

ICES-IOC WGHABD REPORT 2013

SCICOM STEERING GROUP ON HUMAN INTERACTIONS ON ECOSYSTEMS (SSGHIE)

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Report of the Working Group on Harmful Algae Bloom Dynamics (WGHABD)

9-12 April 2013

Belfast, UK



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International Council for
the Exploration of the Sea

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Executive Summary

Highlights

The meeting of the 2013 ICES-IOC Working Group on Harmful Algal Bloom Dynamics was held in Belfast, Northern Ireland, UK the 9th to the 12th April hosted by the Agri Food and Biosciences Institute. The meeting was successful with 15 scientists from 12 countries attending. This includes a participant representing the IOC. A full schedule of terms of reference was worked through and this report is a summary of the deliberations of the group.

Some of the most important items reported and discussed were:

- HAB's remain a serious problem for the aquaculture industry in most ICES countries. Algal toxins accumulating in shellfish is one concern and direct effect on fish in farms is another.
- HAB species and HAB events are observed in new geographic areas. This is likely to be an effect of changed environmental conditions, e.g. warming. Also the spreading of organisms through ballast water etc. may contribute.
- A review of benthic harmful algal blooms is included in the report. Examples include benthic dinoflagellates causing ciguatera have been observed e.g. in the Azores, Canary Islands and in Madeira. Algal toxins in aerosols on beaches may cause breathing problems.
- Six persons in the Bremerhaven area were ill due to ciguatoxins. They had eaten red snapper imported from the Indian Ocean.
- The fish killing flagellate *Fibrocapsa japonica* was observed in Swedish waters for the first time.
- A bloom of the fish killing dinoflagellate *Karenia mikimotoi* caused serious damage to the marine ecosystem in Ireland in 2012.
- Netherlands reported the first observation of a bloom of paralytic shellfish toxin producing *Alexandrium*.
- Cyanobacteria blooms in the Baltic Sea remain a problem but the cold, windy and overcast weather in summer 2012 resulted in few observations of surface scums.
- A novel reporting format for the group was discussed. It was decided to use the Harmful Algal Event database <http://haedat.iode.org> more extensively. A decision by the UNESCO-IOC International Panel on Harmful Algal Blooms to produce global harmful algal reports is an opportunity for further collaboration ICES-IOC.
- Examples of time-series data on harmful algae and algal toxins were presented.
- A HAB session at the 2014 ICES ASC in La Coruna is planned.
- A scientific symposium on Climate change and Harmful Algal Blooms is planned for 2014 or 2015.

The WGHABD plan to meet in IJmuiden, the Netherlands, 29 April to 2 May 2014

1 Welcome and opening of the Meeting

The 2013 ICES-IOC working group on harmful algal bloom dynamics was held in Belfast, Northern Ireland, UK the 9th to the 12th April hosted by the Agri Food and Biosciences Institute. The meeting was successful with 15 scientists from 12 countries attending. This includes a participant representing the IOC. A representative for Poland was not present but has submitted material for the report. On behalf of the host and the venue local organizer Richard Gowen (AFBI, UK) and the working group Chair Bengt Karlson (SMHI, Sweden) opened the meeting and welcomed the participants to the working group meeting.

In the opening of the meeting it was recognized that this expert group meeting provides an excellent opportunity to meet and collectively address the terms of reference that WGHABD itself has proposed and those that have been passed to us through ICES and IOC. Both ICES and IOC have recognized the importance of the work carried out by our working group. ICES have stated on their website that the activities of this group was fundamental to the work of the Oceanography Committee, and this has been the view of the new Steering Group on Human Interactions on Ecosystems to whom we now report. The work of this ICES-IOC WG is deemed high priority.

WGHABD is an important forum for ICES and IOC to review and discuss HAB events and to provide advice and updates on the state of HABs in the region on an annual basis. It also facilitates interaction between scientists working in diverse areas of HAB science and monitoring and provides a useful forum for interchange of useful terms of reference on various approaches to HAB research. The present working group was established in 1994 following a study group on the Dynamics of Algal Blooms, established two years earlier; however its origins go back further into the 1980s and evolved from other study groups within ICES.

The agenda was agreed and *rapporteurs* for the different agenda items were selected. The participants (Annex 1) then introduced themselves and gave a short review of their scientific activities.

The list of participants is presented in Annex 1. The meeting agenda is presented in Annex 2. An ICES SharePoint site was made available before and during the meeting. Over the course of the 4 day meeting the group made presentations addressing the terms of reference. This report presents a summary of these and subsequent discussions. Along with ICES, the IOC is a joint organizer of WGHABD, and provides valuable interaction regarding data collection and management of HAB data through the development of the HAEDAT database. As co-ordinators of the Intergovernmental Panel on HABs, the participation of IOC in WGHABD forms an important linkage between the working group and this panel. The IOC also takes responsibility to promote the working group among IOC Member Countries outside the ICES area to attend WGHABD and some years is in a position to offer travel support. One aspect of the work of WGHABD is to promote international collaboration regarding harmful algal bloom monitoring and research in the whole IOC-area, i.e. on a global scale. Henrik Enevoldsen, from the IOC HAB centre in Copenhagen, represented the IOC.

2 Adoption of the agenda

The group reviewed the agenda (Annex 2) and this was adopted without any change.

3 Terms of References

From the SCICOM Steering Group on Human Interactions on Ecosystems (SSGHIE) Resolutions 2012.

ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD)

2012/2/SSGHIE08 The ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD), chaired by Bengt Karlson, Sweden, will meet in Belfast, Northern Ireland, UK, 9–12 April 2013 to:

- a) Report on new findings in the area of harmful algal bloom dynamics;
- b) Deliver National Reports on harmful algal events and bloom dynamics for the year 2012;
- c) Develop and set up a new reporting format for producing major reports every three years;
- d) Review progress regarding the entering of data onto the HAEDAT database, and how data can be extracted and utilized;
- e) Undertake time-series analysis of HAB species and associated events;
- f) Review state-of-the-art and ongoing research and managerial activities related to emerging benthic HABs in ICES countries;
- g) Finalize plans for Workshop on Automated Harmful Algal Bloom in situ Observation Systems;
- h) Quantify the scale of the problem associated with Fish Killing Algae in the ICES region.

3.1 ToR a) New findings in the area of harmful algal bloom dynamics

3.1.1 Recent extensive fishkills in Danish land-based aquaculture farms

Report by e-mail from Niels Daugbjerg, University of Copenhagen, Denmark

Two major fish killing events have recently occurred in land-based aquaculture farms in Denmark that used recirculated water in closed systems. The bloom of the first fish killing organisms occurred in December 2011-January 2012 in a fish farm, which produces pike-perch (Zander) (*Sander lucioperca*). At the time of the bloom the salinity was 1-3 psu and the temperature 16-22 °C. In total 20 tonnes of pike-perch died. Using single-cell PCR followed by LSU rDNA sequencing the causative fish killer was identified as *Pseudopfiesteria shumwayae*. During the last 20 years *Pseudopfiesteria* has been connected with fish kill cases in the US and nowhere else. The fish killing event that took place in Denmark thus reveals that blooms of *Pseudopfiesteria* should probably be of worldwide concern and if so economic losses are expected to increase. By treating the water regularly with chloramine-T the *Pseudopfiesteria* blooms can be controlled, as the dinoflagellates seem to form resting cysts and thus disappears from the water column.

The second bloom took place in June-July 2012 in a fish plant that produced rainbow trout (*Oncorhynchus mykiss*). In total 25-30 tonnes of rainbow trout died and some days up to 100 tonnes of fish died every hour. During the bloom the salinity and temperature was 27 psu and 16-17 °C, respectively. Again we used single-cell PCR

and LSU rDNA sequencing to identify the fish killer that morphologically looked somewhat different from the causative dinoflagellate species that caused the death of pike-perch. The LSU rDNA sequence was 100 % identical with *Luciella masanensis*. The fish farm that experienced the death of rainbow trout remains closed. This is the first report of *L. masanensis* being the source of a fish kill anywhere in the world. *Luciella masanensis* is currently only known from the US, Korea and Denmark. Following these incidents of massive fishkills a renewed interest in Pfiesteriaceae is expected.

