sites in Bantry, Castlemaine and Dunmanus, and also in the NW for a short period in one sample of *M.edulis* from Bruckless. Molecular analysis conducted on phytoplankton samples from these sites showed the presence of the AZA causative species, *Azadinium spinosum*. AZA concentrations were also observed above the regulatory level during end of July and August in samples of *M.edulis* from Killary and in one sample of *C.gigas* from Achill South No further AZA concentrations were observed above the regulatory level during for the remainder of the year in samples of shellfish submitted.

Irish National HAB Report 2015

In 2015, following a renewed effort to increase coverage in 2014, resulted in a wealth of extra phytoplankton information that has allowed us to provide more accurate forecasting of toxin outbreaks. A record number of 4200 samples of sea water were analysed for toxic species in 2015, and this has helped to produce a weekly publicly available online report giving a synopsis of toxin and harmful algal bloom presence, and a short-term forecast of the likelihood of changes in the status. This report combines monitoring data, satellite and modelled information and has been very well received by both regulatory authorities and aquaculture industry stakeholders.

	Jan				Feb			Mar			Apr				May				Jun			Jul				Aug				Sep				Oct			Nov				Dec		
	1	2	3	4	5	6	7	8	9	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	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
SouthWest																																																					
Adrigole																																						0.17								0.17						
		0.7	0.46	0.43	0.35	0.18																							0.57				0.38					1.11	0.93				0.87			1.71						
Ardgroom																																						0.31														
		0.82	0.43	0.24	0.26	0.23	0.17	0.28	0.17																											0.88	1.21	0.66	0.79	1.82		0.57		0.55		0.47						
Banc Fluich																																						0.21		0.24													
		0.36	0.23		0.25	0.23				0.16																																										
Beare Island																																														0.34						
		0.33	0.22		0.24																																									1.63				0.26	0.27	0.28
Castletownbere																																						0.16								0.24						
		1.02	0.39	0.23	0.29	0.17	0.16				0.2																0.37	0.59	0.22	0.23			0.28					3.21					0.42				0.6					0.26	
Cleandra																																																0.19					
		0.46	0.57	0.18	0.38	0.3	0.22		0.24		0.16																																	0.77	0.16	0.68		0.3	0.18		
Dunmanus Bay																																											0.62					0.24					
Dunmanus Inner																																						0.19															
		0.2																																	0.46	0.45		0.97		1.41	0.59			0.35	0.17	0.25							
Gearhies		0.6																																												0.24							
Glenbeigh																																									0.24												
Glengarriff		0.48	0.43	0.25	0.34	0.16																			0.21			0.19																				0.25	0.33	0.2	0.23	0.16
Kilmakilloge																																						0.23															
		0.48	0.28	0.22																												0.17				0.89	0.89	0.99				1.37	0.35	0.64	0.3						
Newtown		0.52	0.47	0.27	0.27	0.21																													0.19	0.29					1.25	2.03	0.98		0.58	0.22	0.28	0.26	0.31		0.18
North Chapel		0.43	0.28	0.21	0.18	0.17																										0.31				0.53					1.62	1.32	1.43	0.48	0.8	0.35	0.4	0.17	0.18	0.24		
Roaringwater Bay																																				0.16																	
																																		0.43	0.27	0.69	0.66	1.08	0.42	0.41	0.19	0.19											
Snave		0.58	0.27	0.26																									0.23				0.19			0.8					0.24	1.02				0.26	0.22	0.2	0.26		
South Chapel																																										0.16										
		0.54	0.33	0.28	0.18	0.18		0.22																												0.55						2.82		0.42	0.81	0.74	0.35	0.36	0.27	0.21	
Tahilla																																														0.18						
		0.64	0.51	0.46	0.19																							0.36								0.23									0.85				0.21		
South																																																					
Youghal Bay																																0.21																					
Cork Harbour																										904	1128																										
Cysterhaven																																				0.37			0.22	0.18	0.22											
Dungarvan North																												0.16																									
West																																																					
Killary Harbour Outer																																0.16		0.29	0.2																		

Closed - DSP µg/g
Closed - PSP µgSTXdiHCL Equiv.'s/Kg
Closed - AZA µg/g

DSP Summary

2015 was a year where DSP was the main problem in shellfish rather than AZA or mixed toxins that are more usual in Ireland. At the start of the year DSP carryover from 2014, was observed at mussel sites in the Southwest of the country, with production sites within Bantry, Dunmanus, Kenmare & Castlemaine above regulatory levels for DSP. From Jan – Mar these levels slowly decreased resulting in Open status's being assigned for Dunmanus in January, and the large majority of sites within Bantry and Kenmare re-opening from mid-February onwards. However due to residual variability across certain sites, closures were being observed in a small number of sites through to beginning of March. During this time very low levels of Dinophysis were observed in the water samples.

Low cell densities of Dinophysis acuta & Dinophysis acuminata were observed during May in the SW, where towards the end of May these were observed to increase in both cell density and geographic distribution. These low cell densities of continued along the the South & South West coast in June, resulting in increases in DSP toxicity in shellfish, particularly in mussels in the SouthWest, where one closure due to DSP was observed in Glengarriff.

Dinophysis spp. cells no.'s further increased in the SouthWest during July resulting in further closures in sites within Bantry, and in one site within Kenmare. DSP toxicity was observed in samples of *C.gigas* along the south coast during this time, resulting in one closure in Dungarvan.

During August, *Dinophysis acuminata* cells were observed to remain at continually low to moderate levels, whereas cells of *Dinophysis acuta* increased dramatically along the South & SouthWest coastlines, which resulted in sharp increases in DSP levels in mussels in the Bantry, Dunmanus, Roaringwater Bay & Kenmare areas towards the end and during the last week of August and first week of September, where a number of site closures were observed in these areas. Further north, DSP concentrations in mussels from sites within Killary were also observed to increase above regulatory levels during August in Killary Outer.

These cell concentrations of D. acuminata and D. acuta cells were observed at moderately high concentrations during Sept, particularly in the SW. D. acuminata cells were observed to decrease during Oct, whereas D. acuta cell concentrations remained at higher concentrations during this period. This impacted on the DSP concentrations in both M. edulis and the non-edible tissues of the scallop P. maximus which remained at high levels in Sept and the beginning of October in samples submitted from Roaringwater Bay, Bantry, Kenmare and Dunmanus Bays. Towards the end of Oct, first week of November, DSP concentrations were decreasing, however site closures remained in place within these bays through until the year end.

ASP Summary

At the start of the year ASP conc.'s above regulatory levels were observed in the non-edible remainder tissues of scallops from South West classified production areas in Adrigole, Castletownbere, Dunmanus, Glengarriff (where some elevated concentrations were also observed in the Gonad tissues) & the West site at Rosmuc. ASP conc.'s above regulatory levels were also observed in the gonad tissues of scallops from offshore areas ICES rectangle 38-E4 & 37-E4

During February, there was a large population increase in the no.s of *Pseudo-nitzschia spp*. in inshore phytoplankton samples submitted due to the spring bloom observed in a number of bays in the SouthWest. DNA Molecular analysis was also conducted where it was observed the known ASP toxin producing species *P. australis* was present in a number of sites within Bantry Bay in Feb & Mar, ASP toxin analysis was conducted in samples of shellfish from these sites where typically the levels were <LOQ or Not Detected.

From March ASP conc.'s > regulatory levels were observed in the remainder tissues of scallops from a number of classified classified production, and the population Pseudo-nitzschia seriata spp. group increased in phytoplankton samples in a number of bays in the SouthWest & South. DNA molecular analysis was also conducted where it was observed the known ASP toxin producing species P. australis was present in a number of sites within Bantry Bay and Dungarvan. Quantifiable ASP toxin concentration results (below reg level) were observed in samples of M.edulis in Castletownbere & Adrigole, and in samples of C. gigas in Adrigole, Dungarven and Loughras Beag. From June onwards all samples (except scallops) were either <LOD or Not Detected for ASP. Pseudo-nitzschia spp. cells were observed to be decreasing from June onwards along all coasts, both in delicatissma and seriata groups, whereas in August, cell densities increased in the seriata group but no ASP toxicity was detected.

AZA Summary

No AZA concentrations were observed above the regulatory level during the first half of the year in samples of shellfish submitted. Low concentrations were observed during June and July. During August, increases in AZA conc.'s were observed in oysters in a number of sites along the NorthWest coast, particularly in Tra Eanach, and also in a sample of razor clams from the SouthEast, but were below regulatory levels. Along with the sharp increases in DSP toxicity within Dunmanus, Bantry, Kenmare and Roaringwater bays during the last week of August and first week of September, AZA conc.'s were also observed to increase in all mussel sites within these areas, where in Roaringwater Bay, AZA concentrations had increased to reach the regulatory level. Levels above regulatory

levels were observed in mussel samples submitted from Kenmare, Bantry, Dunmanus & Castlemaine during Sept and Oct, and in one cockle sample from Castlemaine Hbr during Oct. but these diminished by year end.

PSP Summary

PSP toxicity increased to above regulatory levels (highest conc. 1128 µg STX diHCl equivalents/Kg) during the last week of June and first week of July in mussels in Cork Harbour. PSP was also observed to increase in samples of *C. gigas* but remained below regulatory levels. PSP analysis was conducted in numerous sites, particularly along the West and South Coasts where *Alexandrium spp.* cells were observed, where no PSP concentrations were observed except at low levels in a sample of oysters in Oysterhaven.

Other HABs

A series of isolated blooms of *Noctiluca scintillans* were reported along the coast in September following a period of calm sunny weather. This resulted in orange discolourations in sheltered bays and attracted much public attention. Cell counts of several million per litere were recorded and there was associated bioluminescence observed in several locations. The blooms did not cause any reported fish kills, but there were local reports of reduced catches of lobster, crab and shrimp . The blooms dissipated after 2 weeks following increased south westerly winds.

Irish National HAB Report 2016

DSP Summary 2016

DSP concentrations above the regulatory level were observed in the remainder tissues of *P. maximus* in samples from Castletownbere during February. DSP carryover from 2015 was observed to decrease further to low levels during February and March. During April, cells of *Dinophysis spp*. were observed around the Irish Coast, particularly in the SouthWest, however no increase in DSP toxicity in samples were observed at this time.

During May, increases in cells of *Dinophysis spp*. were observed around the Irish Coast, particularly in the SouthWest, which resulted in increases in DSP concentrations in the SouthWest, in samples of *M.edulis*, < regulatory levels. Further increases in *Dinophysis* cells in the Southwest during June resulted in DSP concentrations in samples of *M.edulis* exceeding regulatory levels in a number of sites within Bantry, Kenmare and Castlemaine.

During July, DSP concentrations in samples of *M.edulis* were observed to exceed regulatory levels in a number of sites within Bantry & Kenmare, where further increases in *Dinophysis spp.* concentration during July, particularly within Bantry, were observed, leading to further increases in DSP concentrations in samples submitted. Also during

July, DSP concentrations in samples of *M.edulis* from Kenmare Bay decreased to < regulatory levels leading to opening of all sites within Kenmare.

Decreases in DSP concentrations in samples of *M.edulis* submitted from the SouthWest were observed throughout Sept and Oct resulting in all sites re-opening for harvesting by the end of Oct. Corresponding decreases in cells concentrations in *Dinophysis spp.* were also oberserved during this time period.

AZA Summary 2016

In the first half of the year low concentrations of azaspiracids below regulatory levels were observed in all samples submitted as part of the NMP. Sporadic, one off high conc.'s of AZA's were observed in samples of C.gigas submitted from Sherkin and Dungarvan.

During July, increases in AZP concentrations (> regulatory levels) were observed in one sample of *M.edulis* from Killary Outer, whilst AZP conc.'s had increased but remained < reg levels in Killary Middle & Inner, these concentrations were observed to decrease quickly in all three sites within Killary. All other samples analysed during July – Aug < regulatory level.

During Sept – Nov, Azaspiracid concentrations were observed to be below regulatory levels in all samples submitted except in one sample where the remainder tissues of a sample of *P. maximus* from Ballinakill during October were observed just over the regulatory level.

ASP Summary 2016

Typically all samples (except scallops) were either <LOD or N.D. for ASP during Feb - Mar. Increases in the cell no.'s of *Pseudo-nitzschia seriata* spp. complex were observed to increase in April, resulting in quantifiable concentrations of the ASP toxin Domoic acid, below the regulatory level, being observed in M. edulis samples from Bantry during April, these conc.'s were observed to quickly decrease back to <LOD and N.D. during the beginning of May.

During May, small increases in ASP concentrations (< regulatory levels) were observed in samples of *M.edulis* & *C. edule* from the SouthWest, these concentrations were observed to decrease quickly and during June, small increases in ASP concentrations (< regulatory levels) were observed in samples of *C. gigas* from the West in Aughinish, Mannin, Ballyvaughan and Streamstown bays, these concentrations were observed to decrease quickly during June.

Typically all samples submitted (except samples of *P. maximus* & *A. opercularis*) were n.d or <LOD for ASP, where low quantifiable ASP concentrations were observed in samples of *E. siliqua* submitted from the East Coast during July and August from Gormanstown and Malahide

Typically all samples submitted for ASP analysis during Sept - Nov (except samples of *P. maximus* & *A. opercularis*) were n.d or <LOD for ASP. During this time period cell numbers of *Pseudo-nitzschia spp.* were observed to be at low - medium levels

PSP Summary May – June 2016

Alexandrium spp. cells / litre were observed to increase around the coast in May / June, of all samples analysed for PSP, typically Not Detected n.d. were observed. During late June increases in PSP concentrations (< regulatory levels) were observed in samples of *M.edulis* (108 µg/100g STX diHCl equivalents) and in *C. gigas* (5 µg/100g STX diHCl equivalents).

Alexandrium spp. cells were observed to increase in Oysterhaven in July where PSP concentrations in samples of *C.gigas* had increased to 72 µg/100g STX diHCl eq.'s, but quickly decreased. During Aug in Cork Harbour, PSP concentrations in sample of *M.edulis* had increased slightly to 73 µg/100g STX diHCl eq.'s and in samples of *C. gigas* had increased to 45 µg/100g STX diHCl eq.'s

Alexandrium spp. cells were observed to be relatively low in cell concentrations from Sept to Nov, where no quantifiable PSP toxin concentrations were observed in any shellfish samples submitted for PSP analysis.

UK National Report

April McKinney, Steve Milligan, Sarah Swan

2014

Northern Ireland

A maximum abundance of 140 cells L^{-1} was recorded on the 6th May in a sample taken from Belfast Lough. Results from the Biotoxin Programme showed that no shellfish flesh samples, tested as part of the Official Control Programme, contained levels of PSP toxins above the regulatory limit.

The maximum cell abundance recorded was 2320 cells L^{-1} in a sample taken from a Belfast Lough site on 29 September. No shellfish flesh samples contained DSTs above the set regulatory value.

The maximum recorded cell abundance was 262 500 cells L^{-1} in a sample from Dundrum Bay on 28th April. Domoic acid was not detected above the regulatory level of 20 µg/g in shellfish samples tested as part of the Official Control Programme.

England and Wales

One mussel sample from the Yealm production area (collected on 25/06/2014) recording a high value of 315µg STX eq/kg. This is the lowest number of recorded PSP occurrences in England and Wales since the HPLC full quantitative method was introduced in 2008. This may be partially attributed to several sites which have traditionally recorded PSP toxins not being monitored over the period from April to September 2014, due to changes in harvesting activities (Fal, Fowey and Milford Haven).

Yessotoxins (YTXs) were detected in one mussel sample collected from the Brixham production area on 03/06/2014. This is the first time YTXs have been detected in an English

classified production/relaying area since the LCMS method was introduced in 2011. The result did not exceed the MPL (set at 3.75 mg YTX eq/kg). Azaspiracid group toxins (AZAs) were detected in one Pacific oyster sample from the Holy Island production area. The results did not exceed the MPL (set at 160 μg AZA1 eq/kg).

In England 703 inshore shellfish samples were tested for Amnesic Shellfish Poisoning (ASP) toxins using a high performance liquid chromatography (HPLC) method. One sample of mussels exceeded the maximum permitted limit (MPL) of 20 mg [domoic+*epi*-domoic acid]/kg [shellfish tissue}. This sample had been collected from the Portland production area on 13/05/2014. It is the first time that ASP toxins have exceeded the MPL in an English classified production and relaying area since 2001.

Scotland

Alexandrium was recorded at or above the trigger level (set at 20 cells/L until 20-Jul-14 and then at 40 cells/L from 21-Jul-14) in 39.1% of all samples. *Alexandrium* was most frequently observed during May, June and July, and was recorded at or above 40 cells/L in 48.6% of samples during July. The densest recorded *Alexandrium* bloom was observed in Loch Leven (Highland: Lochaber) on 18-Jul-14, with an abundance of 24 660 cells/L. The majority of cells were relatively small in size and although the presence of *Alexandrium minutum* was confirmed, no associated PSP toxicity in shellfish was reported at this time. However, an *Alexandrium* bloom of density 7280 cells/L recorded in Loch Striven (Argyll & Bute) on 17-Jun-14 was associated with an extensive PSP toxic event from late May until late July. PSP toxins were detected in common mussel flesh at more than 18 times the regulatory limit of 800 μg STX eq. kg^{-1}. *Alexandrium* was widespread throughout the Shetland Islands and was continuously present in Sandsound Voe for a period of 23 weeks between 05-Mar-14 and 04-Aug-14. Continuous blooms were also recorded in Braewick Voe (19 weeks from 02-Apr-14) and East of Linga (15 weeks from 30-Apr-14), with maximum densities of 1260 cells/L and 1200 cells/L observed at these sites, respectively on 30-Jul-14. PSP toxins were reported in shellfish from both of these sites and exceeded permitted levels at East of Linga. Toxin-producing *Alexandrium* was also variously recorded between March and July in Barassie (South Ayrshire), Arran: Lamlash Bay (North Ayrshire), Loch Fyne: Ardkinglas and Loch Scridain (Argyll & Bute), Arisaig: Morar Sands (Highland: Lochaber), Loch Laxford and Dornoch Firth (Highland: Sutherland), Forth Estuary: Largo Bay (Fife), and Fersness Bay (Orkney Islands).

Dinophysis was recorded at all sites where regular monitoring took place over the summer months. The earliest blooms were observed in Argyll & Bute and North Ayrshire during late March and early April, although the majority of *Dinophysis* blooms occurred in July and August, with 43.6% of the samples at or exceeding threshold counts in July. The largest recorded *Dinophysis* bloom was observed in Loch Torridon (Highland: Ross & Cromarty) on 22-Jul-14, with an abundance of 3520 cells/L. *Dinophysis* blooms were widespread around North Ayrshire, Argyll & Bute, and the Highland region from May to late September, with associated DSP toxicity reported in shellfish. Arran: Lamlash Bay (North Ayrshire) recorded *Dinophysis* counts at or above trigger level for a continuous period of twenty-one weeks from the second week of May until the end of September. Both Loch Striven and Loch Scridain (Argyll & Bute) also had prolonged bloom periods lasting about three months from late May into August. The blooms of *Dinophysis* that were observed around the Shetland Islands in July and August 2014 were neither as dense nor extended as those that occurred in in 2013. In general, the number of *Dinophysis* blooms

at or exceeding trigger level over the reporting period was similar to the years 2010, 2011 and 2012, but not as high as in 2013.

Pseudo-nitzschia counts in excess of 50 000 cells per litre (threshold level) were recorded in 9.1% of the samples, with almost 13% of the samples analysed in June having greater than threshold cell densities. The earliest blooms were recorded around the Shetland Islands and Dornoch Firth during March. The densest *Pseudo-nitzschia* bloom was observed in Loch Sligachan (Highland: Skye & Lochalsh) on 23-Apr-14, where a maximum density of >3.1 million cells/L was recorded. This bloom was widespread in the Highland region, from Arisaig: Morar Sands (Lochaber) to Loch Eishort (Skye & Lochalsh), Loch Torridon and Loch Ewe (Ross & Cromarty), with some associated ASP toxicity. Blooms exceeding 1 million cells/L were also recorded in Luce Bay (Dumfries & Galloway) in April, and around the Shetland Islands (Vementry South: Seggi Bight, Busta Voe and Olna Firth) on 30-Jun-14, and toxin-producing *Pseudo-nitzschia* was widespread around Shetland between June and August, although the maximum permitted level of 20mg/kg ASP toxins in shellfish tissue was not exceeded.

2015

Northern Ireland

A maximum abundance of 80 *Alexandrium* cells L^{-1} was recorded on the 26th May in a sample taken from a Belfast Lough site. Results from the Biotoxin Programme showed that no official control shellfish flesh samples tested during the year, from any site, contained levels above the regulatory value of 800µg STX/ Kg.

The maximum *Dinophysis* cell abundance recorded was 800 cells L^{-1} in a sample taken from a Belfast Lough site on 29th June. Results from the Biotoxin Programme showed that no shellfish flesh samples contained lipophilic toxins above the set European Union regulatory value of 160 µg/kg.

The potential AST (Amnesic Shellfish Toxin) producer, *Pseudo-nitzschia* spp., was present in all seven of the monitored areas with occurrence ranging from 56% of samples (Larne and Foyle) to 79% of samples (Dundrum Bay). There was also a large difference in the maximum cell abundance recorded for each area, ranging from 17 000 cells L^{-1} in Lough Foyle to 633 200 cells L^{-1} in Belfast Lough. The latter figure was recorded in a sample from Belfast Lough on 6th July. Three official control shellfish flesh (mussel) samples from the Biotoxin Monitoring Programme contained domoic acid above the regulatory value of 20 µg/g. These were collected on the 6th July for testing and recorded a maximum value of 58 µg/g.

England and Wales

Paralytic Shellfish Poisoning (PSP) toxins:

Alexandrium species were recorded in 55 samples from 19 production areas. Since 2013, the number of recorded occurrences and the concentrations detected in England and Wales have remained comparatively low. Part of this decline can be attributed to a reduction in the monitoring of sites with historic issues with PSP toxins and *Alexandrium* spe-

cies (e.g. Milford Haven). Also, the lower number of recorded instances of PSP toxins in flesh samples reflects the decrease in *Alexandrium* species detection over the period from 2013 to 2015.

No inshore shellfish samples required analysis by the full quantitative method. This is consistent with the number and levels detected in 2014, however, is still markedly lower than detection rates recorded between 2010 and 2013.

Dinophysis were detected consistently prior to and during toxins events at several production areas in Cornwall. The highest cell concentration (2800 cells/L) was recorded in a sample from the Helford River, Cornwall in July.

Lipophilic toxins (LTs) were detected in 98 samples from 12 production areas. The highest number of recorded instances of LTs in inshore shellfish samples since the LC-MS/MS method was introduced in 2011. Thirty-four mussel samples from six production areas contained OA/DTX/PTXs above the MPL (set at 160 µg OA eq/kg). These included the St. Austell Bay production area recorded 16 results above the MPL between 15/06/2015 and 14/10/2015, the Fowey production area (adjacent to the St. Austell Bay area), recorded three results above the MPL in mussel samples collected between 22/07/2015 and 06/08/2015, Lantivet Bay (also adjacent to St. Austell Bay and Fowey production areas) was a new production area for 2015. Monitoring commenced in late April. From 09/07/2015 *Dinophysiaceae* were detected consistently in water samples, with OA/DTX/PTX group toxins exceeding the MPL from 15/07/2015 to the 14/10/2015. In total, eight samples exceeded the MPL with the highest concentration (1107 µg/kg) recorded on 28/07/2015. The Taw/Torridge production area recorded three consecutive results above the MPL in samples collected between 10/08/2015 and 25/08/2015. The highest concentration during this event was recorded in a sample collected on 10/08/2015 (260 µg/kg).The Porlock production area was introduced to the programme in February 2015. One sample, collected on 15/06/2015, exceeded the MPL with a result of 205 µg/kg. Subsequent samples recorded results below the reporting limit (<RL) and the second negative result was recorded on 15/07/2015. No *Dinophysiaceae* were recorded in this particular event. Lyme Bay was also a new production area for 2015. The first two samples collected on the 22/07/2015 and 12/08/2015 contained OA/DTX/PTX toxins, with the latter exceeding the MPL with a result of 328 µg/kg. The subsequent two samples also exceeded the MPL with the highest concentration recorded on 27/08/2015 (339 µg/kg). OA/DTX/PTX group toxins were also detected in 6 whole king scallop samples. Two offshore samples landed at Scarborough in January and February and one from Plymouth in July returned results which exceeded the MPL for this toxin group. No lipophilic toxins were detected in the processed scallop samples submitted for analyses.

The highest concentration of *Pseudo-nitzschia* cells was recorded in a sample from Burry Inlet: Machynys collected on 06/05/2015 (873 000 cells/L). None of the inshore shellfish samples tested (cockles (1 sample), mussels (10 samples), Pacific oysters (5 samples) and surf clams (5 samples)) for ASP exceeded the maximum permitted level (MPL) of 20 mg/kg in 2015. The shellfish species affected included.

Ninety-three samples of king scallops were analysed for ASP toxins, comprising 50 whole shellfish samples and 43 samples which had been shucked prior to submission to the laboratory (pre-shucked). Of the 50 whole king scallop samples, 48 contained ASP toxins, with 36 exceeding the MPL. All samples which exceeded the MPL were collected

by LAs along the south west coast of England (Cornwall to Dorset). Where ASP toxins were detected in whole scallop samples, concentrations ranged from 2.9 to 178 mg/kg. Results peaked in October 2015. Of the 43 pre- shucked samples, 12 contained low levels of ASP toxins, ranging from 1.2 to 3.7 mg/kg.

No Yessotoxins were detected in any samples received in 2015

AZAs were detected consistently in St. Austell Bay from late July to late October. Peak concentrations exceeded the MPL on three occasions; once in late August (177 µg AZA1 eq/kg) and twice in late September (251 and 188 µg AZA1 eq/kg). The St. Austell Bay production area was already closed due to the earlier presence of OA/DTX/PTX group toxins exceeding the MPL (described below).

Scotland

Alexandrium spp.: *Alexandrium* spp. was most frequently observed during April, May and June, and was recorded at or exceeding threshold level in 30.2% of the samples analysed during April. The densest recorded *Alexandrium* blooms were observed at Tingwall Pier (Orkney Islands) on 27-Jul-15 with an abundance of 10,400 cells/L, and Loch Eishort (Highland: Skye & Lochalsh) on 25-May-15 with an abundance of 9,600 cells/L. Highly toxic *Alexandrium* blooms were detected around North Ayrshire and Argyll & Bute during April and May, most notably Arran: Lamlash Bay, Campbeltown Loch, Loch Striven, Loch Fyne: Otter Ferry and Loch Fyne: Ardkinglas. PSP toxins were detected in common mussels sampled from Campbeltown Loch (Argyll & Bute) at more than 34 times the regulatory limit of 800 µg STX eq. kg^{-1}, and in common mussels from Arran: Lamlash Bay (North Ayrshire) at more than 25 times the regulatory limit. Blooms associated with PSP toxicity also occurred throughout the Highland region in May and June around Loch Eishort (Skye & Lochalsh), Loch Torridon (Ross & Cromarty), Loch Laxford and Loch Inchard (Sutherland). Toxic *Alexandrium* blooms were observed in Loch Roag: Miavaig and Loch Roag: Barraglom (Lewis & Harris) in early July. *Alexandrium* blooms at or exceeding threshold level were less frequently detected in 2015 compared with both 2013 and 2014, which may be due in part to the absence of prolonged blooms around the Shetland Islands, in contrast to previous years.

Dinophysiaceae: Algal cells belonging to the family Dinophysiaceae, which includes the genus *Dinophysis* and *Phalacroma rotundatum* (synonym *Dinophysis rotundata*), were present in 42.2% of the samples analysed during 2015 and were detected from February to October. Cells were observed at or above threshold level (set at 100 cells/L) in 19.3% of the samples, similar to the percentage recorded in 2014. The earliest bloom exceeding threshold level was recorded in Loch Melfort (Argyll & Bute) in late April. Dinophysiaceae remained in Loch Melfort at or above threshold level for a continuous period of sixteen weeks, from late May until mid September. Overall, the majority of Dinophysiaceae blooms occurred around the Scottish coast in July and August, with 51.5% of the samples exceeding threshold counts in July. The densest Dinophysiaceae blooms were both observed in north-west Scotland in Highland: Ross & Cromarty. An abundance of 16,960 cells/L was recorded in Loch Torridon on 30-Jun-15, and 9,540 cells/L in Loch Ewe on 28-Jul-15. Dinophysiaceae blooms were widespread around Argyll & Bute, and the Highland region from late May to early September, with associated DSP toxicity reported in shellfish. Toxic blooms also occurred in Loch Roag (Lewis & Harris) in July and August. Although *Dinophysis acuminata* type cells tend to dominate Dinophysiaceae blooms

around the Scottish coast, a bloom of *Dinophysis acuta* was observed in south-west Scotland in late summer, reaching a maximum density of 1,780 cells/L at Barassie (South Ayrshire) on 25-Aug-15. This bloom was accompanied by a shift in the profile of DSP toxins found in common mussels, with an increase in the amount of dinophysistoxin-2 detected. The blooms of Dinophysiaceae that were observed around the Shetland Islands in July and August 2015 were not as dense as those that occurred in 2013, although Dinophysiaceae recorded in August and September did have some associated DSP toxicity.

Pseudo-nitzschia spp.:_The earliest blooms were recorded around the Shetland Islands, Dornoch Firth (Highland: Sutherland) and Loch Scridain (Argyll & Bute) during early March. *Pseudo-nitzschia* spp. was widespread around the Highland region, Lewis & Harris, and the Orkney Islands in June and July, and then around the Shetland Islands in August. The densest *Pseudo-nitzschia* bloom was observed in Loch Ailort (Highland: Lochaber) on 21-Sep-15, where a maximum density of >1.2 million cells/L was recorded. Some associated ASP toxicity was reported in Pacific oysters from Loch Ailort at this time. *Pseudo-nitzschia* blooms were also detected nearby at Arisaig: Morar Sands (Highland: Lochaber) and in Argyll & Bute, around the Isle of Mull (Loch Scridain, Loch Na Keal) and Loch Melfort through September and into early October.

Other species*: Protoceratium reticulatum* was recorded at low concentrations in 2.5% of samples between March and September, and was most frequently observed in April and May. The densest bloom occurred in North Ayrshire, with 180 cells/L recorded in Arran: Lamlash Bay on 07-Apr-15, and some associated YTX toxicity at this site.

Lingulodinium polyedrum was detected from June to September 2015 on only seven occasions (0.5 % of samples). It occurred most frequently in Loch Creran, where it appears to bloom annually, although it is rarely abundant. One other observation was recorded in Loch Leven (Highland: Lochaber), as was the case in 2014. A maximum bloom density of 380 cells/L was observed in Loch Creran on 26-Aug-15.

Prorocentrum cordatum was present in 53.1% of samples analysed in 2015. It was observed from February through to October and was most abundant in May and June, being recorded in 81.9% and 81.7% of the samples analysed, respectively. The densest blooms of 2015 occurred in Largo Bay (Fife) at a concentration of 162,769 cells/L on 13-Jul-15, and also in Braewick Voe (Shetland Islands) at 123,898 cells/L on 03-Jun-15.

Similar to 2014, the potentially problematic dinoflagellate *Karenia mikimotoi* was not observed in densities likely to negatively impact aquaculture during 2015, and was detected in only 3.5% of the samples analysed. The densest *Karenia mikimotoi* bloom was observed in Arran: Lamlash Bay on 07-Apr-15, with an abundance of 340 cells/L.

2016

Northern Ireland

Alexandrium had a maximum cell abundance of 300 cells L^{-1} recorded in a sample from Carlingford Lough taken on 27th June. No official control shellfish flesh samples tested during the year contained levels above the regulatory value of 800µg STX/ Kg.

A maximum *Dinophysis* cell abundance of 2140 cells L^{-1} was recorded in a sample from a Belfast Lough site on 13th September. *Prorocentrum lima* was rarely recorded.

Results from the Biotoxin Monitoring Programme showed that no shellfish flesh tested as part of the Official Control Programme contained lipophilic toxins above the regulatory limit set by the European Union.

A maximum *Pseudo-nitzschia* abundance of 92,400 cells L^{-1} was recorded in a sample from Strangford Lough on 20th June. No official control samples from the Biotoxin Monitoring Programme contained domoic acid above the regulatory level of 20 μg/g.

England and Wales

PSP was detected in shellfish from the Salcombe and Swansea production areas. Ten samples in total recorded PSP toxin levels above the trigger level (400μg STX di-HCl eq.)]/kg). These were from the Pont Pill, Geese Quarries and Queens Dock sampling points (Figure 5). The Salcombe production area recorded four results above the MPL between 21/06/2016 and 20/07/2016. The Swansea Bay production area recorded three results above the MPL between 03/05/2016 and 16/05/2016. The peak of the toxin event occurred on 11/05/2016 with a toxin level of 2528 μg/kg. Toxin levels rose sharply and quickly declined during late spring. This was the first time that PSP toxins had been detected from this production area. However, monitoring within the enclosed dock has only occurred since September 2012, prior to this all monitoring occurred in Swansea Bay.

The St. Austell Bay production area recorded 17 results above the MPL for OA/PTX/DTX between 05/07/2016 and 24/10/2016. *Dinophysiaceae,* the predominant toxin producing algal genera in this area, were detected in a water sample on the 28/06/2016, prior to the detection of OA/DTX/PTX group toxins above the MPL (164 μg/kg) on 05/07/2016. Toxin concentrations reached a peak on 17/08/2016 of 2,013 μg/kg. It was not until a sample collected on the 02/11/2016 that the site recorded a second consecutive result below the MPL and was allowed to reopen. The Fowey production area, Lantivet Bay, the Taw/Torridge production area, the Lyme Bay production area, the Brixham production area all experienced closures due to OA/DTX/PTX for extended periods over the summer period.

None of the inshore shellfish samples tested for ASP exceeded the maximum permitted level (MPL) of 20 mg/kg in 2016. The highest ASP concentration was recorded in November (2.7 mg/kg) from the Start Bay production area.

Yessotoxins (YTXs) were not detected in any samples received in 2016.
Azaspiracid group toxins (AZAs) were detected in 14 inshore samples, all from the south Cornish coast but were below the MPL.

Scotland

The densest recorded *Alexandrium* spp. bloom was observed in Loch Creran (Argyll & Bute) on 18th July with an abundance of 5,860 cells/L, although no PSP toxicity was detected in Pacific oysters from this site. Toxic *Alexandrium* spp. blooms were detected in other areas around Argyll & Bute during spring, most notably Campbeltown Loch (440 cells/L on 11th April), Loch Striven (840 cells/L on 5th April), Loch Fyne: Otter Ferry (240 cells/L on 4th April), and Kilfinichen Bay (320 cells/L on 26th April). Some PSP toxicity was also associated with *Alexandrium* recorded in the Highland region in May, around Loch

Sligachan (Skye & Lochalsh) and Loch Laxford (Sutherland). Overall, the percentage of *Alexandrium* spp. blooms at or exceeding trigger level during 2016 (21.52%) was very similar to that in 2015 (21.67%).

The majority of *Dinophysis* spp. blooms occurred around the Scottish coast in June and July, with 55.63% of the samples exceeding threshold counts in July. Two exceptionally dense blooms were observed during 2016. An abundance of 24,340 cells/L was recorded in Loch Ewe (Highland: Ross & Cromarty) on 6th June and 90,274 cells/L in Loch Fyne: Ardkinglas (Argyll & Bute) on 22nd June. *Dinophysis* spp. blooms were widespread around Argyll & Bute, and the Highland region from late May to early September, with associated DSP toxicity reported in shellfish. Toxic blooms also occurred in Loch Stockinish and Loch Erisort (Lewis & Harris) in June. Blooms of *Dinophysis* spp. were recorded around the Shetland Islands from June to mid-August, with widespread toxicity throughout July and August.