3.1.2 Occurrence of saxitoxin producing *Alexandrium* sp. in Puck Bay (Southern Baltic Sea)

Hanna Mazur-Marzec and Justyna Kobos, Institute of Oceanography, University of Gdańsk, Poland

In Puck Bay (Southern Baltic Sea), the first blooms of *Alexandrium* were recorded in 2001, and then two years later, in 2003. After 9 years with no records of *Alexandrium*, this dinoflagellates were observed in the same shallow water body again (54° 37' 59" N, 18° 30' 30" E). The bioluminescent bloom was restricted to a small strip of water along the costal part of the bay. The highest abundance of $7.8 - 8.5 \times 10^5$ cells L⁻¹ was recorded from 24 till 30 August 2012 (18.5 µg L⁻¹ bimoass). *Alexandrium* was still observed at the beginning of September, when it constituted approx. 41% of phytoplankton biomass.

Two strains of *Alexandrium* were isolated and the LSU rDNA fragments were sequenced (GenBank accession numbers KF040968 and KF040969). The obtained data suggests that the two strains (CCNP4101 and CCNP4102) from the southern part of the Baltic Sea and the *A. ostenfeldii* strains from the northern part of the sea are genetically closely related.

The presence of three PSP toxins (STX, GTX2/3) was confirmed by liquid chromatography-tandem mass spectrometry (LC-MS/MS) operating in MRM mode. Toxicity of samples was confirmed in ELISA test. The collected samples were toxic towards *Artemia franciscana* (Artoxkit), but no fish kills were observed.

3.1.3 Development of an Unstructured Grid Model for Harmful Algal Bloom Prediction in Scottish Waters.

Dmitry Aleynik, Andrew Dale, and Keith Davidson

Coastal waters are important location for finfish and shellfish aquaculture worldwide. Estuaries and fjordic embayments often provide a sheltered environment for such activity, but frequently experience problems related to the appearance of harmful algal blooms (HABs). Methods that allow early warning of such blooms are urgently required, with mathematical models being a potential approach. However, traditional advection/diffusion models of phytoplankton, including harmful species, are based on a gridded lattice of points that cover the model domain. In areas of complex topography such as the Scottish west coast, such models do not resolve the fjordic sea lochs within which most aquaculture sites are situated. This prevents realistic modelling of the advective transport and growth of HAB species in the region. A novel numerical model based on the Finite Volume Coastal Ocean Model (FVCOM) has therefore been developed as part of the Asimuth EU FP7 project to simulate HAB transport and development in the region. This model has triangular grid elements of variable size, allowing us to simulate cross-shelf transport of cells regions but still resolve sea lochs. Here we present the approach taken to model development and

hindcasts of transport of blooms of the of the fish killing dinoflagellate *Karenia mikimotoi* that has been prevalent in the region since 2006.

3.1.4 Variation in AZA levels in Irish Shellfish in the Netherlands

Marnix Poelman

In October 2012 112 people were reported to suffer from DSP-symptoms in an elderly home in Belgium. The cause of illness (Azaspiracid poisoning) was traced back to mussels, imported from the Netherlands. These mussels were imported from Ireland prior to be relayed at the relaying plots in the Netherlands. The mussels were sourced from Castlemaine Harbour in the South West of Ireland, which was opened for shellfish harvesting. The area was closed or closed pending in the period of September through October. Due to spatial variation in toxin levels at different sites in Castlemaine Harbour shellfish could be harvested and exported to the Netherlands. The shellfish were stored at 5 relaying areas prior to further processing. A part of the shellfish were harvested and sold. Following the reported illness in a Belgium elderly house all relaying areas containing the mussels were closed, and sampled. Only one plot contained only Irish mussels, all other plots contained Irish and Dutch mussels. A sampling campaign of 38 samples indicated a high degree of heterogeneity of AZA in the mussels, ranging from <20 to 1.038 µg AZA1-eq/kg. This was followed by a second action in which individual mussels were analysed. Again this proved a high degree of heterogeneity of 4 positive mussels and 26 negative mussels. The mussel plots remained closed until proven absence of AZA. A sampling protocol was developed for the analysis of the plots, in which 13 samples of 4x1.4 kg were sampled. Mixed samples as well as individual samples were analysed. Again there was a high degree of heterogeneity. This episode indicated that there is a lack of sampling strategies for marine biotoxins. Also the interpretation of the EU legislation of a maximum level of AZA is the 160 µg AZA1-eq/kg is difficult, because sample size is not determined (1 mussel, 1 kg shellfish meat, 100 g shellfish meat (mainly done) or should every single mussel comply. This needs further elaboration.

3.1.5 *Alexandrium ostenfeldii* treated in a polder system in the Netherlands

Marnix Poelman (on behalf of University of Amsterdam).

In august 2012 a dead dog was observed in a creek system in the Netherlands (Ouwkerkse kreek). This creek system is part of the water management system of the polder water, and is used as a discharge system of excessive polder water to the Oosterschelde system. In first instance, it was expected that the mortality of the dog was a result of cyanobacteria in the water. However, it was concluded that an *Alexandrium ostenfeldii* bloom was present.

The water management organisation (Waterschap) required the water body for possible upcoming rainwater discharge, however mussel culture is performed in adjacent waters. Therefore the ministry of Waterworks, and the Food Safety Authority, as well as the mussel industry were keen on negative side effects of *Alexandrium* rich water discharge. It was decided to investigate the potential to eliminate the *Alexandrium ostenfeldii* cells from the creek water prior to discharge to the Oosterschelde.

Several options for treatment were explored; no treatment, ultrasonification treatment, biological (mussel) filtration, and hydrogen peroxide treatment. Biological filtration seemed ineffective based on the present water volumes, ultrasonification was considered to be unachievable under the given circumstances. Hydrogen peroxide treatment was explored further. Lab studies and field trials by Arcadis and Universi-

ty of Amsterdam had proved adequate water treatment of cyanobacteria blooms, indications for effective Alexandrium treatment were present. Following lab studies indicated a rapid decrease of photosynthetic capacity and Alexandrium cells with H₂O₂ levels of minimal 30 mg/L within a couple of hours. Literature studies indicated no adverse effects to aquatic organisms at these concentrations.

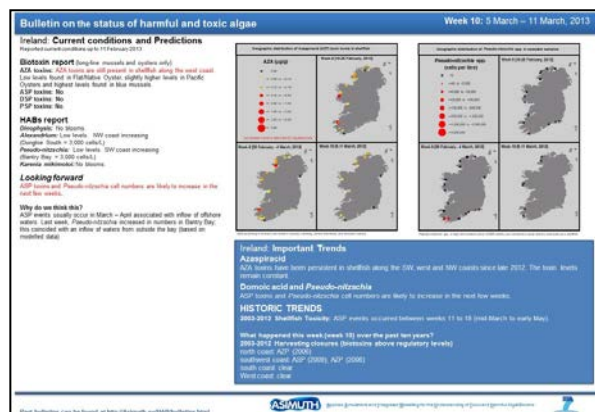
Further details cannot be given due to pending publication. A potential applied method for the treatment of brackish, and marine enclosed systems is successfully tested in this occasion. The system has already been tested for fresh water treatment on cyanobacteria.

3.1.6 ASIMUTH

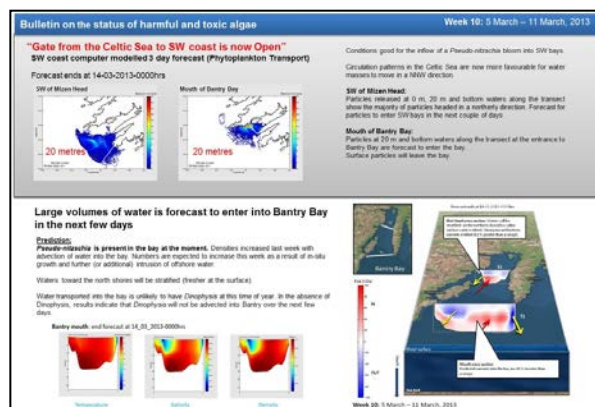
“Applied Simulations and Integrated Modelling for the Understanding of Toxic and Harmful Algal Blooms” (ASIMUTH) is a 3 year EU FP 7 (Space Theme) funded project. The project began 1st December 2010 and will run until 30th November 2013. The aim of ASIMUTH is to develop a short range HAB forecasting system in partner countries (Portugal, Spain, France, Ireland and Scotland). The project seeks to demonstrate that the physical, chemical and biological drivers, available through the GMES Marine core services and ongoing monitoring, can be used in a risk analysis / forecasting product to enable more successful mitigation of potential negative impacts to the aquaculture industry. HAB bulletins are prepared using a combination of model forecasts, satellite imagery, in-situ networks and ground data (e.g. National Monitoring Programmes) along with expertise provided by biology experts. A draft of the HAB bulletin for the Irish aquaculture industry was presented to the WGHABD to get feedback on the content. The three page bulletin contains information on the location, extent and potential for development or movement of harmful algal blooms (Figure 1). The bulletin contains distribution maps that show the intensity and extent of target HAB species and biotoxins in Irish coastal waters over the last three weeks, historic trends for the week in question and some predictions for the next three days (Figure 1a). Modelled numerical predictions (particle tracking and volumetric fluxes) for the SW coast are presented in more detail on page two (Figure 1b). Satellite images are included on the last page of the bulletin and show the spatial extent of Chl *a* and SST. Current cell count data of the high biomass bloom forming dinoflagellate, *Karenia mikimotoi* are superimposed on the chlorophyll map while a separate map shows predicted relative abundance of *Karenia mikimotoi*, derived from the biological model, in Irish territorial waters.