The densest bloom of *Protoceratium reticulatum* occurred in Argyll & Bute, with 1,360 cells/L recorded at Loch Fyne: Ardkinglas on 22nd June, although no YTX toxicity was detected in Pacific oysters from this site. However, low levels of YTX toxins were detected in common mussels from Campbeltown Loch, Loch Striven and Loch Melfort (Argyll & Bute) when *Protoceratium reticulatum* was present.

Lingulodinium polyedrum is rarely abundant in Scottish coastal waters and was detected on only three occasions (0.23 % of samples), all in Argyll & Bute during 2016.

A dense bloom of *Karenia mikimotoi* was observed around the Firth of Clyde in July and August, with a maximum density in excess of four million cells/L observed in Loch Ryan (Dumfries & Galloway) on 25th July. The bloom persisted through September and into October at this site.

Denmark National Report 2014–2016

Per Anderson

DSP closures were enforced twice during 2014. Week no 28 at the East Coast of Jutland (area 63) – Mytilus edulis: AO = 280 ug OA-eq/kg, Dinophysis acuminata = 0 cells/L and in week no 34 in the outer Wadden Sea (area 144) – Spisula subtruncata: 144 ug OA-eq/kg, no algae info A number of cases (total: 8) below critical limit (37–77 ug OA-eq/kg) occurred also in the Limfjord, together with high concentrations of Dinophysis acuminata (3.000–122.800 cells/L).Only traces of domoic acid (max. conc. 7 ug DA/kg) during weeks 11–14. No PSP in 2014 – Alexandrium tamarense max. conc. 200 cells/L in week 22 in the Limfjord. During the spring (week: 11–13) a minor bloom of Pseudochattonella (probably P. farcimen) (max. conc. 20.000 cells/L) followed by a major bloom in weeks 14–17 (max. conc. 3,3 mill . cells/L) of small round Pseudochattonella/Dictyocha-like cells delayed the release of trout to fish cages in the coastal waters. No fish kills at marine aquaculture sites during the spring bloom events - because no fish were in the sea yet. No reports on negative impacts on the natural stock of sea trout fishing in the bloom period. No other dead fish species observed during the bloom. No negative effects reported on birds and mammals either. During 2015 closures of shellfish harvesting areas owing to high concentrations of DSP toxins in Blåvandshuk, Waddensea and the east coast of

Denmark were enforced. During 2016, closures of shellfish harvesting areas in Limfjorden owing to high concentration of ASP toxins were enforced. DSP toxins above the closure limit were recorded in the Wadden Sea. Closures of harvesting areas for high concentrations of PSP toxins were enforced in Limfjorden and the Kattegat.

Norway National Report 2014–2016

Wenche Eikrem and Lars Naustvoll

Information about harmful algae and toxic mussels in coastal areas of Norway can be found on the following web pages http://algeinfo.imr.no and http://www.matportalen.no/verktoy/blaskjellvarsel/. The monitoring is carried out by IMR (www. imr.no), SINTEF (www.sintef.no) and NIVA (www.niva.no)

2014

Coscinodiscus conncinus. A mucus producing bloom of *Coscinodiscus conncinus* took place in March 2014 along the Southern and Western coasts of Norway. Other species were also present, but *C. conncinus* was dominating the samples and was registered in quantities not encountered before in Norwegian waters. In Flødevigen 460 cells/liter was recorded on 26 March. It was suggested that the bloom had itsorigin in the North Sea and was transported to the coast by wind and currents. Fishermen had their nets and other equipment fouled by mucus produced by the *C. concinnus* bloom. The event was described in several newspapers (e.g. Bergens tidene and Sunnmørsposten) and illustrated by pictures of fishing nets full of brown slippery mucus (see picture below from Sunnmørsposten), quite unpleasant for those involved. *Vicicitus globosus.* In October/November of 2014 a bloom of *Vicicitus globosus* was observed in the Kattegat and Skagerrak. The first report was from Havstensfjorden, on the Swedish West Coast in the beginning of October. It was registered in October and November on the Southern and Western coasts of Norway and in Flødevigen the highest abundance was recorded on October 24 at 1000 cells/liter. No harmful events were registered although initially the bloom was suspected to beassociated with the death of large quantities of *Crassostrea gigas*, but was shown later to be caused by a herpes virus. In Norway we have indications that *Vicicitus globosum* is a life cycle stage of *Dictyocha fibula*. The latter occurs commonly in the fall in Norwegian waters.. PSP, DSP and ASP were also detected in Norwegian mussel farms.

2015

The national monitoring program for HA in Norway had a total of 44 stations in 2015. The program covers the Norwegian coast from south at the Swedish boarder to Tromsø in the northern Norway. The program ran from March to November 2015, except for 4 routine station that are monitored from January to December. Detailed information regarding HA and toxins is found at http://www.matportalen.no/verktoy/blaskjellvarsel and non-toxic species at http://algeinfo.imr.no.

Along the Skagerrak coast the main problem in 2015 was DSP/*Dinophysis*. DSP and *Dinophysis* cells appeared in early May and were present throughout the monitoring period

at one or several monitoring sites. The inner and eastern part has more problem with *Dinophysis*/DSP then the south-west part of Skagerrak where *Dinophysis*/DSP only were observed above warning levels from July and in the autumn. PSP/*Alexandrium* were present during the spring and result in closure for shorter periods in April-May.

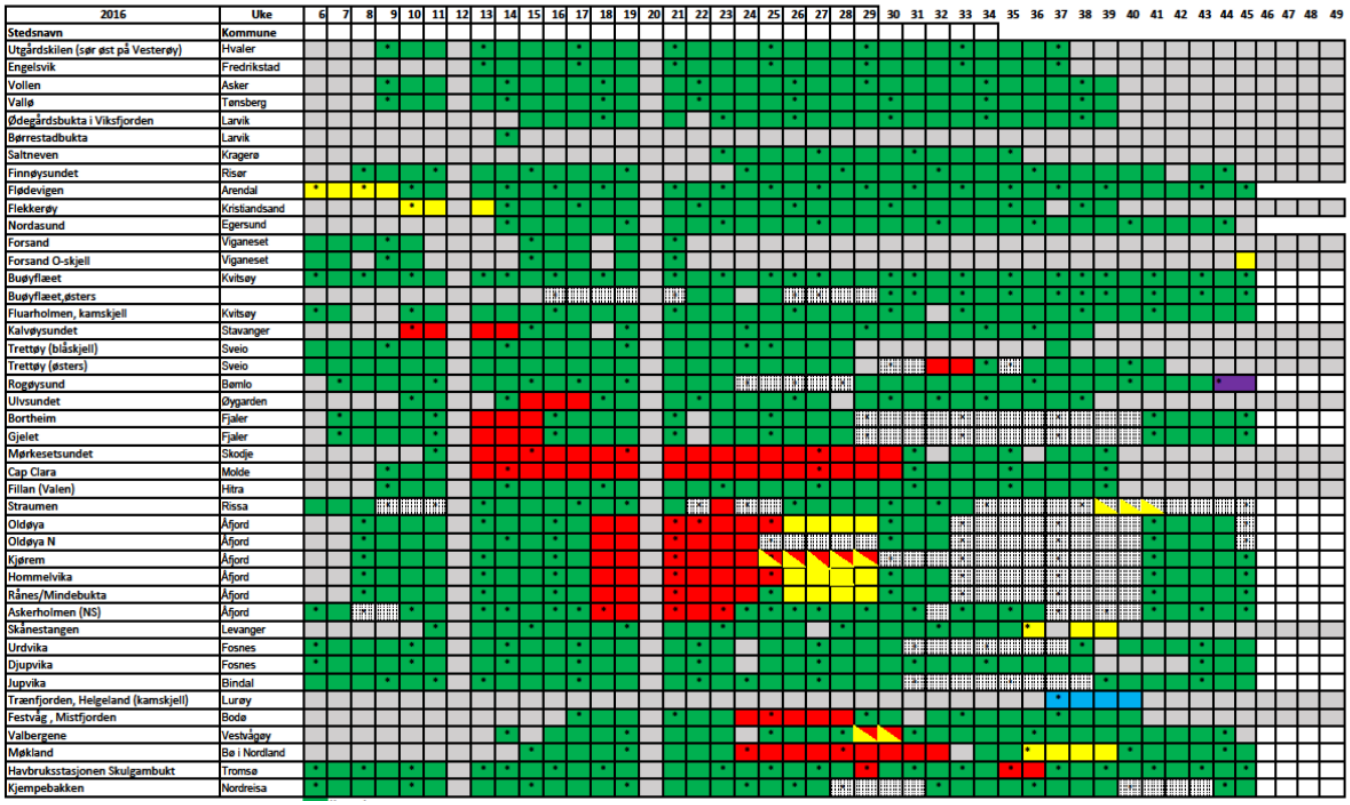
From Rogaland (south coast) and up to Trøndelag (middle of Norway) the main problem were PSP/*Alexandrium* in 2015. The presence of PSP/*Alexandrium* result in closures at most monitoring sites from late March to May in this area. The dominating PSP producing species were *Alexandrium tamarense* during this period. At some few stations DSP/*Dinophysis* were above warning levels in autumn.

At some few stations in Trøndelag (mid Norway) there were no or few problems with HA species and toxic accumulation. Most of these sites are located in the outer coast. From northern part of Trøndelag and up to Nordland there were shorter periods with closures due to DSP/*Dinophysis* in March and June at the southern stations. Whereas at stations in the northern area *Alaxandrium tamarense* resulted in closures in April – May. In the Troms county *Alexandrium* resulted in accumulation of PSP above warning levels from June to September.

Azaspiracids were only found above warning levels at one station at the south coast of Norway in November.

2016

The national monitoring program for HA in Norway had a total of 44 stations in 2016. The program covers the Norwegian coast from south at the Swedish boarder to Tromsø in the northern Norway. The program ran from March to November 2015, except for 4 routine station that are monitored from January to December. Detailed information regarding HA and toxins is found at http://www.matportalen.no/verktoy/blaskjellvarsel and non-toxic species at http://algeinfo.imr.no. The figure below summaries the HAB events (HA and toxin accumulated) in 2016.



Norwegian HAB monitoring program 2016. Green; open (toxins and HA under threshold levels), Yellow; DSP or Dinophysis above threshold, Red; PSP or Alexandrium above threshold, Blue; ASP above and lilac; AZA above. Skagerrak stations at the top of the figure and northern part of Norway in the bottom.

Along the Skagerrak coast there were only some minor problems with DSP/Dinophysis during 2016 in February and March. In the Bay of Flødevigen the DSP level were above threshold levels since September 2015 until March 2016. In April – May there were observed fish mortality in one fish farm at the Skagerrak coast, caused by *Pseudochattonella* sp.

From Rogaland (south coast) and up to Trøndelag (middle of Norway) the main problem was PSP/*Alexandrium* in 2016. The presence of PSP/*Alexandrium* result in closures at some stations in April in the southern areas. At two stations on the Norwegian west coast there was a long closure due to PSP/Alexandrium from April to August in 2016. The dominating PSP producing species were *Alexandrium tamarense* during this period. For this part of the coastline there were no problems with DSP/*Dinophysis* in 2016. At some few stations DSP/*Dinophysis* were above warning levels in autumn.

At most of the stations in Trøndelag (mid Norway) there were problems with HA species and toxic accumulation from April to August. In late April to mid-June the PSP/Alexandrium was above threshold. At most of the stations with PSP problems, DSP accumulated above threshold from June to August. In the Nordland county there were periods of closures due to PSP in June-August, with some minor problems with DSP in September. In Troms county, there was only some minor problem with closure due to PSP/Alexandrium during the summer period. AZA result in only one closure at one loca-

tion November 2016 in Rogaland. ASP above regulation levels was found in Nordland at one location. However, accumulation was not observed in blue mussel but in king scallops.

Poland National Report 2014 – 2016

Justyna Kobos, Hanna Mazur-Marzec

There are approximately 98 beaches and bathing sites in coastal area of Poland, and each year thousands of tourists visit the places during their holidays. In summer months, when water temperature reaches 20°C, their leisure time is disrupted by beach closures caused by massive occurrence of toxic cyanobacteria. The bathing sites are regularly monitored, and decisions in line with the regulations included in Bathing Water Directive (2006/7/EC) are taken.

2014

In summer 2014, open and coastal waters of the Gulf of Gdansk (Southern Baltic) were 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. The highest biomass of *N. spumigena* (185.4 mg/L) and the highest concentration of nodularin (1,590 μg/L) in coastal waters were recorded on 08 July. In the sample collected on that day, *A. flosaquae* (11.8 mg/L) and *D. lemmermannii* (0.4 mg/L) were also present. In bathing season, 14 beaches were closed in July for 1–4 days.

Alexandrium ostenfeldii (Paulsen) Balech & Tangen was observed in Puck Bay at the end of August. The cell number of this species reached 3,980 cells/L and was four times higher than in the previous year.

2015

In summer 2015, in open and coastal waters of the Gulf of Gdańsk, cyanobacterial blooms occurred later than in previous years (probably due to shift in summer temperature maximum). In July, the non-toxic species *A. flosaquae* dominated. In August, massive bloom of nodularin-producing *N. spumigena* and microcystin-producing *D. lemmermannii* was recorded. In coastal areas, the highest biomass of *N. spumigena* (3,016.5 mg/L) and the highest concentration of nodularin (35,280.0 μg/L) were determined on 11 August. In samples collected on that day, the biomass of *D. lemmermannii* reached 58.0 mg/L and two microcystins variants were detected. LC-MS/MS analysis did not reveal the presence of anatoxin-a. The biomass of co-occurring *A. flosaquae* was 85.8 mg/L. On 2–3 July and on 4 August, due to water discoloration, 3 beaches were closed and warnings were issued. Other 12 events of beach closure, caused by massive occurrence of toxic cyanobacteria, were on 10–14 August and lasted 1–5 days. All the places were located in Pomeranian District: Gulf of Gdansk; code area PL-01.

As in previous years, *Alexandrium ostenfeldii* occurred in Puck Bay (inner part of the Gulf of Gdansk) in August. The highest cell number of this species (collected on 05 August) was only 67 cells/L.

2016

In July 2016, along the Polish coast line, *N. spumigena*, *A. flosaquae* and different species of *Dolichospermum* dominated. In area PL-02 (Słupsk Bank; Stolpe Bank), the highest biomass of *N. spumigena* and the highest concentration of nodularin (142.3 µg/L) were on 01 July. In this area, the bloom of *N. spumigena* was also observed in late July. In area PL-01, the highest biomass of *N. spumigena* (180.3 mg/L) and the highest concentration of nodularin (257.95 µg/L) were on 26 July. In sample collected on that day, *A. flosaquae* (7.0 mg/L) and *Dolichospermum* spp. (15.3 mg/L) were also present. In July, this situation caused 10 beach closures in the Gulf of Gdańsk and 8 closures in Puck Bay (PL-01) (2–7 days and 2–5 days, respectively). This year, the visible presence of cyanobacteria (surface accumulates) was recorded exceptionally long - till mid-September. Unlike in previous years *A. ostenfeldii* did not occur in Puck Bay.

Sweden national report for years 2014–2016

Bengt Karlson, SMHI

Background

Harmful Algal Blooms (HAB's) 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 Bothnian bay and the Bothnian Sea

Satellite data indicate surface accumulations of cyanobacteria in summers of 2014–2016, mainly in the south eastern part of the Bothnian Sea (Figs. 1 and 2). The information Centre for the Gulf of Bothnia has reported about local algal blooms visible as surface accumulations of algae along the Swedish coast from July to November (Fig. 3). The autumn blooms often caused discoloration on beaches, sometimes resembling spilled paint (Fig.4). Species and genera include *Nodularia spumigena* (producer of the toxin nodularin), *Dolichospermum* spp. (synonym *Anabaena* spp.) and *Aphanizomenon*.

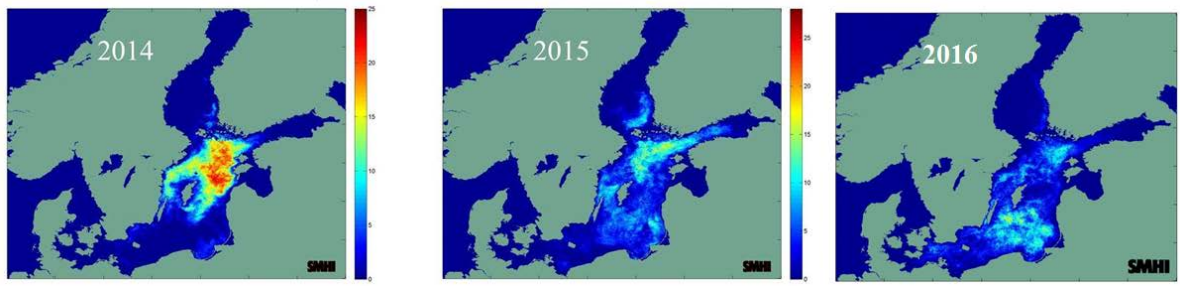
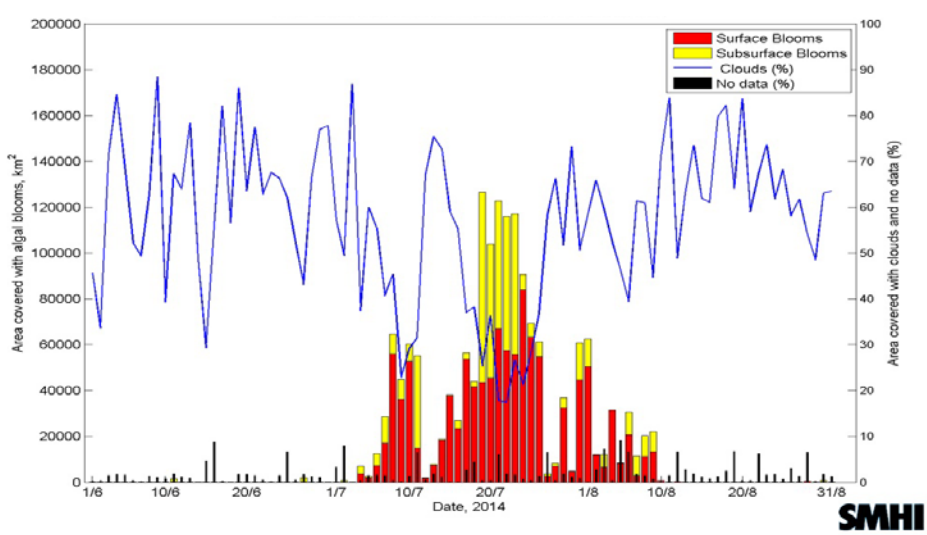


Figure 1. The number of days of observations of cyanobacteria surface accumulations. Data from the SMHI Baltic Algae Watch System. Öberg. 2014–2016.

http://helcom.fi/baltic-sea-trends/environment-fact-sheets/eutrophication/cyanobacterial-blooms-in-the-baltic-sea

Table 1. Satellite observations of cyanobacteria accumulations. Summary of results for years 2014–2016. See Öberg 2014–2016 for details.

Year	Normalized bloom intensity, km² days	Normalised extent, km²	Duration, days	Maximum area covered, km²	Date for maximum area covered
2014	26293	3337	7.8	~83 000	July 24
2015	25332	5183	4.9	~125 000	August 14
2016	12082	2707	4.5	~86 000	July 25



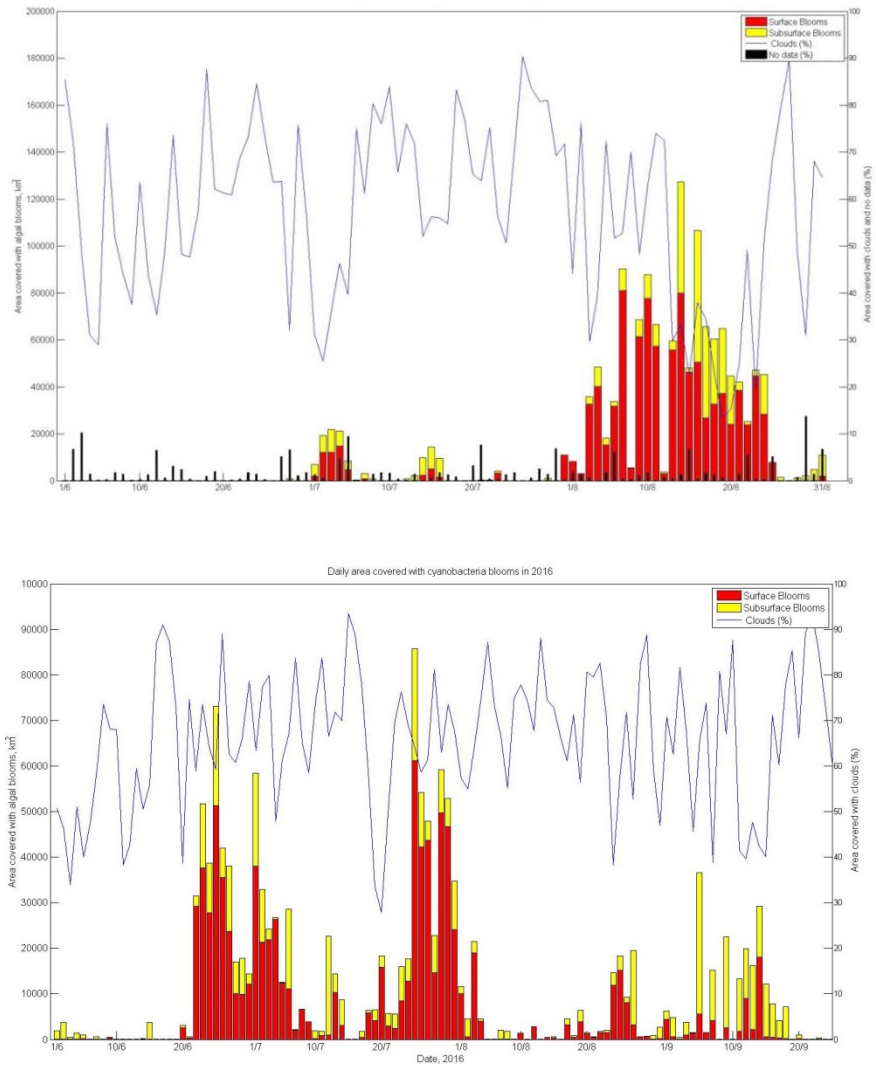


Figure 2. The area of cyanobacteria surface accumulations in summers 2014–2015 and 2016 as observed by satellite. Note that the scale of the y-axis and the x-axis is different for year 2016 compared to 2014–2015. September is included in 2016. Data from the SMHI Baltic Algae Watch System. Öberg. 2014–2016.

http://helcom.fi/baltic-sea-trends/environment-fact-sheets/eutrophication/cyanobacterial-blooms-in-the-baltic-sea

http://www.helcom.fi/Documents/Baltic%20sea%20trends/Environment%20fact%20sheets/BSEFS_Cyanobacteria_blooms_in_the_Baltic_Sea_2015.pdf

http://helcom.fi/Documents/Baltic%20sea%20trends/Environment%20fact%20sheets/BSEFS%20Cyanobacterial%20blooms%20in%20the%20Baltic%20Sea%202014.pdf

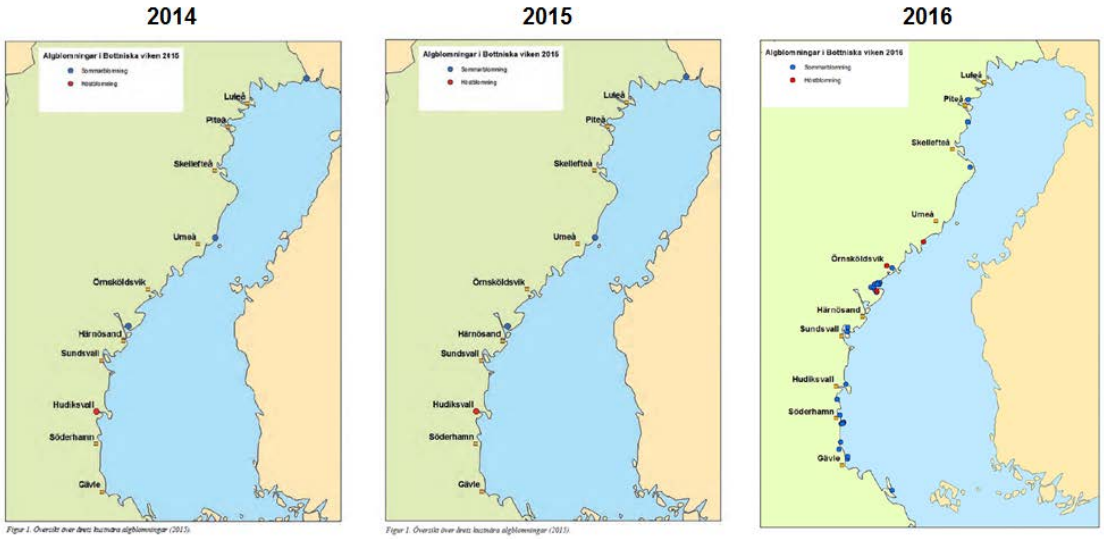


Figure 3. Observations of local algal blooms (accumulations of algae) at the Swedish coast of the Gulf of Botnia reported by the Marine Information Centre for the Gulf of Bothnia.

Figure 4. Cyanobacteria on a beach at Fagervik in Hemrångefjärden in 2016. The cyanobacteria resemble spilled paint. Photo: The county of Gävle.

The Baltic proper

Blooms of cyanobacteria were observed from satellite all years (Figs. 1 and 2) and also from the air (Fig. 5) and by the public. The bloom in 2014 was most intense in the northern part of the Baltic proper. Surface scums were observed in the Archipelago of Stock-

holm. The bloom in 2015 was unusual in the sense that it continued into August. The bloom in 2016 started already in June and lasted even longer, until September. The peak of the bloom is usually in July. The toxic species *Nodularia spumigena* was observed mainly in July (Fig. 6). The non-toxic species *Aphanizomenon flos-aquae* is likely to have been the most important component of the surface accumulations forming nuisance blooms. Also *Dolichospermum* spp. (synonym *Anabaena* spp.) is a major component of the cyanobacteria biomass.

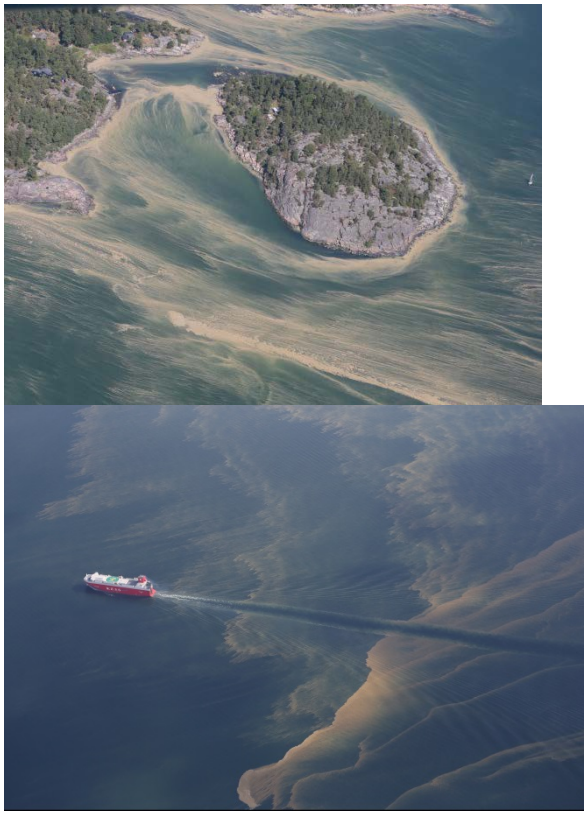


Figure 5. Surface accumulations of cyanobacteria in the Baltic Sea. Left: Baltic Proper near Oxelösund, 25 July 2014. Right: Accumulations South of the Island of Gotland 14 September 2016. Photos: Swedish coast guard.

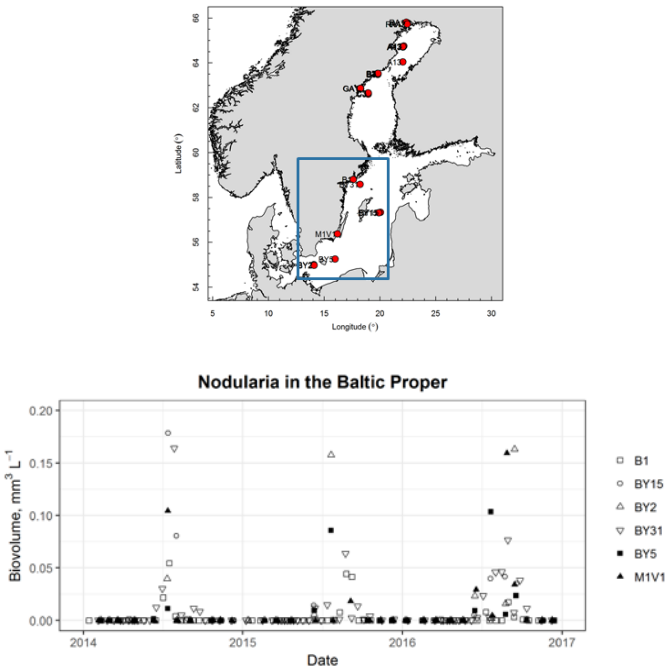


Figure 6. Map illustrates the sampling locations for Swedish National monitoring of phytoplankton in the Baltic Sea. The biovolume of *Nodularia spumigena* in the Baltic Proper in 2014–2015 is illustraded in the graph. Data from 2016 was not available at the time of report writing.

The Skagerrak and the Kattegat

Fisk killing algae

Several fish killing species or genera were observed in 2014–2016 but no effects were reported. The organisms include: *Prymnesium* spp., (syn. *Chrysochromulina* spp.), *Dictyocha* spp. (also the naked form), *Pseudochattonella* sp., *Karenia mikimotoi*, *Heterosigma* sp. and *Karlodinium* sp.

Algae causing shellfish toxicity

Commercial harvesting of shellfish is only carried out along the Skagerrak coast (Figs. 7–8). 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*), pacific oysters (*Crassostrea gigas*) and cockles (*Cerastoderma edule*) are harvested. In years 2014–2016 there were closures of shellfish harvesting in some harvesting areas due to phycotoxins algae several times. It should be noted that during the same periods there were other areas where harvesting was allowed since levels of phycotoxins in the shellfish were below the regulatory limit.

DST and *Dinophysis*

Concentrations of Diarrhetic Shellfish Toxins (DST) above the regulatory limit were detected all years (Fig. 9) causing closures of harvesting of wild and farmed mussels in some areas. This coincided with high abundances of *Dinophysis* spp. (Fig. 13). In year 2016 the abundances of *D. acuta* and *D. norvegica* were lower than usual. Mostly the DST levels in the month of July are low but year 2016 was an exception. *D. acuminata* is considered to be the cause of high DST levels in July 2016.

PST and *Alexandrium*

Concentrations of Paralytic Shellfish Toxins (PST) were above the regulatory limit in 2014 and at the limit in 2015 (Fig. 10). Harvesting areas were closed during these events. The high concentrations of PST in 2014 coincided with high abundances of *Alexandrium* spp. (Fig. 14). The species observed include *A. tamarense*, *A. ostenfeldii* and *A. minitum*. In addtition *A. pseudogonyaulax* was observed, mainly in July and August. *A. pseudogonyaulax* has been shown to produce the toxin godiodomin.

YTX, *Lingulodinium* and *Protoceratium*

Yessotoxins (YTX) above the regulatory limit were not detected in any of the harvested shellfish. The data on blue mussels is presented in Fig. 11. The dinoflagellates *Lingulodinium polyedrum* and *Protoceratium reticulatum* 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 not detected. A producer of AZT, cf. *Azadinium* sp. was detected at abundances up to 22500 cells L^{-1}. The identification has not been confirmed with electron microscopy or molecular methods.

AST and *Pseudo-nitzschia* spp.

Concentrations of Amnesic Shellfish Toxins (AST) above the regulatory level were detected in year 2016 (Fig. 12). *Pseudo-nitzschia* spp. produces AST. High cell numbers of *Pseudo-nitzschia* spp. have been observed during periods when no AST was detected in shellfish. This indicates that not all *Pseudo-nitzschia* spp. in the area are toxic, at least not always.

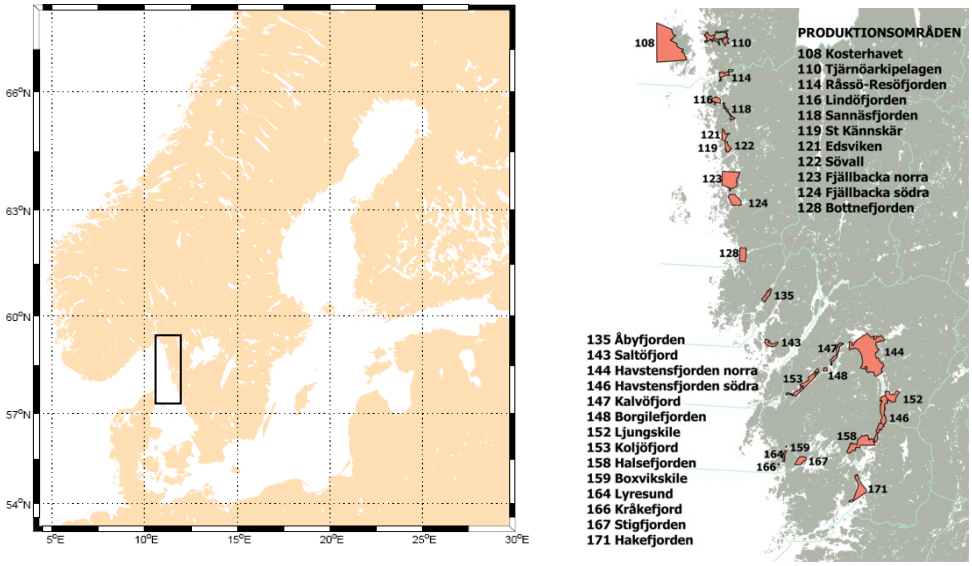


Figure 7. Left. Map of Scandinavia. The rectangle indicates the Swedish Skagerrak coast. Right: Harvesting areas for bivalves in year 2016 (source. The Swedish National Food Agency).