The bulletin is prepared by the biological experts in each country and it is planned to distribute the test HAB alerts to the aquaculture industry online on the ASIMUTH website (www.asimuth.eu) as a PDF document.

a)



b)



c)

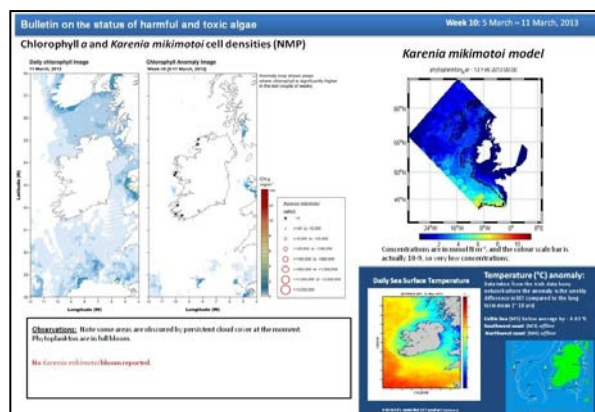


Figure 1. Layout of proposed Irish ASIMUTH bulletin.

a = page 1 and presents current conditions of biotoxins and HABs, trends and predictions.

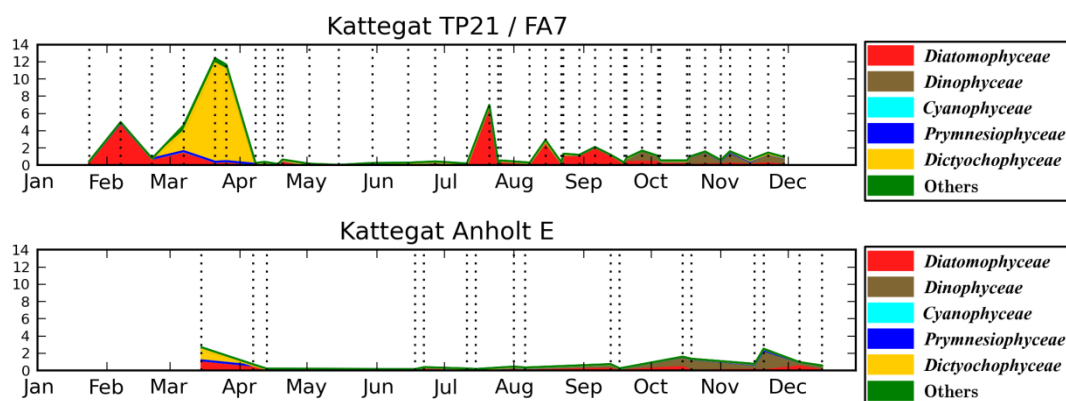
b = page 2 shows details on numerical predictions in relation to physical dynamics.

c = page 3 presents satellite imagery, large spatial scale distribution of Chl *a* and SST, *Karenia mikimotoi* cell densities from the national monitoring programme are overlaid on the maps. Model predictions on the relative abundance of *Karenia mikimotoi* are also presented.

3.1.7 *Pseudochattonella* bloom dynamics studied using FerryBox systems and traditional research vessel sampling

Presented by Bengt Karlson

The fish killing flagellate *Pseudochattonella* spp. have been blooming in the Skagerrak-Kattegat area most years since 1998. In March 2011 an extensive blooms was observed in Danish and Swedish waters. Results from frequent sampling using FerryBox systems on Ships of Opportunity show the value of frequent sampling. In the figure below results from sampling using the FerryBox-systems are presented in the top frame and results from regular sampling from research vessel in the bottom frame. The biovolume of the class Dictyochophyceae is almost entirely made up of *Pseudochattonella* sp.



3.2 ToR b) Deliver National Reports on harmful algal events and bloom dynamics for the year 2012

3.2.1 Canada national report 2012

West Coast:

PSP

Shellfish harvesting closures as a result of unacceptable levels of PSP toxins are recurring, annual events along Canada's west coast. During 2012, the highest PSP shellfish toxicity (5,200 mg STX equiv. 100g) was detected at Effingham Inlet (British Columbia) in blue mussels (*Mytilus edulis*) on July 17.

ASP

Domoic acid above the regulatory level (41.68 µg/g) was measured in razor clams (*Siliqua patula*) in mid September at Graham Island.

DSP

Okadaic acid and DTX-1 (0.2 ug/g) were detected in blue mussels (*M. edulis*) at Effingham Island in mid September resulting in shellfish areas being closed to harvesting.

Salmon mortalities in fish culture operations:

Heterosigma akashiwo was responsible for salmon mortalities in Nanaimo Harbour on July 19 when concentrations were 30 million cells•L⁻¹. *H. akashiwo* was also implicated in salmon mortalities on July 27 when concentrations reached 3 million cells•L⁻¹ in Clayoquot Sound and on Aug. 14 in Quatsino Sound with 400,000 cells•L⁻¹. On Aug. 25 and Sept. 11, fish farms in Mathieson Channel and Nootka Sound were affected when *Chatonella* cf. *marina* populations reached 100,000 and 70,000 cells•L⁻¹, respectively. *Chaetoceros convolutus* caused kills in the Sechelt Inlet from Apr 26-June 21 with maximum detected cell concentrations of 65,000 cells•L⁻¹ detected. In addition, *Pseudopedinella pyriformis* was implicated (for the first time in British Columbia) when salmon mortalities occurred in late May when 3 million cells•L⁻¹ were observed.

East Coast**PSP**

2012 would be considered to be a “lower than normal” year with the regular periodic closures of shellfish harvesting areas due to unsafe levels of PSP toxins on the east coast. Highest concentrations of Alexandrium fundyense observed in the Bay of Fundy, southwest New Brunswick, were 15,780 cells•L⁻¹ and highest shellfish toxicity detected in Mya arenaria was 715 µg 100 g STX equiv.

The Atlantic coast of Nova Scotia toxicity values did not exceed 80 µg 100g STX equiv. and no shellfish beds were closed to harvesting.

No report was received from the St Lawrence Estuary but shellfish harvesting areas were above threshold levels and closed to harvesting for a portion of the spring/summer.

Newfoundland and the Gulf of St Lawrence did not experience any shellfish closures in 2012.

DSP

No shellfish harvesting areas were closed due to unacceptable levels of DSP toxins in shellfish in 2012.

ASP

No shellfish harvesting areas were closed due to unacceptable levels of DA in shellfish in 2012.

Salmon Mortalities

There were no salmon mortalities at aquaculture operations on the east coast associated with HABs in 2012.

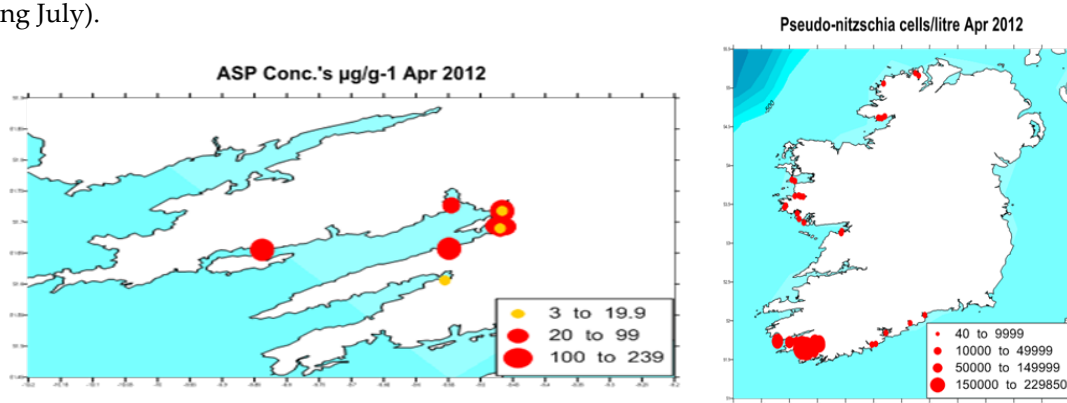
3.2.2 Ireland national report 2012

2012 was a year which was dominated by two major HAB events in Irish waters. The Marine Institute in conjunction with the Irish Sea Fisheries Protection Authority and the Food Safety Authority of Ireland conducted a monitoring programme in shellfish growing areas to comply with EU legislation for placing molluscan shellfish on the

market. In the course of the year shellfish toxins including Amnesic Shellfish Poison (ASP), Diarrhetic Shellfish Poison (DSP), Azaspiracid Shellfish Poison (AZP) and Paralytic Shellfish Poison (PSP) were detected. Of these, the most serious was due to Azaspiracid (AZA) levels which were extremely high at the end of summer in a number of locations and resulted in a long closure of these shellfisheries. The other major HAB event of 2013 was an extensive bloom of *Karenia mikimotoi* in the west and Northwest of the country which resulted in large-scale mortalities of marine pelagic, demersal and benthic organisms. Shellfish farms in particular *Crassostrea gigas* oyster farms suffered stock mortalities, in some cases up to 80% of market sized product which were growing at the lower intertidal zone in trestle and bag culture.

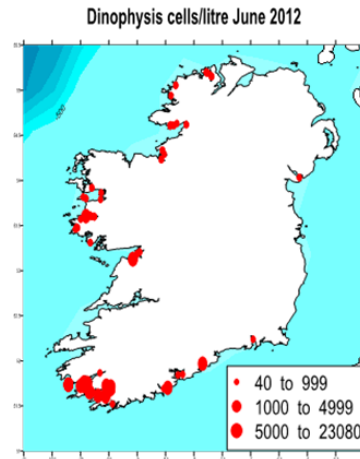
ASP 2012 Summary

Cell counts up to 230000 *Pseudonitzschia* were associated with an ASP event max 240ug/g observed in the SouthWest during Apr / May. Following this no further quantifiable domoic acid concentrations were observed in (non-pectinidae) samples submitted from Jun –Oct (except one low level observed in a sample of *L. lutraria* during July).



DSP Summary

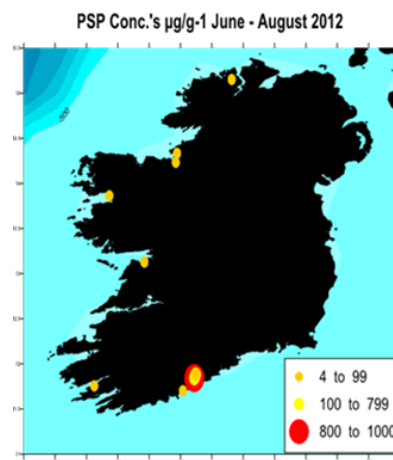
DSP conc.'s above the regulatory level were observed from Jun – Aug mainly in samples of *M. edulis* from the SW and West coasts. These levels were observed to decrease in the majority of these sites during August under the regulatory level, and by the end of September all sites were below the regulatory level. The highest no.'s of *Dinophysis spp.* cells were observed during June in these affected sites. From October onwards, concentrations had decreased further and by January 2013, levels were typically <LOD / <LOQ. Up to the end of December 2012, and during Jan 2013, all PTX and YTX results were <LOD / <LOQ



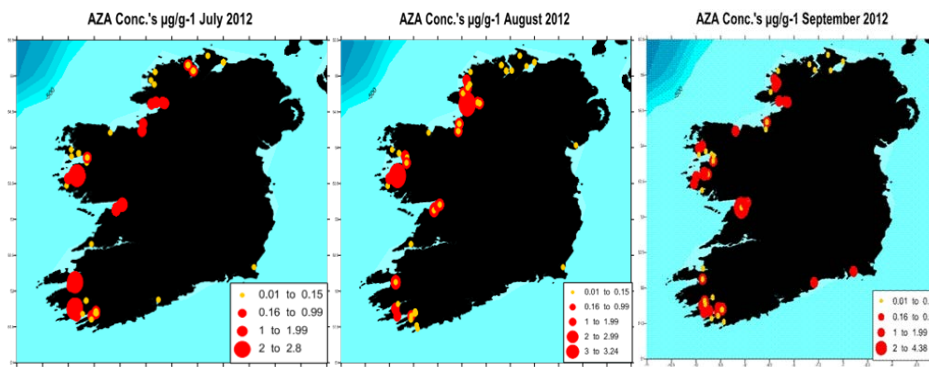
PSP Summary

Conc.'s of STXdiHCl equiv.'s were observed above the regulatory level (up to 981 µg/kg) in samples of *M.edulis* submitted from Cork Harbour during the first week of June, all other quantifiable conc.'s observed were < regulatory levels. Highest PSP conc.'s observed in samples of *C.gigas* from Cork harbour was 114 µg/kg, also during the first week of June.

Minor quantifiable concentrations (typically < 10 µg/kg) were observed during Jun – Aug in samples of *M.edulis* submitted from Mulroy, Ballysadare, Drumcliff, Clew Bay North, Ballyvaughan, Ardgroom and in samples of *C.gigas* from Oysterhaven. The presence of *Alexandrium spp.* were observed in relatively large numbers during June and July, predominantly in the West, reducing to significantly smaller numbers in these localities during August. High no.'s were observed in August in the NorthWest and in one site in the SouthEast. In all cases very low levels of associated toxicity conc.'s were observed. From September to December, *Alexandrium spp.* cell no.'s further decreased, where all shellfish samples analysed were <LOD or Not detected for PSP toxins



AZP 2012 Summary



AZA conc.'s above the regulatory level were first observed in samples of *M.edulis* submitted from a number of sites in the SouthWest, NorthWest, West and also in samples of *C.gigas* submitted from the West in June. During July - August these conc.'s increased particularly in sites in the West and NorthWest and was also observed above the regulatory levels in a number of other sites (in samples of *M.edulis*, *T.philipinarium*, *C. edule*, *S. solida* and *O.edulis*, *C.gigas*). A small number of these affected sites in the West and NorthWest had decreased below the regulatory during September - October, with remaining sites in these areas increased AZA concentrations including some particularly high levels (up to 4.4 ug/g) that broke previous record concentrations in Shellfish.

AZA conc.'s were observed to decrease below the regulatory levels in *M.edulis* samples from Bantry from August onwards, however an increase in AZA's was detected in a no. of sites in the southwest during middle September, some persisting right into the first quarter of 2013.

For the first time, significant quantifiable AZA conc.'s were observed in 2 samples of periwinkle *Littorina littorea*, submitted from Achill North (0.09 AZA eq.'s) and Achill South (0.12 AZA eq.'s) during October.

Karenia Bloom 2012

An extensive bloom of *Karenia mikimotoi* was detected along the Northwest from Mayo to Donegal and at lower concentrations down along the rest of the West coast during July and August with considerable impact on coastal marine life in several areas. The bloom was dense with reports of discoloured red or brown water in some areas and several areas also reported dead marine life washing up on the shoreline. Cell counts up to 1.5 Million cells were observed.

In Inner Donegal Bay, large numbers of dead fish including turbot, flounder, scorpion fish and shore rockling. Other dead species were worm pipefish, lesser weavers, grey gurnard, shanny, sand goby, pollock, sole, plaice, flounder and dabs have been washing up on Rossnowlagh and Murvagh beaches and for a short period red flags were raised by local authorities to forbid bathing in affected beaches due the large numbers of dead fish.