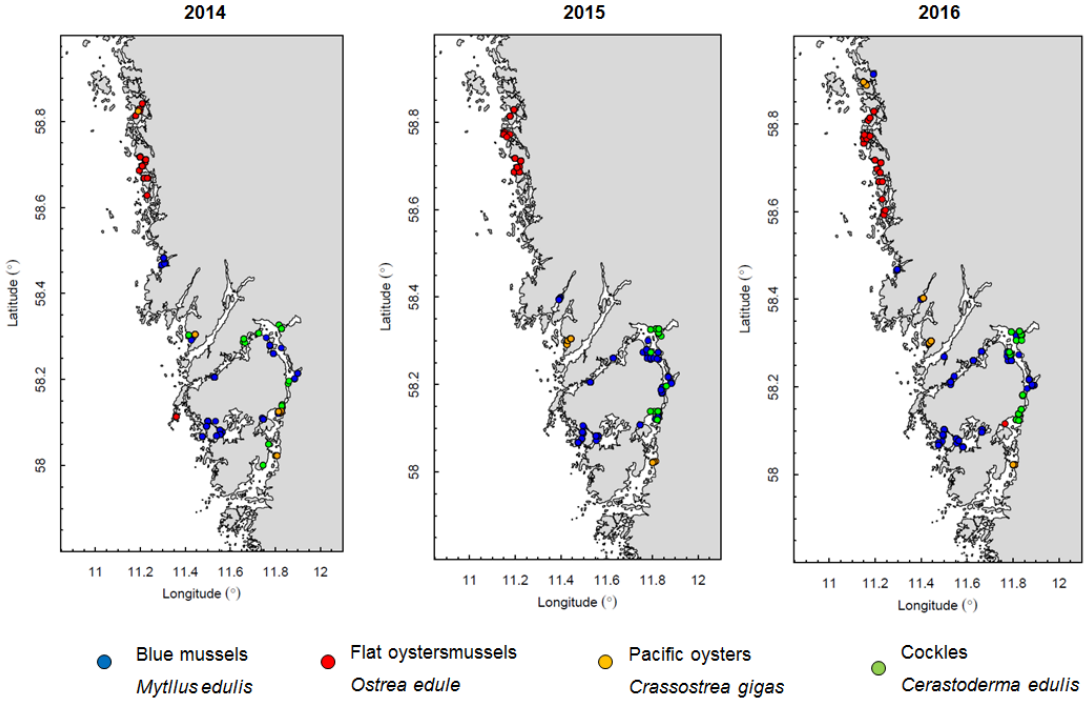


Figure 8. The maps illustrates the locations for commercial mussel and oyster harvesting in Sweden 2014–2016.

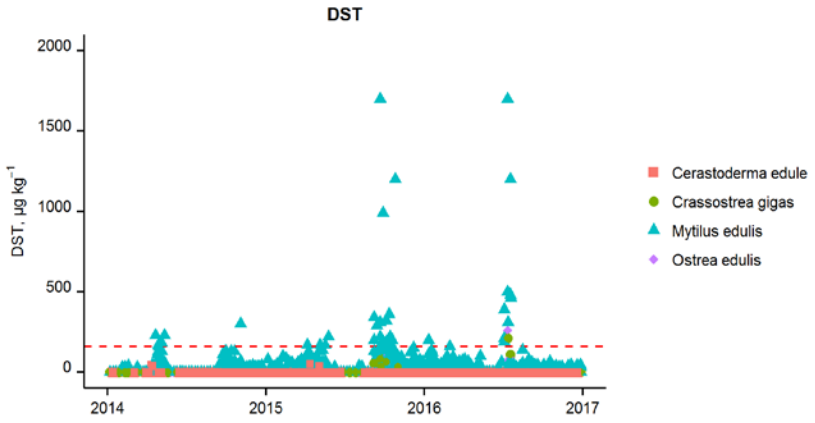


Figure 9. Concentrations of Dinophysis Shellfish Toxins in bivalves from the Swedish Skagerrak coast 2014–2016. The red line denotes the regulatory limit. Data from the Swedish National Food Agency monitoring program.

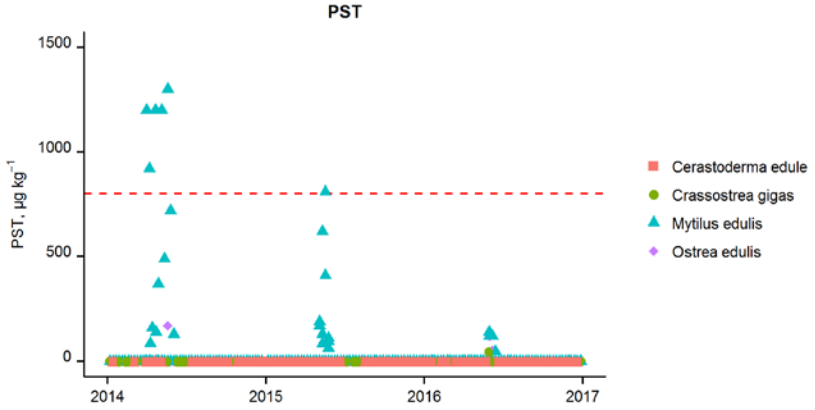


Figure 10. Concentrations of Paralytic Shellfish Toxins in bivalves from the Swedish Skagerrak coast 2014–2016. The red line denotes the regulatory limit. Data from the Swedish National Food Agency monitoring program.

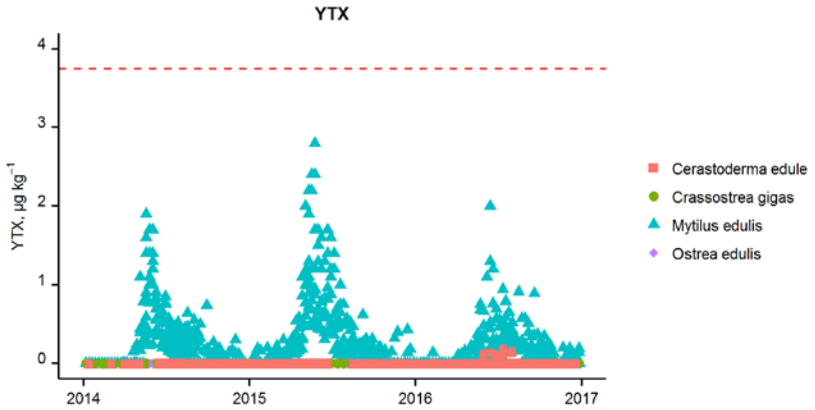


Figure 11. Concentrations of yessotoxins in bivalves from the Swedish Skagerrak coast 2014–2016. The red line denotes the regulatory limit. Data from the Swedish National Food Agency monitoring program.

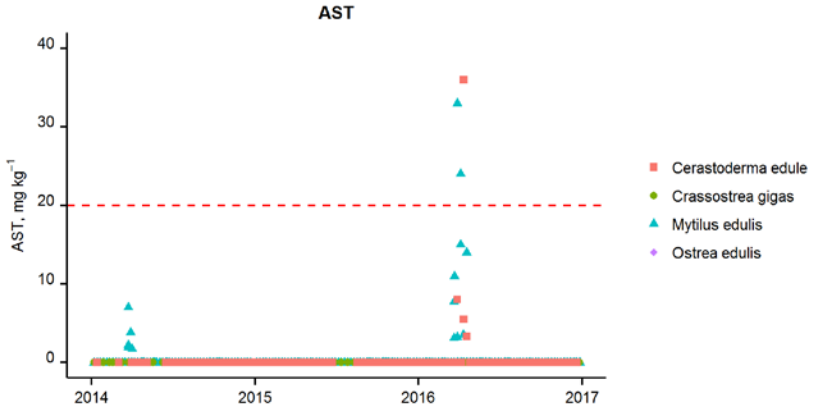


Figure 12. Concentrations of Amnesic Shellfish Toxins in bivalves from the Swedish Skagerrak coast 2014–2016. The red line denotes the regulatory limit. Data from the Swedish National Food Agency monitoring program.

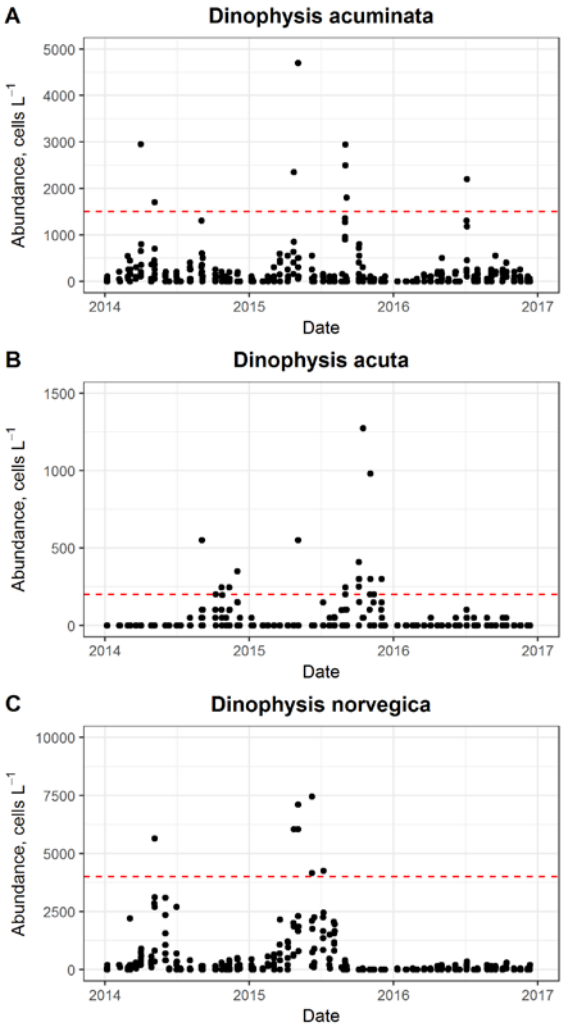


Figure 13. Abundance of *Dinophysis* species in the Kattegat-Skagerrak in 2014–2016. Red line denotes warning limit. Data from the national marine monitoring programme, national food agency monitoring program and regional monitoring programmes.

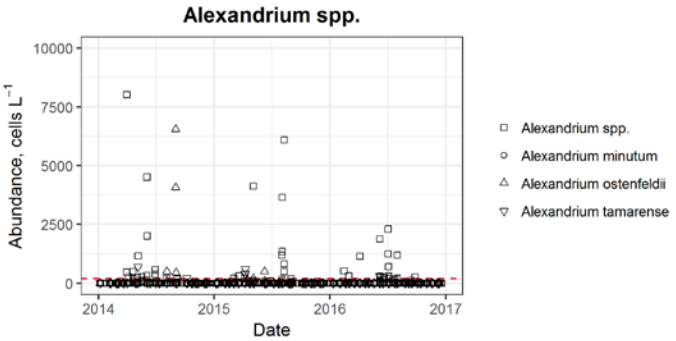


Figure 14. Abundance of *Alexandrium* species in the Kattegat-Skagerrak in 2014–2016. Red line denotes warning limit. Data from the national marine monitoring programme, national food agency monitoring program and regional monitoring programmes.

Finland National Report 2014–2016

Anke Kremp, Finnish Environment Institute, Marine Research Centre

Filamentous N fixing cyanobacteria are the main HAB species in Finnish waters. Blooms consisting of non-toxic *Aphanizomenon* spp., hepatotoxic *Nodularia spumigena* and microcystin producing *Dolichospermum* spp. occur every year. The blooms produce noxious surface scums, which - when washed ashore - may become a health risk. Cyanobacteria are monitored routinely by Finnish municipal, regional and governmental authorities. A prognosis, based on wintertime nutrient levels and spring bloom intensity, for cyanobacterial bloom formation is published in June.

For the years of 2014–16 an increased risk of cyanobacterial blooms was predicted for the coastal areas based on high surface phosphorus levels remaining after the spring blooms. The winter of 2013/14 had been unusually stormy which caused extensive mixing of nutrient rich deep water into the surface layer of these areas. In 2015 and 16 phosphorus levels were high due to pronounced inflow of deep P-rich water from the central Baltic into the N and E Basins suggesting an even higher risk of cyanobacterial bloom formation. In 2014 the prognosis was confirmed when extensive surface blooms developed at the SW coast of Finland after mid- July 2014. Continuous surface scums of *Nodularia spumigena* covered the entire Northern Baltic proper and coastal areas of Finland and Sweden for approximately 3 weeks. The summer cyanobacterial bloom of 2014 was exceptionally intense with high chla (> 40 ug/L) surface concentrations. The Finninsh Environment Institute as well as regional and municipal authorities informed the media respectively and advised the public on health risks of the *Nodularia* scums. In 2015 the bloom season started only in August due to cold weather in early summer, but cell concentrations and surface accumulations were the late summer bloom became even more extensive than in the previous year. In 2016, cyanobacteria occurred early in the water column, but blooms were quickly dispersed due to heavy winds. The intensity of the 2016 cyanobacterial blooms was less severe than expected and management activities of the authorities were not needed.

In addition to cyanobacteria, toxic dinoflagellate blooms may occur in shallow coastal waters of Finland. In August 2014 a dense bloom of *Alexandrium ostenfeldii* was detected in the Föglö archipelago of Åland. The bloom was exceptionally dense, reaching > 6 x 10^6 cells L^{-1}. PST concentrations of ca. 14 µg L^{-1} were measured in the water. Besides PSTs, Baltic *A. ostenfeldii* produces Gymnodimines. The major compound is GYM D of which considerable amounts were measured in the 2014 Föglö bloom. No incidences of toxicity were reported. In 2015 and 2016 *A. ostenfeldii* did not bloom at the Finnish coasts. However, a fish-kill in the Tammisaari Archipelago, SW coast of Finland, reported by the Raasepori municipal authority in July 2015, was related to a bloom of *Karlodinium veneficum*. Samples taken from the bloom site revealed cell concentrations of >10 000 000 cells/L. Though toxins were not measured at the time of the fish kill, it was concluded that a bioactive effect of *K. veneficum* was responsible for the event, since oxygen levels were not critical and laboratory tests on isolates confirmed lytic activity on blood and fish-gill cells. The event was the first harmful *K. veneficum* bloom documented for the Baltic Sea.

Annex 6: ToR c) HAE-DAT

Data from the HAE-DAT database is to be used as the foundation for the Global HAB Status Report (GSHR) currently being produced by the IOC. This GSHR report will present an overview of the data in HAE-DAT on a global scale and will provide a service to scientists, managers of regulatory monitoring programmes as well as policy administrators allowing them to access to high quality data on the biogeography of harmful species and occurrence of harmful algal events from across the world. These condensed and synthesized data will be available to society, and contribute to larger assessments (GEO, WOA, IPBES, IPCC), in order to get the issue of impacts from HABs increasingly recognized, prioritized and funded. The WGHABD Harmful Algal Event Status Report will be the ICES contribution to this global scale assessment.

The GHSR editorial board is will complete an information booklet about the report to be released at the International Conference for Harmful Algae (ICHA) in Nantes, France in 2018. The provisional chapter list for the GSHR is:

- Globally increased awareness and increased monitoring of HABs
- Eutrophication as a regional driver of HABs (Seto Inland Sea; Hong Kong; Europe)
- Anthropogenic transport of HAB species (*Ostreopsis; Alexandrium catenella; Gymnodinium catenatum*)
- HAB range expansions and contractions (*Noctiluca, Pyrodinium, Cochlodinium*)
- Macroalgal blooms
- Freshwater HABs
- Is ciguatera increasing?
- Climate Change and HABs

During 2017–2018 efforts will continue at all regional HAB meetings across the globe to encourage region/ country coordinators to enter data into OBIS and HAEDAT to ensure that HAB events and impacts and species distribution (HAEDAT and OBIS/HABMAP) are present in one integrated HAB data portal within OBIS. Acitivities associated with the GSHR will continue over the following two years and beyond. These include;

- Oct 2018; Dedicated ICHA Nantes session to explain the nature of the data base and extract preliminary global conclusions. Launch of GHSR information booklet
- 2019; Publish a special HARALG GHSR issue with regional reviews
- 2020; ICHA Mexico et seq. Present GHSR updates at every ICHA meeting.
- Produce Global HAB Status Report every 2–5 years (are things changing? was 2016 a once off exceptional year etc).

WGHABD reviewed progress with HAE-DAT during the year and the outputs circulated amongst the group by Pieter Proovost from the IOC programming centre. Some data entry queries were clarified. These included the criteria to enter a harmful algal event for CFP in HAE-DAT which is the incidence of people getting sick; brevetoxins are recorded

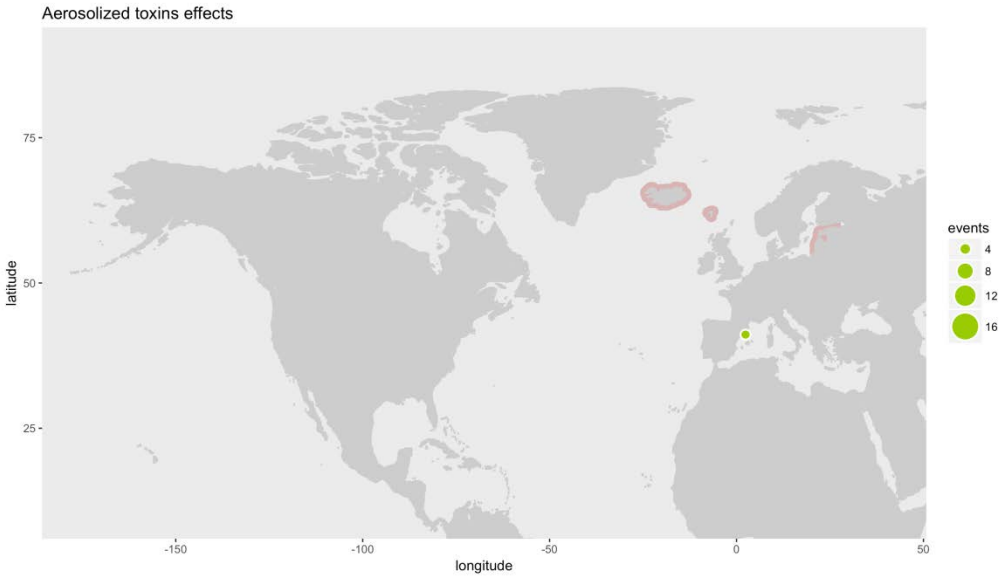
and entered as NSP in the USA. This is different to records of aerosolised toxins in Europe which is related to incidence of *Ostreopsis*. The lack of entry of region codes in historic data will result in data being excluded from maps. Delegates are to recheck historic data to see if these have all been entered. Data in HAE-DAT for the 2014, 2015 and 2016 period are to be updated so products can be included in the final WG report. All historic data to be entered and quality checked in HAE-DAT by Dec 15th 2017.

Examples of outputs from HAE-DAT are given in two formats in Annex 7. HAE-DAT data relating to aerosolized toxins, amnesic shellfish poisoning, azaspiracids, ciguatera fish poisoning, cyanobacteria, diarrhetic shellfish poisoning, neurotoxic shellfish poisoning , paralytic shellfish poisoning as well as 'other' events from each country in the ICES area are presented. Data from the Pacific coast of the USA and Canada are also included. Each country in HAE-DAT is divided into a number of different area codes. Maps i – vii show the number of harmful algal events for each area code in ICES area countries only during the reporting period 2014, 2015, 2016. Maps xiv - xvi show the number of years where events were recorded in each area during the same reporting period. Countries with a pink boundary have yet to enter data into HAE-DAT. It should be noted that low monitoring effort in some country areas e.g. northern Canada, Greenland, means that there is no data to enter as opposed to no harmful algal events.