Dead fish on Rossnowlagh Beach Photo Credit: P. Ennis

Local sea anglers reported low fish catches along the Donegal coast, and in some areas a complete absence of any fish. Lobster and Prawn fishers have also reported very poor catches in the Donegal area. Satellite imagery suggested that the bloom originates offshore as a natural part of its summer life cycle, and the impacts of marine mortalities were due to concentration effects when the bloom was transported against the coast with tidal and coastal currents.

A similar event was observed in 2005 which was followed by a bloom that affected the Scottish coast the following year. It remains to be seen if this bloom to the west of Ireland is followed by a bloom in Scotland in 2013 which may suggest an inter-regional connectivity via coastal currents..

3.2.3 Germany national report 2012

HAB Species Observations in the Wadden Sea

Alexandrium tamarense

A. ostentfeldii

Dinophysis acuminata

D. acuta

D. norvegica

Heterocapsa spp. (possibly included *Azadinium* spp.)

Noctiluca miliaris

- red tide end of June 2012

Pseudo-nitzschia delicatissima -complex

Pseudo-nitzschia pungens -complex

Phaeocystis globosa - bloom end of May until beginning of June

Fibrocapsa japonica

Shellfish toxins monitoring from German coast

ASP-, DSP-, PSP-type

231 samples from the North Sea (192 mussels, 23 oysters) and the western Baltic Sea (16 mussels)

In September 2012, 2 mussel samples near Sylt island contained okadaic acid and esters (max. 65 µg/kg). In the other samples no appreciable amounts of toxins were found

Cyanobacteria

During an earlier cruise with RV “Meteor” during the first three weeks of July 2012, the expected cyanobacteria bloom development in the Eastern Gotland Sea and the northern Baltic Proper was not detected. Also during the present cruise, only few cyanobacteria aggregates were visible in the water and no bloom appeared in the investigated areas of the Baltic Proper (except for Arkona Sea and Pomeranian Bight).

Toxins in fish imported to Germany

Six persons in the Bremerhaven area were ill due to ciguatoxins. They had eaten red snapper imported from the Indian Ocean. Ciguatoxins are described in the section on benthic HAB's.

3.2.4 Netherlands national report 2012

During 2012 the shellfish production areas; North Sea, Lake Grevelingen, Wadden Sea, Oosterschelde and Veerse Meer were monitored for the presence of toxic phytoplankton. This program was based on the National Shellfish Food Safety Program on a monthly basis from November until April and a weekly basis from May until October.

In the whole period of 2012 no toxins were found in the routing Shellfish monitoring program. There have been two occasions of toxicity besides the regular monitoring. One was found in shellfish traded from Ireland, and relayed in the Oosterschelde. The second was a bloom of *Alexandrium ostenfeldii* in a creek/polder system. Both events are separately described in the new findings.

Dinophysis acuminata was detected in Lake Grevelingen during the last week of August till mid-October. The threshold (100 cells/litre) was exceeded during August and September, with maximum densities in mid-September peaking at 1.300 cells/litre, whereas 200-300 cells per litre was common in that period.

The North Sea is monitored from February through October. Only one occasion of 19 cells of *D. acuminata* was found. In the Oosterschelde *D. acuminata* was found in background (<20 cells/L) concentrations in September. In Lake Veere 3 weeks of prevalence of *D. acuminata* is recorded. In the first week cell densities were just above the threshold value (105 cells/L), where the second week it peaked to 1.200 cells/L, followed by a decrease to 42 cells per litre. Then *D. acuminata* temporarily disappeared, and reappeared in September and October, peaking in the third week at 100 cells /l. *D. acuminata* is found in the Waddensea at three occasions at background concentrations below 35 cells/l.

Pseudo-nitzschia sp. is found in many samples (figure NL). No thresholds are exceeded in 2012. The threshold is 500.000 cells/L as an Early Warning indicator. The highest values are found in Lake Grevelingen at 185.000 and 105.000 cells/L.

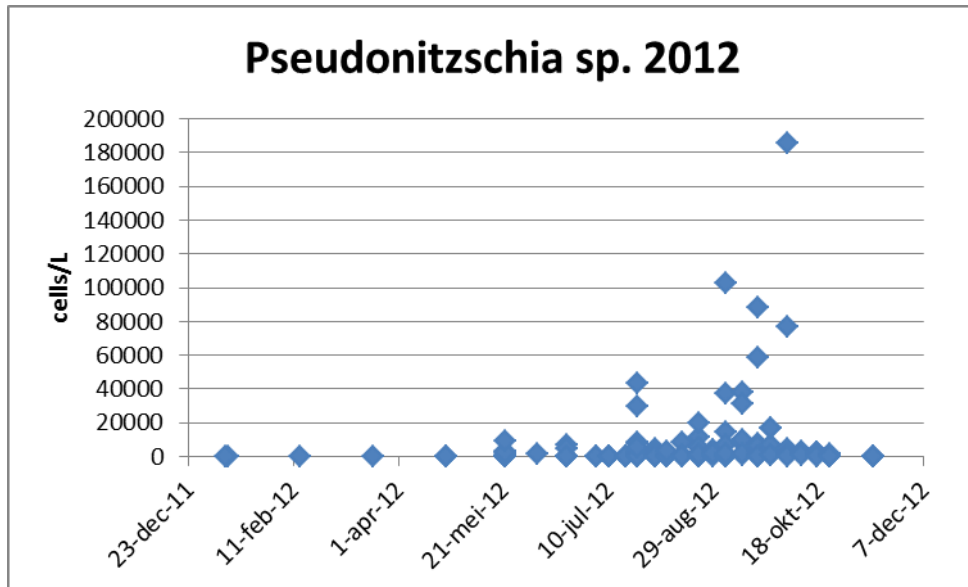


Figure NL. *Pseudo-nitzschia* sp. results of the national shellfish monitoring program 2012.

3.2.5 Norway national report 2012

Information in this report is based on weekly monitoring of toxic algae and algal toxins in mussels at 38 stations from the Swedish to the Russian border.

DSP

DSP were a minor problem this year. In the eastern part of Norway DSP above the regulatory level (160 µg/kg) was recorded in short periods at the beginning of the year and at summertime. At the west coast DSP was recorded sporadic mostly at summertime, while in the central part of Norway DSP was found at a couple of stations in inner parts of fjords in autumn and early winter. In northern Norway DSP was not recorded at all.

PSP

In 2012 PSP-toxins was the main problem caused by *Alexandrium tamarense*. However, along the Skagerrak coast PSP was absent. At the west coast PSP was above the regulatory level (400 µg/l) mainly from April to June, while in the central part there were closures only a month in early summer. In the north the PSP-problem was most serious and at some stations lasted throughout most of the growing season.

ASP

Pseudo-nitzschia seriata caused accumulation of ASP in blue mussels (*Mytilus edulis*) and edible crab (*Cancer pagurus*), but was not recorded above the regulatory level (20,000 µg/kg) in mussels in 2012. However, at one location in the central part of Norway crabs containing 35,000 µg ASP/kg was recorded.

Yessotoxins

Yessotoxins (YTX) were detected above the regulatory level (1,000 µg/kg) for a period of 12 weeks during summer at one monitoring station at the west coast of Norway. The only known YTX-producer found at this station in this period was *Protoceratium reticulatum*, but the concentrations were very low. At all the other stations YTX was no problem.

Other toxins

No other toxins were recorded above regulatory levels.

At the turn of August and September (24 Aug – 4 Sept), *Alexandrium* together with water bioluminescence were recorded in Puck Bay off Reda. The maximal cell number of this dinoflagellate was 8.5×10^5 cell dm^{-3} (30 August). The LC-MS/MS analyses revealed the presence of three PSP toxins: STX, GTX2/3.

3.2.7 Portugal national report 2012

The Portuguese Monitoring of HABs and phytotoxins, conducted by IPMA (Portuguese Institute for the Sea and Atmosphere, www.ipma.pt/), covers the whole coast of Portugal except Madeira and Açores archipelagos where there is no official monitoring. The year of 2012 was considered atypical concerning the location and timing of the blooms: (i) along the NW coast, blooms mainly occurred in the first half of the year; (ii) on the S coast, blooms were quite continuous from May until mid-November and caused by a succession of different species in space and time

			Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec							
	Coast of Portugal	Week nº	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	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
2012	NW	ASP																																																				
		PSP																																																				
		DSP																																																				
	SW	ASP																																																				
		PSP																																																				
		DSP																																																				
	S	ASP																																																				
		PSP																																																				
		DSP																																																				

PSP

In opposition to the previous years, when PSP outbreaks mainly occurred on the NW coast, in 2012 they were observed on the S coast.

NW coast:

A very short outbreak of *Gymnodinium catenatum* was detected (3×10^3 cells L^{-1}) at the entrance of Ria de Aveiro on 3 September. No shellfish harvesting areas were closed since levels of PSP toxins were not above the threshold levels.

S coast :

Shellfish closures from early August until the end of October were due to high concentrations of *Gymnodinium catenatum*. Several maxima of this species were observed along Faro-Olhão coast (151×10^3 cells L^{-1} on 20 July, 12×10^3 cells L^{-1} on 15 August). The highest levels of PSP toxins (5790 and 8140 μg STX Kg^{-1}) were detected in *Donax* spp. about 3 weeks later.

DSP

DSP outbreaks were observed all over the coast, as in 2011. However, in the NW coast they occurred much earlier in the year. Instead, on the south coast they were observed later, mainly during summer and autumn.

NW coast:

There were two closure periods of shellfish harvesting due to DSP toxins. The first, from 13 February to 9 May, was related to *Dinophysis acuminata* that attained 6×10^3 cells L^{-1} on 10 April. The second event occurred from 11 June to 20 July with a maximum of *D. acuminata* of 880 cells L^{-1} on 31 May. Toxicity values reached maxima of 5420 and 3150 μg OA equiv. Kg^{-1} in *Mytilus galloprovincialis* inside Ria de Aveiro and off F.Foz respectively, during the first closure at the beginning of April.

Center/SW Coast

From 8 August to 16 November shellfish harvesting was closed due to the development of *Dinophysis acuta* populations that reached 6×10^3 cells L^{-1} in Lisbon bay. A maximum of 2190 μg OA equiv. Kg^{-1} in *Donax* spp. was observed on 31 August.

In this region, there are semi-enclosed coastal Lagoons that presented specific situations as following: Óbidos lagoon was closed from 13 to 29 February and from 5 to 25 June due to *D. acuminata* proliferations (max 2.7×10^3 cells L^{-1}) associated with values of 462 μg OA equiv. Kg^{-1} in *M. galloprovincialis*; Albufeira lagoon was closed from 10 August to 28 September due to *D. acuta* (max.: 2.4×10^3 cells L^{-1}) responsible for a highest concentration of 724 μg OA equiv. Kg^{-1} , detected in mussels on 19 September .

S coast:

Concentrations of DSP toxins were above the regulatory level (max 532 μg OA equiv. Kg^{-1} in *M. galloprovincialis*) between 25 May and 9 July due to *D. acuminata* (max. 2.2×10^3 cells L^{-1} on 16 May) and between 8 August and 16 November (max: 378 μg OA equiv. Kg^{-1} in *Donax* on 3 October) due to *D. acuta* and *D. acuminata* that reached, respectively, 1.3×10^3 cells L^{-1} on 16 August and 2.8×10^3 cells L^{-1} on 10 September.

ASP

Compared with the previous years, characterized by single 1-2weeks events of ASP, 2012 had a significant bloom that lasted more than one month. All the toxic events were related to the presence of *Pseudo-nitzschia australis*.

On the NW coast, a very short one week ASP event was observed due to a peak of *Pseudo-nitzschia* spp. (196×10^3 cells L^{-1}). On the S coast, a longer period of shellfish harvesting closures (4 June until 9 July) occurred, with *Pseudo-nitzschia* spp. reaching 1.5×10^6 cells L^{-1} on 19 June. This closure coincided with a maximum of 120 mg DA Kg^{-1} observed in mussels .

YTX producing species

Since the last major bloom in 2005 in Lisbon bay that no high concentrations of *Lingulodinium polyedra* were observed as in 2012 along the eastern area of the S coast of Portugal. The blooms were detected on 18 July in the mouth of Guadiana river (S Portuguese/Spanish boarder) and lasted until 23 October reaching 11×10^6 cells L^{-1} on 20 July at Olhão coast.

Benthic HABs

No blooms of *Ostreopsis cf. ovata* were detected in 2012 after the 2011 first reported outbreak observed at Praia D. Ana at the south coast of Portugal. The 2011 bloom reached densities as high as high as 5420 cells L^{-1} in water samples, although concentrations remained lower (40 to 320 cells L^{-1}) in adjacent areas. In a coastal management context, local authorities closed several beaches for bathing for 5 days once informed about the bloom occurrence and model predictions for its transport (David et al., 2012, HAN45). Only one case of respiratory and skin irritation was reported.

3.2.8 Spain national report 2012

The year 2012 was characterized by very intense DSP outbreaks in shellfish harvesting areas in the whole country, both in the Atlantic and Mediterranean sites; the absence of *Gymnodinium catenatum* blooms in Galicia (NW Spain) but its occurrence in both, the Atlantic (Huelva) and the Mediterranean coasts of Andalucía; a new outbreak of respiratory and skin irritation associated with an *Ostreopsis* bloom at the hot spot of these events in Llanerones (north of Barcelona); fish kills (*Karlodinium* spp.) in the Ebro River Delta and moderate ASP outbreaks (*Pseudo-nitzschia* cf. *australis*) in Galicia and in eastern and western Andalucía.

Andalucia

Atlantic coast

DSP

First *Dinophysis acuminata* event in mid-May in Huelva with closures of some shellfish production areas; more intense to the west (Portuguese Algarve border) (max. $5.08 \cdot 10^3$ cell·L⁻¹). Growth of *D. acuta* (max. $2 \cdot 10^3$ cell·L⁻¹) in mid-July combined with several peaks of *D. acuminata* in August and early September led to an almost full closure of all production areas.

PSP

Gymnodinium catenatum exhibited a bimodal summer growth season in Huelva. First peak in mid-July (max. $25 \cdot 10^3$ cell·L⁻¹) and a second in August (max. $19.4 \cdot 10^3$ cell·L⁻¹). Harvesting closures of several species.

ASP

Blooms of *Pseudo-nitzschia australis* in Huelva during June (max. $2.4 \cdot 10^5$ cell·L⁻¹) caused closures in several production areas.

Mediterranean coast

DSP

D. acuminata densities increased during June-July but with more moderate values than in the Atlantic sites. Maximal densities of 720 and 1440 cell·L⁻¹ in Cádiz and Málaga respectively. Toxins above regulatory limits in several shellfish species in both provinces.

PSP

A bloom of *G. catenatum* in August, with cell maxima of $19.4 \cdot 10^3$ cell·L⁻¹ and $19.8 \cdot 10^3$ cell·L⁻¹ in Cádiz and Málaga respectively, caused harvesting closures of several species in the two provinces.

ASP

Maximal densities of *Pseudo-nitzschia australis* in Cádiz ($2.4 \cdot 10^5$ cell·L⁻¹) and Málaga ($4.4 \cdot 10^5$ cell·L⁻¹) were observed from late April to early May. Harvesting closures in both provinces.

The monitoring of toxin producing phytoplankton of classified production areas in Andalucía is conducted by the Laboratorio de Control de Calidad de Recursos Pesqueros (LCCRRPP) <https://ws128.juntadeandalucia.es/agriculturaypesca/moluweb/>

Basque Country

In 2012, analyses of DSP, ASP and PSP toxins were conducted in wild mussels and oysters collected, once a week, from October to December in the Butrón estuary and from October to March in the Oka estuary. This monitoring strategy coincides with the sites and seasons allowed by the local authorities for shellfish harvesting activities. Biotoxins of the three groups were below detection levels in all samples.

In addition, phytoplankton composition and abundance were analysed at 3 offshore, 16 coastal and 32 estuarine stations as part of the Littoral Water Quality Monitoring and Control Network conducted by the Basque Water Agency (URA). Samples for Utermöhl counts were collected during four campaigns (spring, summer, autumn and winter), in surface waters (0-1 m). Several potentially harmful phytoplankton taxa were observed in most of the marine and estuarine stations.