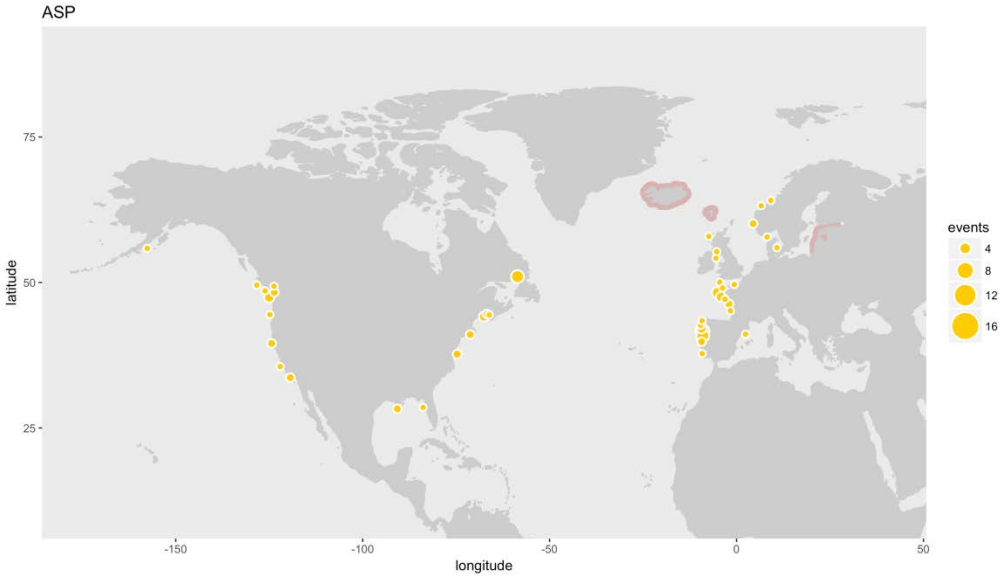
Writing the results section of the report will begin in the new year of 2018. Intro and methodologies will begin earlier. The WGHABD Harmful Algal Status Report will be finalised at the 2018 WGHABD meeting. Pieter Provoost from IOC IODE will be invited to along to resolve any issues that will crop up during the year.

HAE-DAT Maps of ICES area countries

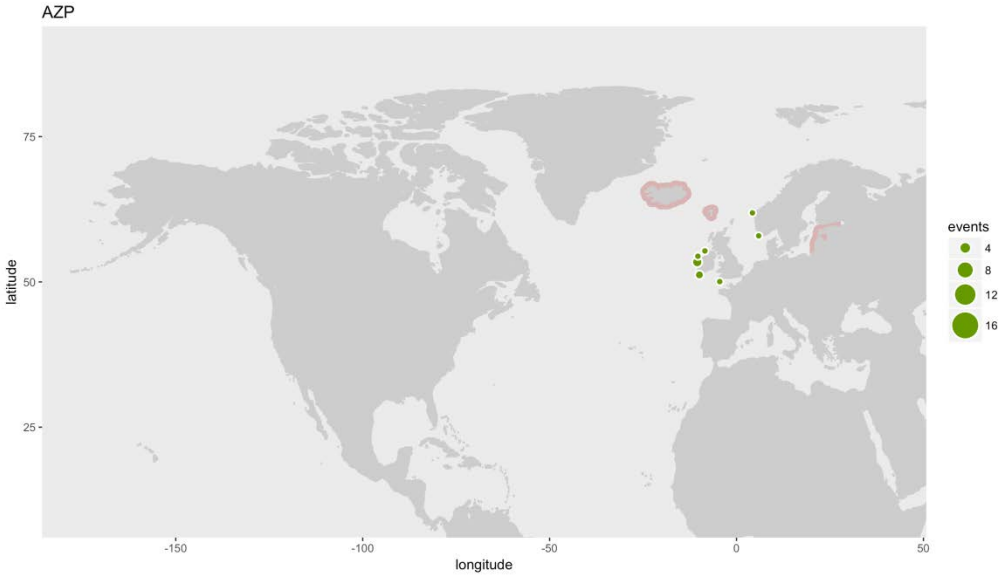
(i) Aerosolised Toxin Events 2014–2016



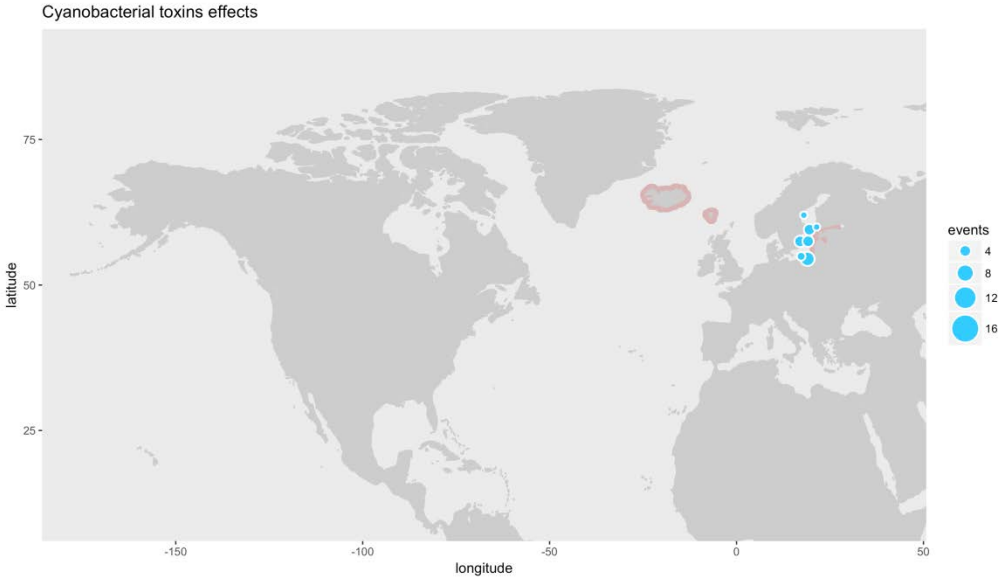
(ii) Amnesic Shellfish Poisoning Events 2014–2016



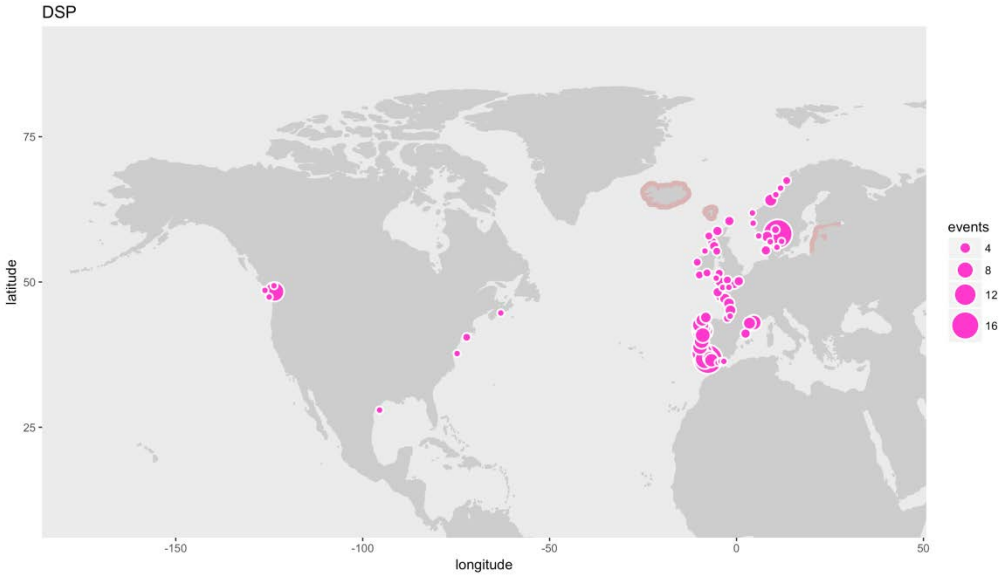
(iii) Azaspiracid 2014–2016



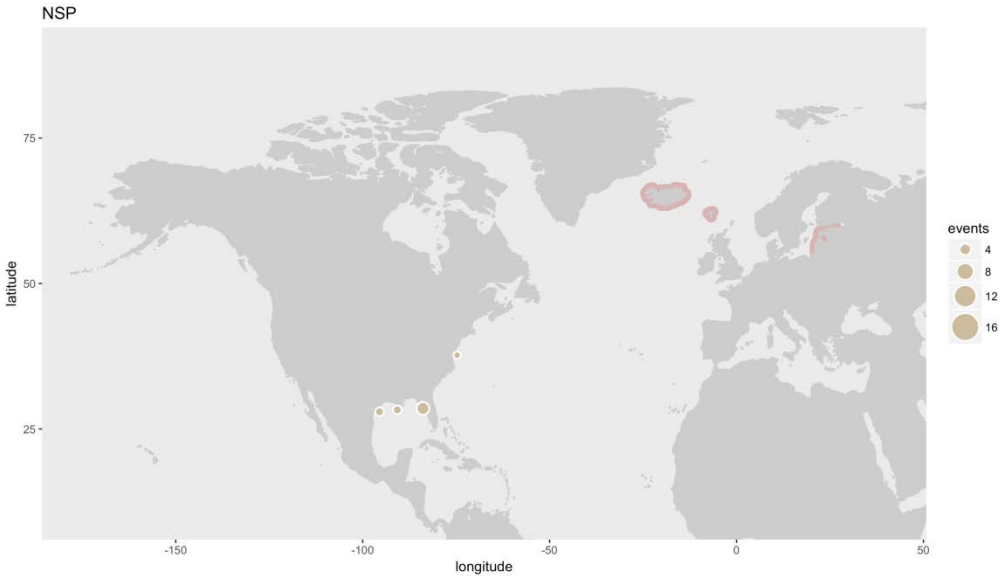
(iv) Cyanobacteria Events 2014–2016



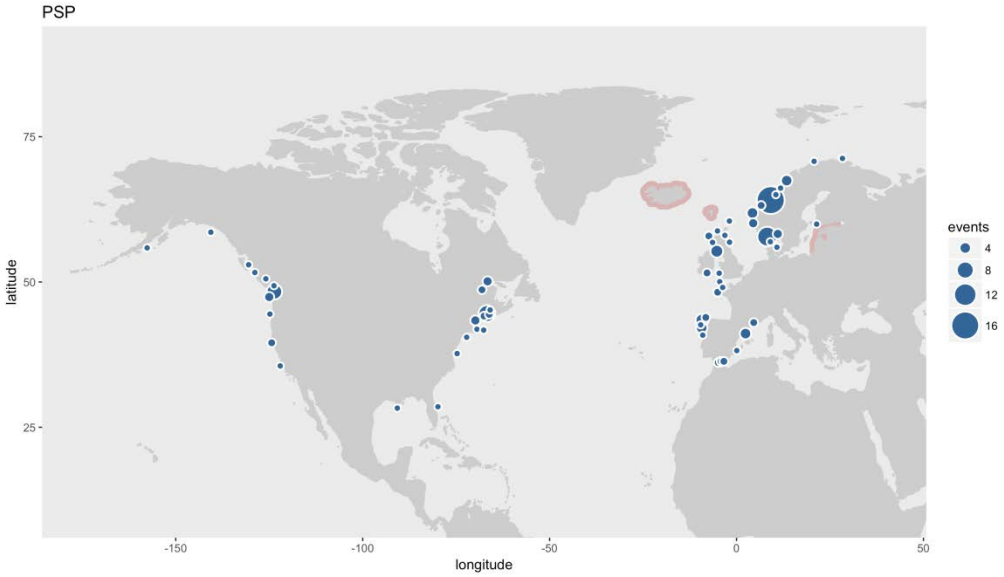
(v) Diarrhetic Shellfish Toxin Events 2014–2016



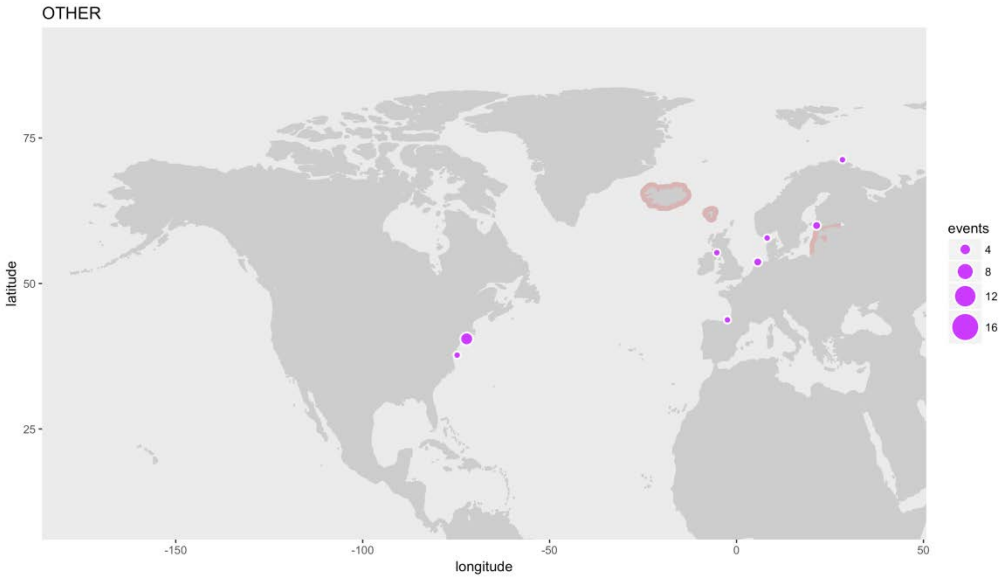
(vi) Neurotoxin Shellfish Toxin Events 2014–2016



(vii) Paralytic Shellfish Toxin Events 2014–2016

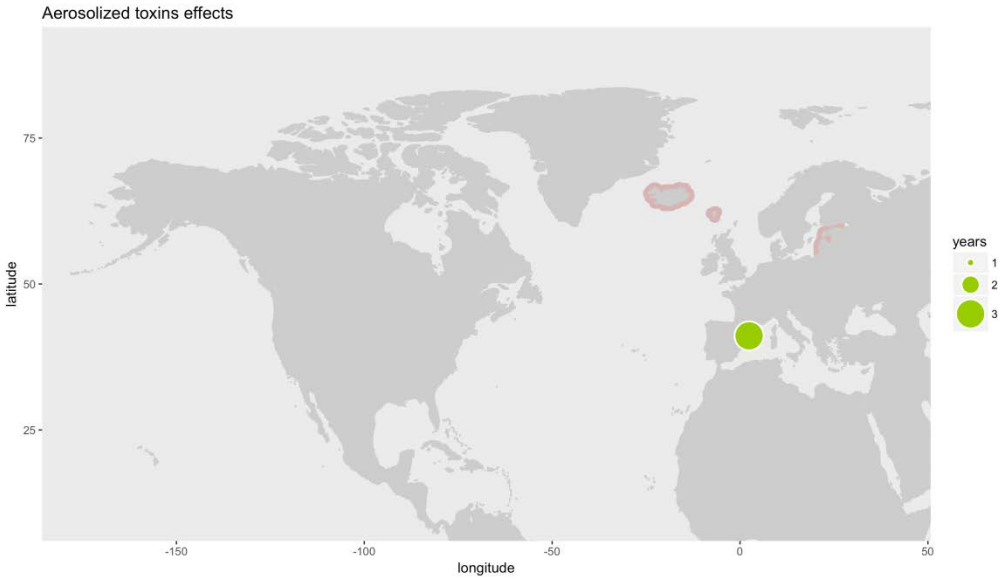


(viii) 'Other' Harmful Algal Events 2014–2016

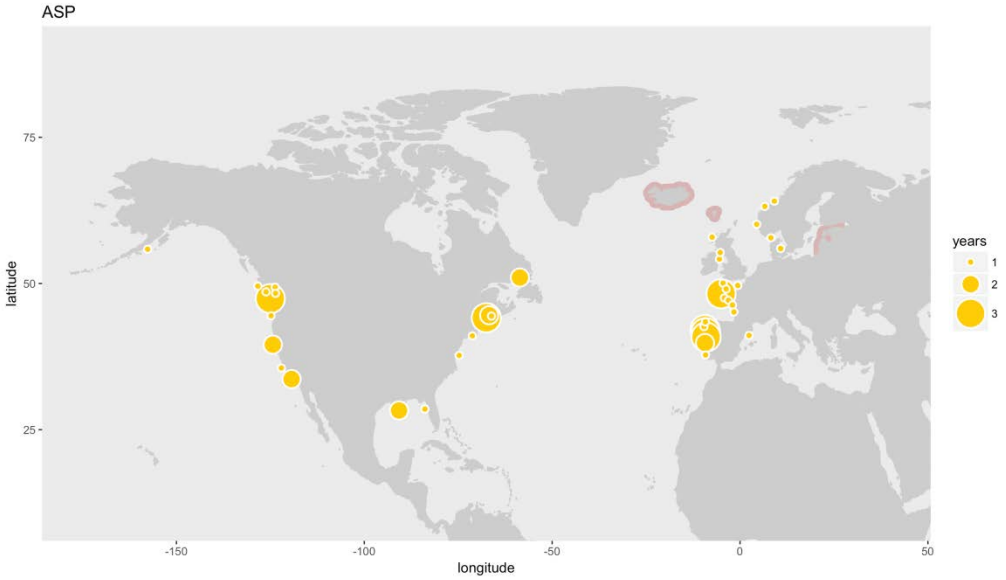


Number of years with Harmful Algal Events 2014–2016

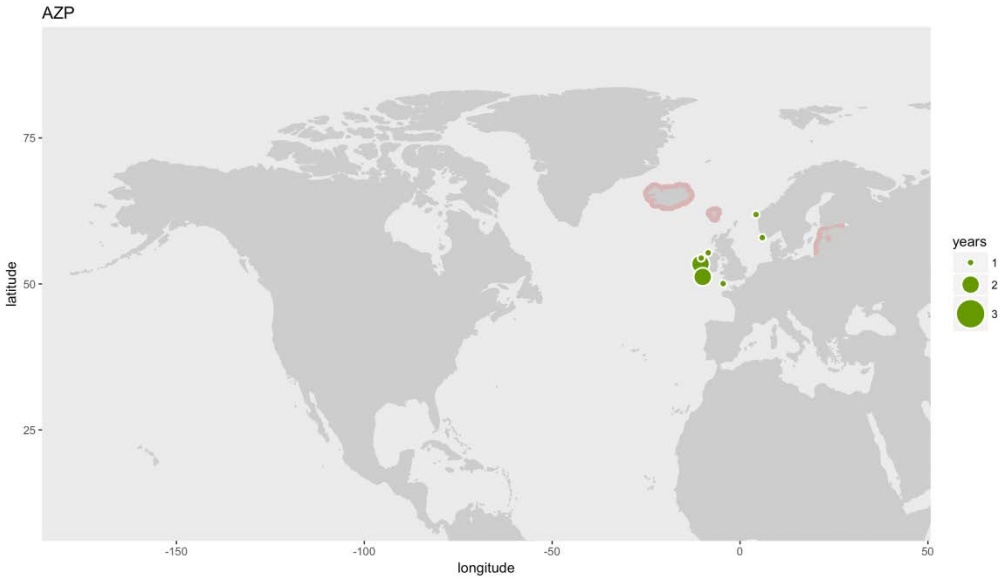
(ix) Years with Aerosolised Toxins Events 2014–2016