Regarding the offshore zone, *Karenia* cf. *mikimotoi* reached $1024 \text{ cell} \cdot \text{L}^{-1}$ in summer. Other potentially toxic dinoflagellates such as *Dinophysis acuminata*, *D. tripos* and *Phalacroma rotundatum* were observed, but always at densities below $300 \text{ cell} \cdot \text{L}^{-1}$. In spring, the potentially toxic diatoms *Pseudo-nitzschia* spp. reached $6372 \text{ cell} \cdot \text{L}^{-1}$. Also, phytoplankton taxa that are considered harmful for the ecosystems were detected. Among these, the highest abundances corresponded to the dinoflagellates *Gyrodinium* spp. with $4 \cdot 10^4 \text{ cell} \cdot \text{L}^{-1}$ and the *Chrysochromulina/Imantonia/Phaeocystis* (prymnesiophyceans) with $1 \cdot 10^5 \text{ cell} \cdot \text{L}^{-1}$.

In the coastal zone, among the taxa that are potentially toxic for humans, the diatoms *Pseudo-nitzschia* spp. showed the highest abundance (up to $1.11 \cdot 10^6 \text{ cell} \cdot \text{L}^{-1}$) in spring. Within the group of dinoflagellates, *Alexandrium* spp. reached $2,124 \text{ cell} \cdot \text{L}^{-1}$, *Karenia* cf. *mikimotoi* and *D. acuminata* were up to $425 \text{ cell} \cdot \text{L}^{-1}$, while *D. tripos*, *D. cf. ovum* and *Phalacroma rotundatum* were up to $40 \text{ cell} \cdot \text{L}^{-1}$. Among the taxa that are potentially harmful for the ecosystems it can be mentioned *Gyrodinium* spp. with $1 \cdot 10^5 \text{ cell} \cdot \text{L}^{-1}$ and *Chrysochromulina/Imantonia/Phaeocystis* with $5 \cdot 10^5 \text{ cell} \cdot \text{L}^{-1}$.

With regard to the estuaries, *Pseudo-nitzschia* spp. were found in the outer zones of almost all systems, all year round, but especially in spring. In the estuaries of the Nervión and the Oka rivers these diatoms reached very high abundances (1.04 and $1.51 \cdot 10^6 \text{ cell} \cdot \text{L}^{-1}$ respectively). Potentially toxic dinoflagellates were also observed, although in fewer samples and with lesser abundances: cf. *Pfiesteria* showed its maximum in summer ($5.7 \cdot 10^5 \text{ cell} \cdot \text{L}^{-1}$), and *D. acuminata* in spring ($2,124 \text{ cell} \cdot \text{L}^{-1}$). In addition, blooms that could cause harmful effects in the ecosystems were observed in the upper reaches of some estuaries in summer. It must be mentioned the dinoflagellate *Kryptoperidinium foliaceum* with $2.41 \cdot 10^6 \text{ cell} \cdot \text{L}^{-1}$ in the Artibai, and the cryptophyte *Urgorri complanatus* with $1.15 \cdot 10^6 \text{ cell} \cdot \text{L}^{-1}$ in the Lea. Finally, among the raphidophyceans that are potentially harmful for fish, *Heterosigma akashiwo* reached a maximum of $5.5 \cdot 10^5 \text{ cell} \cdot \text{L}^{-1}$ in the Bidasoa estuary during summer.

Information provided by AZTI-Tecnalia (<http://www.azti.es/>) in cooperation with the University of the Basque Country (UPV).

Canary Islands

Ciguatera

On 27th April 2012, the Food Safety Department of the Canary Islands Government (Dirección General de Salud Pública) reported sixteen cases of ciguatera fish poisoning in Lanzarote. The first outbreak was between 28th January and 28th February and ten persons were affected by consumption of medregal (*Seriola rivoliana*) served in

two local restaurants. The second outbreak was in April and affected six persons after eating the same fish at the same local restaurant. This information was reported by the local press in April and generated public alarm. After these outbreaks and subsequent public concern, the local authorities prohibited the consumption of *Seriola rivoliana* specimens larger than 55 kg, and created awareness within the population about the need to get large fish analysed by the Food Safety Department to prevent new intoxications.

High biomass blooms. In March 2012, fishers from the southern part of Fuerteventura island alerted the Spanish Bank of Algae (BEA) about an intense orange discolouration on the shores of Jandia, an important tourist resort, which generated social alarm. Experts from BEA determined the patches were caused by a *Noctiluca* blooms and other associated dinoflagellate species and communicated it to the local authorities.

There is no official monitoring for harmful algae and phycotoxins in the Canary Islands. The above observations were reported by Carolina Pérez from the Banco Español de Algas (BEA) <http://bea.marinebiotechnology.org/en>

Catalonia

Potentially toxic phytoplankton and phycotoxins monitoring (IRTA)

DSP and Yessotoxins (YTXs)

DSP producing species have been present in different locations throughout the coast of Catalonia in different times of the year leading to harvesting closures in Alfacs and Fangar bays, north of Vilanova and Roses. *Dinophysis sacculus* was over alert level during 3 months in Alfacs Bay (max. $2 \cdot 10^3$ cells \cdot L⁻¹), causing a long (January to mid-April) DSP closure, and in November-December in Fangar Bay. YTXs were detected in Alfacs Bay in July-August at concentrations below regulatory levels in shellfish associated with low densities of *Gonyaulax spinifera* and *Protoceratium reticulatum*, but in September, yessotoxins concentration in mussels ($1340 \mu\text{g eq. YTX} \cdot \text{kg}^{-1}$) exceeded the regulatory level according to LC-MS/MS analyses, although MBA results (applying the annex of SOP5 for lipophilic toxins) were negative for the same samples. The maximal of *P. reticulatum* ($1.4 \cdot 10^3$ cells \cdot L⁻¹) was in September. At the same time and after 3 weeks of seawater temperatures over 28°C, all mussels from Alfacs Bay died and closures enforcement was not necessary. YTXs concentration in other shellfish species kept below regulatory levels.

PSP

Alexandrium minutum reached $5 \cdot 10^3$ cells \cdot L⁻¹ in Alfacs Bay although PSP toxins were always below regulatory levels. Abundances of *A. minutum* were also over alert levels in other areas along the Catalan coast in March.

ASP

Pseudo-nitzschia spp. reached high abundances in the south ($6 \cdot 10^6$ cells L⁻¹). Domoic acid under regulatory levels was found in shellfish from the northern and middle areas of the Catalan coast in February and March.

Fish Killers

Karlodinium spp. reached $1.4 \cdot 10^6$ cells \cdot L⁻¹ in April, fish kills occurred associated to this event and the bloom lasted from February to June in Alfacs Bay.

The monitoring of toxin producing phytoplankton of classified production areas is conducted by IRTA (Research and Technology Institute for Agriculture and Food). <http://www.irta.cat/ca-ES/RIT/A/A3/Pagines/A31.aspx>

Environmental Quality Monitoring (ICM-CSIC)

Benthic HABs

Ostreopsis spp. bloomed at Sant Andreu de Llavaneres (Catalan coast) during summer (June to October), reaching very high concentrations in water (up to $2 \cdot 10^5$ cell \cdot L⁻¹) and macroalgae (up to $2 \cdot 10^6$ cell \cdot g⁻¹ w.w. macroalga) in late July-early August. In late July, coinciding with the highest concentrations of *Ostreopsis* spp. in seawater, there was an outbreak of respiratory disease in the area that affected 13 people who were participating in a fishing cane contest. All contestants, aged between 20 and 50 years, showed mild symptoms of impairment and throat irritation: sore throat, dry cough, headache, sneezing, etc. The event was reported in the press media (El País, La Vanguardia, El Periódico, among others). As part of the cooperation between the EBITOX research project and the monitoring programme, ICM-CSIC scientists involved in the project contacted the Catalan Water Agency (ACA) whenever *Ostreopsis* concentrations reached $\sim 10^5$ cells \cdot g⁻¹ w.w. macroalgae or $\sim 10^4$ cells \cdot L⁻¹ in seawater at Llavaneres. This threshold is based on our observations that at those concentrations health problems in humans may occur if the wind is blowing landwards (Vila et al. 2012).