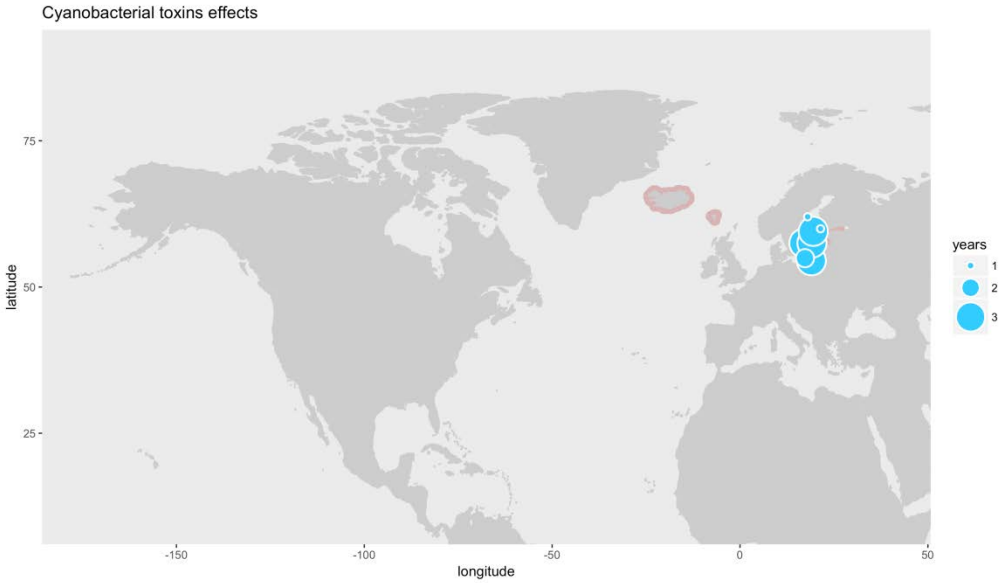
(x) Years with Amnesic Shellfish Toxin Events 2014–2016



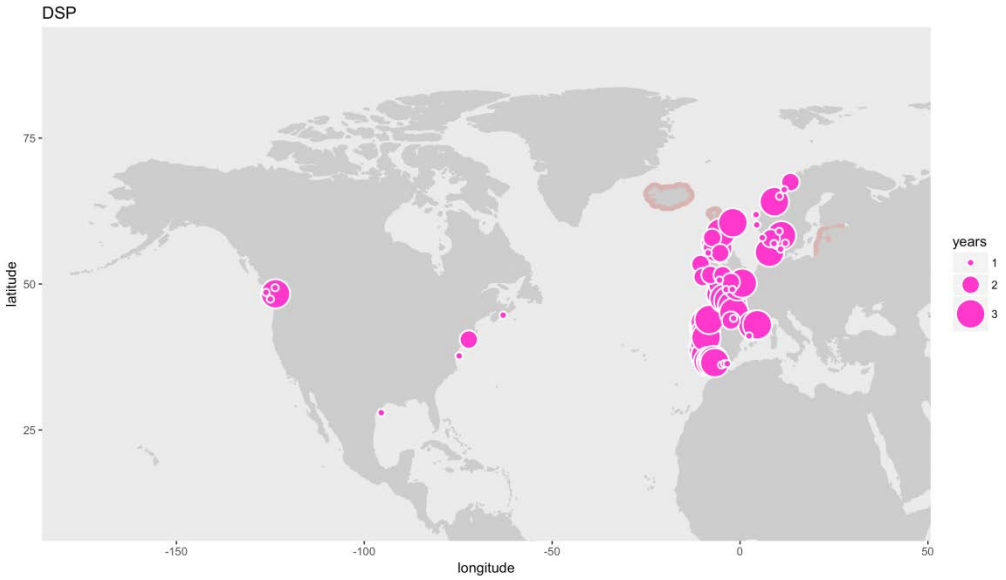
(xi) Years with Azaspiracid Events 2014–2016



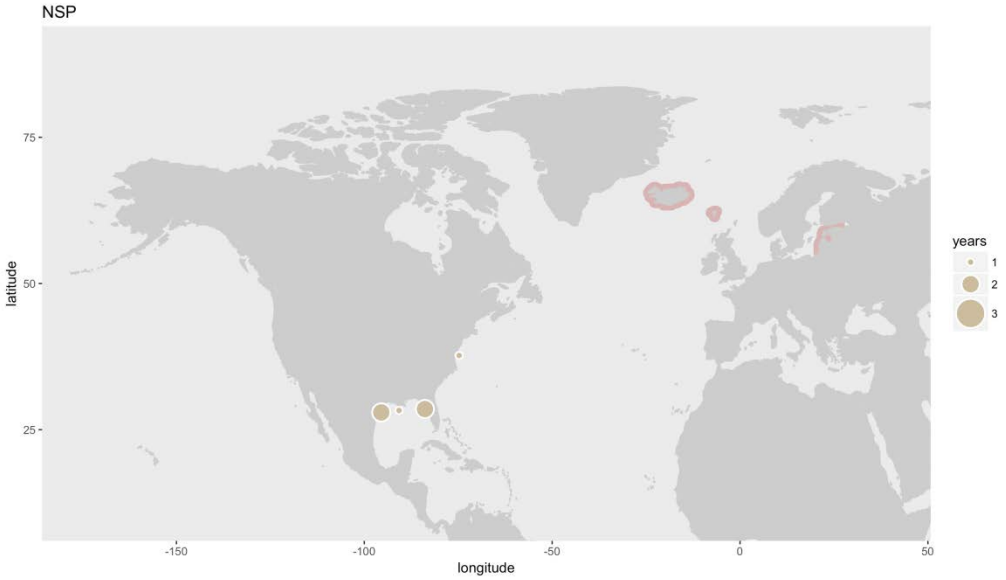
(xii) Years with Cyanobacterial Events 2014–2016



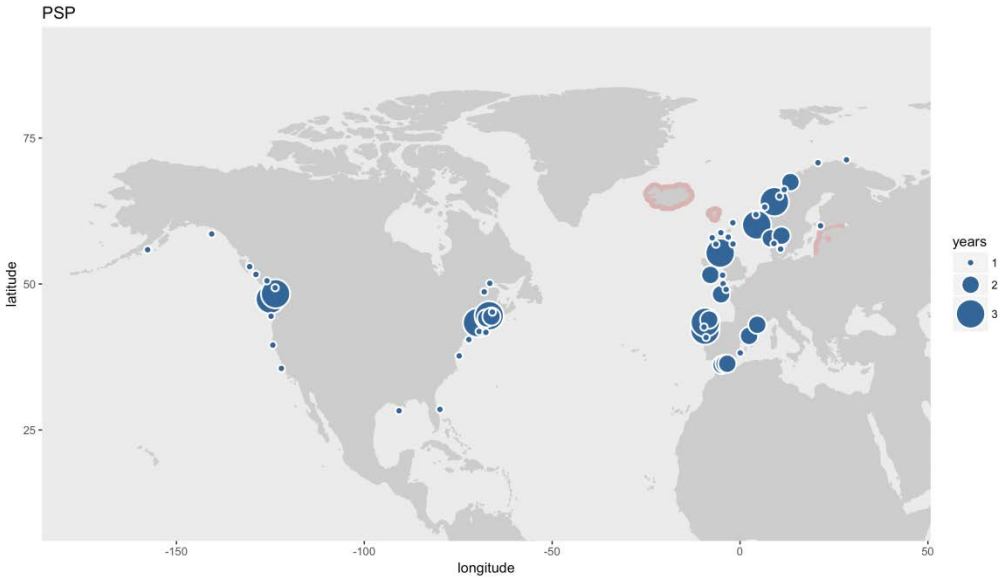
(xiii) Years with Diarrhetic Shellfish Toxin Events 2014–2016



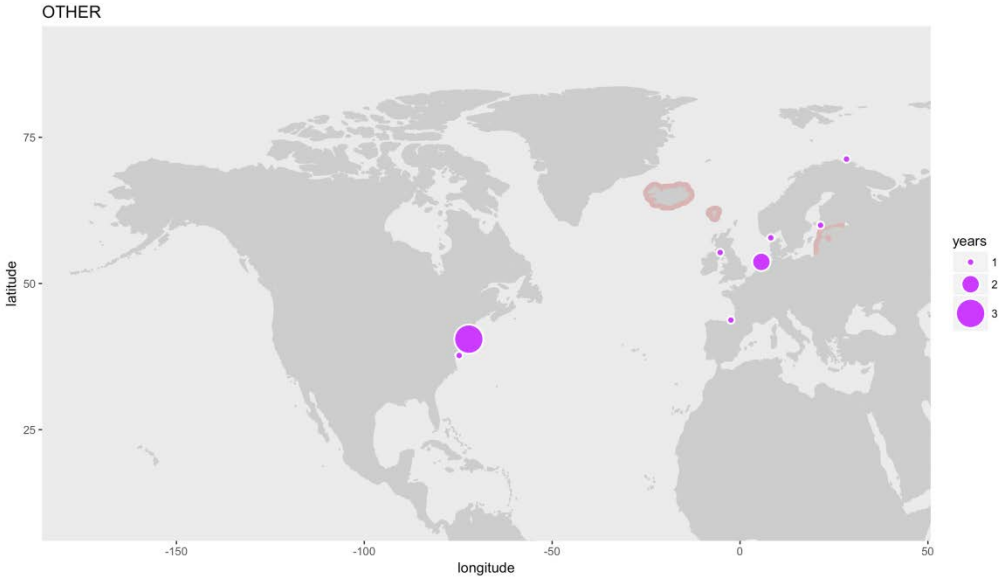
(xiv) Years with Neurtoxin Toxin Events



(xv) Years with Paralytic Shellfish Toxin Events 2014–2016



(xvi) Years with 'Other' Events 2014–2016



Annex 7: ToR e) New Findings

1. Reconstruction of the history of toxic *Nodularia spumigena* blooms in the Baltic Sea and Oslofjorden

Hanna Mazur-Marzec, Anna Touńska-Sitarz, Marta Cegłowska, Katarzyna Kajdana, Robert Konkel, Justyna Kobos, Poland.

The history of *Nodularia spumigena* blooms in the Baltic Sea (Gulf of Gdańsk) and Oslofjorden (inner part) was reconstructed. For the purpose of the study, the presence of specific molecular markers in sediment samples was determined. Short (SC, 30 cm) and long sediment cores (LC, 380 cm) were collected from the same stations located in both water bodies and divided into 2-cm layers. Nodularin (NOD), anabaenopeptins (APs), gene involved in NOD biosynthesis (*nod*F) and the sequences of the phycocyanin intergenic spacer and its flanking regions (*cpcBA-IGS*) were analyzed. In both cores from the Baltic Sea, NOD was detected in all layers with maximum concentrations of 4.32 ng/g dw in SC and 225.94 ng/g dw in LC. Based on the reconstructed climate changes in north part of Europe, the peaks in NOD concentrations in LC correspond to the climate warming during Neoglacial (3300–2500 years BP) and Roman Warm Period (2500–1600 BP). The presence of *N. spumigena* blooms in Baltic Sea thousands of years ago was also confirmed with genetic markers (*nda*F and PC-IGS).

For short core (SC) from Oslofjorden, all markers gave negative results, which is in agreement with lack of published records on *N. spumigena* occurrence in this area. However, in the long core (LC), NOD was detected in many layers, with maximum concentration of 5.25 ng/g in 32–34 cm layer, indicating the presence of *N. spumigena* in Oslofjorden 7000 years BC and longer time ago. As in the case of the Baltic Sea, the changes in NOD concentration in subsequent layers of LC from Oslofjorden corresponded to the reconstructed climate changes.

As the application of specific chemical (AP) and genetic (PC-IGS) markers led to identification of the same sub-population of *N. spumiegena* in both area of study, conclusions can be drown that the Baltic and Oslofjorden populations have the same origin.

2. Major HAB events and social disruption in Chile – 2016

Don Anderson, USA

This presentation was a report on several HAB events in Chile in 2016 that caused major social upheaval, and thus was of interest to WGHABD delegates.

Marine HABs in Chile's southern waters have been documented since 1972, but in the summer of 2016, two major HAB events of two separate species occurred in close succession, causing severe economic damage and social disruption. These events were linked to extreme conditions of an ongoing El Niño event as well as to changing ocean conditions possibly related to climate change. Artisanal fishermen of shellfish and fish species, as well as mussel farmers and salmon farmers suffered the worst damage from HABs ever in Chile's history. A third event, a mass mortality of nearshore fish, invertebrates, squid and many other organisms also occurred at that time, contributing to the social unrest.

That event was likely not caused by HABs, but rather the wind-driven upwelling of water with zero or low oxygen.

First, in February and March, a bloom of the algal species *Pseudochattonella sp.* killed 39 million salmon, mostly in farms in Reloncavi Sound and Fjord and to a lesser extent in the adjacent Gulf of Ancud, worth US$800 million at a harvest weight of 100 000 metric tons. Subsequently, a prolonged and extensive bloom of the PSP toxin producer *Alexandrium catenella* spread up the coast from the south, affecting both the east and west coasts of the island of Chiloe and further north along the open coast. It was the first time a bloom of this magnitude had occurred that far north. The bloom also affected the west coast of Chiloe – the first time this had happened along the open-ocean coast. The outbreak caused wild-caught shellfish species, crustaceans, and farmed mussels to become contaminated with PSP toxins, leading to harvesting closures in the affected areas.

When the harvest and sale of shellfish and other affected organisms was banned by Chilean food safety authorities, both artisanal fishermen and mussel farmers had no income. This caused much suffering among their families and communities, and led to massively disruptive social protests (blocked highways and ferries, marches, etc.) that lasted three weeks. These protests were also motivated by the belief of many that the *Alexandrium* red tide was exacerbated by the offshore dumping of farmed salmon that had died in the previous *Pseudochattonella* bloom. Later reports from government and university scientists stating that this attribution was wrong and that the PSP red tide event was caused by exceptional climatic and oceanic conditions of early in 2016 did not dispel this belief.

There were also observations of other mass mortality events in the region in the same period. One was responsible for a large kill of multiple species of wild fish, squid, and shellfish, which caused further anger and economic pain to artisanal fishermen. In this instance, all evidence points to the cause being upwelling of deep, low-oxygen waters, as the mortalities were indiscriminate – many different species killed at the same time, as is typical with hypoxia events. There are also remote sensing images that show nearshore upwelling in the areas of these mass mortalities. Given the highly visible impacts of the *Pseudochattonella* and *Alexandrium* blooms, however, this event was mistakenly attributed to the *Alexandrium* red tide, as commonly happens when the kills happen so quickly that field monitoring and other data collection are not possible.

These incidents and the public turmoil that accompanied them served to heighten awareness among regional government officials of the vulnerability of their coastal communities to HABs and of the need for better understanding and improved management tools. This also raised questions about the nature, quality and timeliness of available data that might allow them to better coordinate and manage fisheries resources during future HAB events.

3. First and second report of Tetrodotoxins in shellfish in the Netherlands

Marnix Poelman, The Netherlands

In 2015 and 2016 the first observations of Tetrodotoxins (TTX) in Dutch Shellfish have been reported, which is the third report in Europe. Based on the results and given that no regulatory limits for TTX in shellfish are available in Europe, the Dutch authority (NVWA, Food Safety Authority) commissioned a Risk Assessment on TTX in shellfish

and provided a provisional threshold of 20 μg TTX / kg shellfish tissue. This is discussed on a national and European level.

In 2015 Tetrodotoxins (TTX) were found in 16 samples in the Eastern Scheldt in the Netherlands. In 2016, TTX were monitored and introduced in the legal framework. TTX was found at two harvesting areas, and rewatering plots for the Dutch shellfish industry. Levels in oysters were reported to a maximum of 253 ug / kg shellfish flesh. Levels in mussels reached a maximum 101 ug/kg shellfish flesh. An intensive monitoring program and research program to elucidate the source was carried out. Closures occurred at the start of the mussel season, which resulted in closures of areas in the Easter Scheldt for 3 weeks.

A research program has been set up to elucidate the source of the toxin. Indications of the presence of Vibrio, and Pseudomonas bacteria in water and shellfish, as well as toxin in the shellfish indicate a potential route associated with microbiological factors, however the host is not yet confirmed. Literature studies revealed potential routes via amongst others sediment, phytoplankton, zooplankton, and water born bacteria. In 2017 the chemical methods for detection of toxins in environmental samples (non-shellfish) are improved. A full research program will be employed. This case demonstrates the need for awareness of emerging toxins, as well as potential alternative routes. EFSA only recently published an advice on TTX.

The ICES WGHABD will follow the TTX dossier, since phytoplankton as a vector or precursor may be a potential route for contamination.

Other countries are not yet incorporating TTX in the monitoring programs, however awareness is increasing.

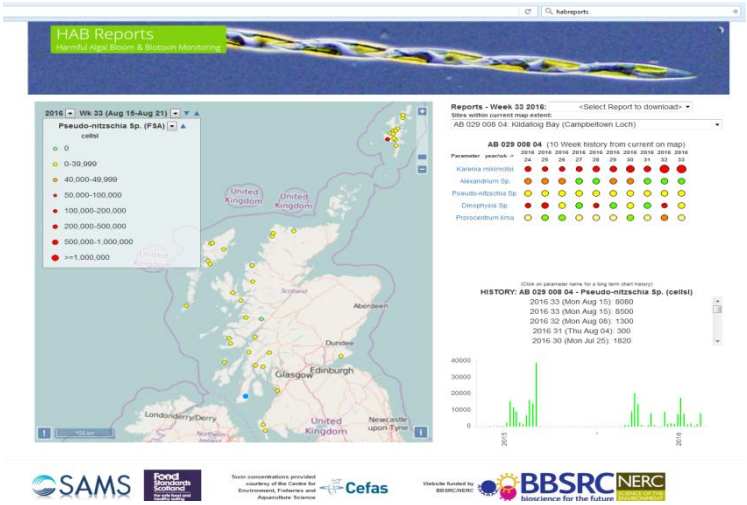
4. Harmful Algal Monitoring and Early Warning in Scottish Waters

Keith Davidson (SAMS), Scotland

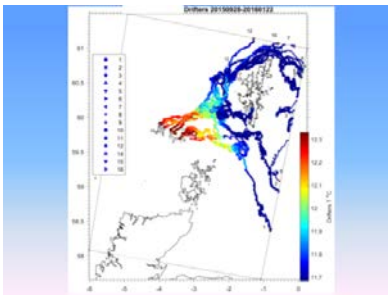
Biotoxin producing phytoplankton and their associated shellfish toxins are monitored in Scottish waters as a regulatory requirement. In parallel some phytoplankton species harmful to farmed fish are also enumerated.

This presentation outlined developments in methods to graphically summarise these data, in relation to other environmental information, in the Scottish Shetland Islands. Expert interpretation of these data then allows a short term risk assessment and early warning bulletin to be produced for the aquaculture industry in Shetland on a weekly basis.

A web site www.HABreports.org is used to disseminate this risk assessment and also make available information on current and historical HAB data Scotland wide.



The presentation also explained recent work to improve methods of predicting the appearance of advective harmful genera at Scottish coastal aquaculture sites. This work involved in situ validation (using drifters) of mathematical model predictions of water currents in Scottish coastal waters.



Now that confidence in the ability of the models to predict the transport of particles has been established, we are undertaking a suite of simulations to evaluate areas of high and low risk for harmful algal bloom initiation.

Finally, we are currently in the process of operationalizing the use of model simulations, initialised by satellite or in situ monitoring, to predict bloom transport and development over the subsequent four days.

5. Update on satellite techniques for monitoring for HABs

Peter Miller, UK (via video conference)

First he gave a recap on his published methodology for discriminating certain high-biomass HABs from harmless algae by their characteristic colour, using a classifier trained using satellite ocean colour scenes of known HAB events. This technique is being further developed within the UK BBSRC-funded *ShellEye* project, with encouraging validation results for detecting blooms of *Psuedo-nitzschia*, strains of which produce domoic acid that can shut shellfish farms for months. The project is also exploiting satellite data to improve predictive models for biotoxin presence near aquaculture farms. For example one model uses satellite-derived sea-surface temperature and solar radiation, together with rainfall data, to enable an early warning of toxins exceeding the threshold level.

Higher resolution (10–30m) optical satellite data track the suspended sediment in river plumes, helping to predict the dispersion of pollutants such as *E. coli*. ShellEye will now benefit from the recently commissioned European Sentinel-3 OLCI sensor, providing detailed ocean colour at 300m resolution. The EC FP7 AQUA-USERS project concluded successfully in September 2016, after testing the satellite HAB discrimination method on many further HAB species in 7 European aquaculture regions. Finally, PML is about to coordinate a new Interreg project *S-3 EUROHAB*, to promote the application of Sentinel-3 data to HAB detection/prediction and water quality monitoring in the French-English Channel.

6. Spatio-temporal variation of phytoplankton along the Basque coast: study of toxicity and quality as a food resource for bivalves

Oihane Muniz, Spain

The motivation of this study comes, in general, from the great development that world aquaculture has undergone in the last decades, but more concretely, from the increasing interest on implementing bivalve offshore aquaculture in the Basque Country (southeastern Bay of Biscay). Here, in 2012 an experimental bivalve farm was installed and a toxin and phytoplankton monitoring study is being carried out in the last years. The project is divided into two main parts: on the one hand, a long time series with data along the whole Basque coast was studied to evaluate phytoplankton quality and toxicity risk, as well as their relationship with environmental conditions. On the other hand, samplings were carried out in the experimental site along the water column. Phytoplankton community, environmental variables and toxin content in mussels were studied.

7. EUROCIGUA: RISK CHARACTERIZATION OF CIGUATERA FOOD POISONING IN EUROPE GP/EFSA/FSCO/2015/03

Margarita Fernandez Tejedor, Spain

Since 2008, several autochthonous outbreaks of Ciguatera Food Poisoning (CFP) have been reported in Spain (Canary Island) and Portugal (Madeira). The presence of some species of the genera *Gambierdiscus* and *Fukuyoa* has been reported in the Canary Islands, Madeira and also in some areas of the Western and the Eastern Mediterranean Sea. Other European countries have experience outbreaks of CFP due to consumption of fish imported from endemic areas. The project EuroCigua focuses on the characterization of the risk of CFP in Europe through three different axes: a) determination of the incidence and epidemiological characteristics of ciguatera cases in Europe, b) the evaluation of ciguatoxins (CTX) in seafood and the environment with the preparation of reference material, c) characterization of CTX present by LC-MS/MS and HRMS: development of standards and secondary reference materials.

In order to evaluate the presence of ciguatoxins in seafood and the environment, the sampling effort for *Gambierdiscus* and *Fukuyoa* is concentrated in areas where these species have been previously reported or there is presence of contaminated fish: Canary Islands and Madeira in the Atlantic Ocean, Cyprus, Crete and Balearic Islands in the Mediterranean Sea. Some sampling campaigns have already been conducted in these areas during the first year of the project, some strains have been isolated and the cultures

are in the process of being scaled-up to evaluate CTX production using cell-based assay (CBA). The most toxicogenic strains will be used to produce large scale cultures. At the same time fish is being captured from areas where *Gambierdiscus* or *Fukuyoa* are present and areas where contaminated fish has being reported, these samples are tested by CBA, positive samples are confirmed by LC-MS/MS. The results will allow defining the areas of risk of ciguatera together with epidemiological data. To further understand the ecological mechanisms leading to toxins accumulation in fish it is necessary to distinguish between the production of CTX by local populations of *Gambierdiscus* or *Fukuyoa* and transfer through food webs. The experience gained in other geographical areas Pacific and Caribbean with long experience in CFP will be a referent to understand migration of ciguateric fish and to forecast outbreaks and population dynamics of *Gambierdiscus* and *Fukuyoa*.

The project is co-funded by the European Food Safety Authority (EFSA), it was launched on June 2016 and will be completed in September 2020. Fourteen organizations from 6 Member States are part of the consortium. The Spanish Agency for Consumer Affairs, Food Safety and Nutrition (AECOSAN) is the coordinator of the project, the Institute of Health Carlos III (ISCIII), the Institute for Research and Technology in Food and Agriculture (IRTA) and the University of Vigo are coordinators of the specific agreements.

http://www.aecosan.msssi.gob.es/AECOSAN/web/ciguatera/home/aecosan_home_ciguatera.htm

Annex 8: ToR k) Physical and biological interactions to control the dynamics of relevant harmful microalgal blooms

Lindehoff, E.[1,2], Jerney J.1; Le Tortorec, A.[1]; Legrand, C.[2]; Savela, H.

University of Turku, Finland[3]; Svahn, E.[2]; Suikkanen, S.[1]; Kremp, A.[1]

NITROGEN SUPPLY MECHANISMS IN TOXIC DINOFLAGELLATE *ALEXANDRIUM OSTENFELDII* – THE KEY TO BLOOM EXPANSION IN COASTAL BALTIC WATERS?

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Linnæus University Sweden [2]

University of Turku, Finland[3]

The toxic dinoflagellate *Alexandrium ostenfeldii* forms dense blooms in shallow waters of the coastal Baltic Sea proper during late summer, when concentrations of inorganic nitrogen (N) are low and dissolved organic N (DON) high. If *A.ostenfeldii* is mixotrophic, a trait common among the genus *Alexandrium*, vegetation or phytoplankton derived DON could drive these blooms. We used 15N-tracer experiments to confirm mixotrophic behaviour of *A.ostenfeldii* through uptake and preference for several N species. Uptake of DON from lysed co-occurring phytoplankton cells was also shown. We performed *in situ* incubations during dense blooms (6×106 cells L-1) in Åland archipelago, Finland during August of 2014 and 2016. Nitrogen uptake rate and preference for 15Nnitrate (15NO3), 15N-ammonium (15NH4), 15N-urea and 15N-amino acids (15N-Aa) were measured with antibiotics chloramphenicol (CAP) added as a bacterial control. Uptakes rates of 15NH4 and 15N-Aa were significantly higher than that of 15N-urea and 15NO3, regardless if bacteria were inhibited. *A. ostenfeldii* consistently preferred amino acids over other tested N species. We visualized the direct uptake of DON from a co-occurring cryptophyte *Rhinomonas nottbecki*, pre-cultivated on 15NO3 and lysed by the released allelochemicals of *A.ostenfeldii* using second iron mass spectrometry (SIMS). Our findings support the concept that dense blooms of *A. ostenfeldii* utilize DON as N source and that it's allelopathic activity facilitates N uptake. Using observation data a species distribution model was constructed using the Maxent package to examine a possible relationship between *A. ostenfeldii* occurrences and DON-rich coastal habitats. The model showed that distance to shore, temperature, and depth are important explanatory factors. When combined with ratios between background concentrations of inorganic and DON it can improve the prediction of the potential bloom sites of *A. ostenfeldii*. In conclusion we show that nitrogen supply and utilization mechanisms are an important part of understanding bloom expansion of *A. ostenfeldii*.

Monitoring Baltic Sea *A. ostenfeldii* using qPCR – early experiences

Henna Savela

Department of Biochemistry, University of Turku

High density blooms of the dinoflagellate *Alexandrium ostenfeldii* have been recorded in the Baltic Sea since the early 2000s (Kremp *et al.* 2009). In this area, the species is a known producer of paralytic shellfish toxins (PSTs), the typical toxin profile consisting of saxitoxin (STX) and gonyautoxins 2 and 3 (GTX2, GTX3). The elucidation of the first saxitoxin biosynthesis gene sequences (Stüken *et al.* 2011) has made it possible to investigate the genetic background of PST production in *Alexandrium* spp., including *A. ostenfeldii*. The objective of this study was to characterize these genes and assess their potential for use in *A. ostenfeldii* bloom monitoring.

The gene *sxt*A (*sxt*A1 through *sxt*A4) is known to be responsible for the first step of PST biosynthesis in cyanobacteria (Kellmann *et al.* 2008), and thought to have the same function in dinoflagellates. The characterization of partial *sxt*A1 and *sxt*A4 genes in *A. ostenfeldii* has shown that *sxt*A4 is specific to detectable PST biosynthesis and is present at low (<12) genomic copy numbers in the species (Savela *et al.* 2016) and that *sxt*A1 is present, potentially as non-functional pseudogenes, also in non-PST-producing *A. ostenfeldii* (Suikkanen *et al.* 2013). Therefore, *sxt*A4 was chosen as the target gene for the development of qPCR assay aimed at monitoring and, if possible, prediction of toxic *A. ostenfeldii* blooms.

The correlation between genomic *sxt*A4 and LSU gene copy numbers, *A. ostenfeldii* cell densities, and PST concentrations was studied in samples collected at Föglö, Åland Islands, Finland, located in the northern part of Baltic proper. Data from low, intermediate, and high cell density samples collected in 2016, 2010 and 2014, respectively, were included in the study. At cell densities below 1×10^3 L^{-1}, determined by direct counting under a microscope and/or quantification of LSU copy numbers, *sxt*A4 was typically undetectable, likely as a result of its low genomic copy numbers. At higher cell densities of up to 5×10^3 cells L^{-1} *sxt*A4 was detectable, as were the toxins STX, GTX2, and GTX3. However, at these cell densities, *sxt*A4 copy numbers still typically remained under the limit of quantification. In bloom conditions, with *A. ostenfeldii* cell densities ranging from 1×10^4 to above 1×10^6 cells L^{-1}, it was observed that both LSU and *sxt*A4 gene copy numbers reflected both the cell density and PST production in the Föglö *A. ostenfeldii*.

In conclusion, the presence of *sxt*A4 indicates active PST biosynthesis in *A. ostenfeldii*, and a positive correlation between the variables measured in this study was observed when studying field samples. The sequence differences in the targeted gene compared to *sxtA*4 in other *Alexandrium* spp. have consequences for monitoring in terms of method specificity. The *sxt*A4 sequences define a separate *A. ostenfeldii* group within the PST-producing dinoflagellates, whereas recent experiments have indicated that the *A. ostenfeldii sxt*G shows a higher level of similarity to *sxt*G in other *Alexandrium* spp. The low genomic *sxt*A4 copy number in *A. ostenfeldii* affects the practical limit of detection and quantification. At the moment, for very sensitive detection, the LSU gene is a good alternative as it is a high copy number gene and enables species identification and enumeration. At bloom densities *sxt*A4 provides a direct indication of toxin production and can be used to estimate PST concentrations.

Forecasting cyanobacterial blooms in the Baltic

Harri Kuosi, Finland

The methodology used to predict the risk from cyanobacterial blooms in the Baltic was reviewed. Example of output using this method is given below.

http://www.syke.fi/en-US/Current/Press_releases/Algal_forecast_considerable_risk_of_blue(33683).

Finnish cyanobacteria bloom risk assessment in 2017

The risk of blue-green algae blooms is most affected by the amount of nitrogen and phosphorus during the previous winter. Data on them was obtained from nutritional samples taken by SYKE and the Swedish Meteorological and Hydrological Institute (SMHI) on the research vessel Aranda during the winter of 2017. The risk of algae blooms was assessed using the Baltic Sea ecosystem model in co-operation between SYKE and the Finnish Meteorological Institute.

The weather conditions over the coming summer, however, cannot be forecasted with sufficient accuracy, so the blue-green algae bloom prediction is based on the wind, current and temperature conditions of the five previous years. The risk prediction of blue-green algae blooms best describes the conditions in open sea areas.

The results provided by the model have been analysed by specialists. The final risk prediction included consideration of the uncertainty factors and utilised experiences from the predictions and observations of previous years. In addition, the development of nutrition concentrations during the 2017 spring was considered, using the results from Alg@line monitoring performed by merchant vessels. A detailed account for 2017 is available in:

http://www.syke.fi/en-US/Current/Significant_bluegreen_algae_blooms_possi(43313).

Finnish national algal bloom monitoring

Sirpa Lehtinen, Finland

In Finland, national algal reviews are published by the Finnish Environment institute (SYKE) weekly on Thursdays from June to the end of August. Algal review provides an overview of the state of algal blooms throughout Finland's lakes and coastal waters and the Finnish open sea areas of the northern Baltic Sea. Algal bloom monitoring is organized jointly by the Marine Research Centre and the Freshwater Centre of SYKE, Centres for Economic Development, Transport and the Environment (local ELY-Centres), and municipal environmental officials. Algal bloom monitoring is concentrated on cyanobacterial blooms, as they are the main harmful algae in the Finnish waters. Also occurrences of other phytoplankton algae are considered, whenever observed (usually harmless occurrences of water coloured red by the dinoflagellate Heterocapsa triquetra, for example). The amount of cyanobacteria is assessed from ca. 250 sites by the lakes and ca. 30 sites along the Finnish coast by observing how the water looks when standing on the beach, by using the following categories: 0 = no cyanobacteria; 1 = some cyanobacteria; 2 = abundant; 3 = very abundant. Information on the current algal situation in the Finnish

open sea areas comes from the remote-sensing group of SYKE (satellite based algal products), the Finnish coast guard, and the following parties of the Finnish FINMARI research infrastructure: SYKE's research vessel R/V Aranda, Alg@line ferry box systems which are installed in the commercial ferries, and the Imaging FlowCytoBot which sends images of phytoplankton from the Utö atmospheric and marine research station. It should be noted that the purpose of the summer-time algal bloom monitoring is to provide information of potentially harmful algal events to the citizens. For assessing the environmental status of the Finnish sea areas, the long-term monitoring of the phytoplankton community as well as cyanobacterial biomass is carried out using quantitative water samples which are collected regularly as a part of the HELCOM COMBINE monitoring.

More information can be found at:

Algal bloom reviews: http://www.syke.fi/en-US/Current/Algal_reviews

Information concerning cyanobacteria in Finnish:

https://www.jarviwiki.fi/wiki/Ohje:N%C3%A4in_teet_sinilev%C3%A4havainnon;
https://www.jarviwiki.fi/wiki/Lev%C3%A4tilanne