High biomass toxigenic HABs

Local blooms of *Alexandrium minutum* were detected in several ports of Catalonia (Arenys de Mar, Port Olímpic and Cambrils). The maximum concentration was detected in Arenys de Mar ($1.7 \cdot 10^6$ cell \cdot L⁻¹). Significant concentrations of *Dinophysis sacculus* (2500-3000 cell \cdot L⁻¹) were also detected at two ports, Arenys de Mar and Vilanova i la Geltrú. An *Alexandrium catenella* bloom (up to $1.4 \cdot 10^5$ cell \cdot L⁻¹) was recorded in July in Port de Tarragona. Finally, high concentrations ($\geq 5 \cdot 10^5$ cell \cdot L⁻¹) of *Pseudo-nitzschia* spp have been detected in Port Olímpic and Port of Tarragona, and on certain beaches in the north and center of the country (Estartit and Castelldefels). Also we want to highlight the proliferation of a raphidophycean microalgae (*Fibrocapsa japonica*) in July in Castelldefels and Viladecans (max: $3.8 \cdot 10^6$ cell \cdot L⁻¹).

Monitoring of potentially harmful microalgae for the Catalan Water Agency (ACA) is carried out by the “Grupo de Investigación en Procesos Biológicos Litorales” at the Instituto de Ciencias del Mar (CSIC, Barcelona) <http://pbl.cmima.csic.es/es/content/portada>

Galicia

PSP

Gymnodinium catenatum did not bloom in 2011. Cells were no longer present at the beginning of the year, but PSP toxins from the previous autumn outbreak kept above regulatory levels until mid-January.

A. minutum (max. 8162 cell \cdot L⁻¹ in mid-May) led to harvesting closures in Baiona in April. Nevertheless, infauna shellfish quarantine lasted almost until the end of the year, with maximal levels of 2960 μ g equiv STX di.HCl/Kg in mid-April. In the northern Ría de Ares-Betanzos, *A. minutum* bloomed from late April until the end of May

(max. 25970 cell·L⁻¹ in mid-May at St. L2). A maximum of 1220 µg equiv STX di.HCl·Kg⁻¹ in mussels from the polygon Sada A was observed in mid May. Short-term closures affected harvesting of infaunal species in Ares and Camariñas.

DSP

D. acuminata first bloom of the year was unusually early and intense, causing extensive raft-mussel harvesting closures in all the Rías Baixas (Muros, Arousa, Pontevedra and Vigo) that lasted from late March until mid-August with the exception of the innermost parts of Arousa and Vigo. Record cell densities for the season were found in Ria de Pontevedra (43·10³ cell·L⁻¹ in integrated 10-15m hose-samples in Bueu; 54·10³ cell·L⁻¹ and 32·10³ cell·L⁻¹ in 0-15m samples in the innermost stations P0 and P3). Harvesting closures were extended to infaunal shellfish from both the northern rías and open coastal waters, i.e.. Costa da Morte, Rías de Ortigueira, Cedeira, Ferrol, Ares-Betanzos and A Coruña) and the southern rías (Pontevedra, Muros-Noia).

Associated with a moderate autumn peak (max. 760 cell·L⁻¹ of *D. acuminata* and 200 cell·L⁻¹ of *D. fortii* at st. 7 in Pontevedra) in early October, new shellfish closures were enforced in several mussel-raft areas in Pontevedra (the whole Ría), Vigo, Muros-Noia and Ares-Betanzos. Short lasting closures also affected infaunal species in the north (Baldaio and rías of Ortigueira, Cedeira, Ferrol and y O Burgo).

ASP

Pseudo-nitzschia cf. australis bloomed in Baiona Estuary in early February (max. 1.5·10⁵ cell·L⁻¹ at st. B1) and 2 weeks later in Ría de Pontevedra (max. 2.2·10⁵ cell·L⁻¹ at P8, 59.1 mg DA·Kg⁻¹ in Bueu) leading to harvesting closures in all the production areas there. This outbreak affected also infaunal shellfish from Ría de Pontevedra and parts of Ría de Vigo (max. 63.9 DA·Kg⁻¹ in clams, zone III of Pontevedra). Another light 2-weeks ASP outbreak affected mussel harvesting in the northern Ría de Ares-Betanzos in April (max. 2.05 cell·L⁻¹ st. L1; 40.4 mg DA·Kg⁻¹ in Sada A) and led to brief closures of infaunal species in Ferrol, Ares, Corme y Camariñas. In early October a new bloom of *P. cf. australis* led to short-term mussel harvesting closures in the north (Ría de Ares-Betanzos) and part of the Rías Baixas (Muros-Noia) (max. 1.8-1.9·10⁵ cell·L⁻¹ in Muros, st. M1 and M3, and 37.0 mg DA·Kg⁻¹ in Noia A). Infaunal shellfish harvesting was enforced in the north (Cedeira, O Burgo-Coruña) and Zone-II in Pontevedra, with max. levels of 82.8 mg DA·Kg⁻¹ in cockles from Pasaxe.

Scallops (*Pecten maximus*) contained domoic acid above regulatory levels all year-round. Restricted harvesting with evisceration (according to Directive 2002/226/EC) was carried out whenever possible.

The monitoring of toxin producing phytoplankton and phycotoxins of classified production areas in Galicia is conducted by the "Instituto Tecnológico para o Control do Medio Mariño de Galicia" (INTECMAR) (www.intecmar.org)

3.2.9 Sweden national report 2012

Bengt Karlson

No major harmful algal blooms occurred in the seas surrounding Sweden in 2012.

Background

Harmful Algal Blooms (HAB's) are recurrent phenomena in the waters surrounding Sweden. Most are likely to be of natural origin. 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) is the major concern. 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

Local algal blooms visible as surface accumulations of algae were reported along the Swedish coast from 1 July to early November. The autumn blooms often caused discolouration on beaches resembling spilled paint. Species and genera include *Nodularia spumigena* (producing the toxin nodularin), *Dolichospermum* spp. (synonym *Anabaena* spp.) and *Aphanizomenon*. Satellite observations of the off shore areas of the Bothnian Sea indicated surface scums of cyanobacteria mainly on the Finnish side in August 2012.

The Baltic proper

In general few observations of HAB's were made in 2012. On 8 July 2012 the first satellite observations of surface accumulations of cyanobacteria were made in the southern part of the Baltic proper. Strong winds and overcast weather is likely to be the cause of that no observations of strong surface accumulations were made until 25 July. From then until mid-August several observations of surface scums of cyanobacteria were made. Very few accumulations reached the Swedish coast. Strong winds probably mixed the cyanobacteria deeper into the water column. In autumn local surface accumulations of cyanobacteria were observed in some bays on the Swedish coast.

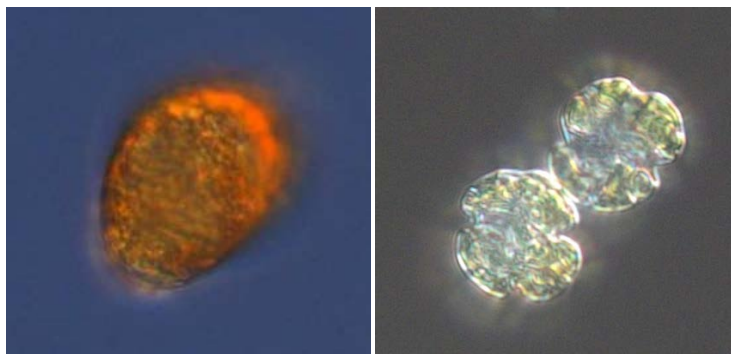


Surface scums of cyanobacteria South of the island of Gotland. Photo by the Swedish Coast Guard.

The Skagerrak and the Kattegat

The fish killing species *Fibrocapsa japonica* Toriumi and Takano, 1973, was reported from the Swedish west coast for the first time. No harmful effects of *F. japonica* were reported. Closures of harvesting of shellfish (mainly blue mussels, *Mytilus edulis*) due to accumulation of algal toxins occurred on the Skagerrak coast but not for long periods. The main reason was levels of Diarrhetic Shellfish Toxins above the regulatory

level in some areas. The first period of closures was in January to February and the second in August to November. During these periods it was possible to harvest shellfish in some areas. In March 2012 chemical analysis indicated Paralytic Shellfish Toxins (PST) in blue mussels on one occasion. Presence of *Alexandrium* resulted in closures in March and May.



Left: *Fibrocapsa japonica*, right: *Karenia mikimotoi* Photos by Malin Mohlin

Source: www.nordicmicroalgae.org

The dinoflagellate *Karenia mikimotoi*, which may cause fish mortalities and mortalities of filter-feeders, was observed in August in the Kattegat-Skagerrak front near Skagen. Vertical profiles of chlorophyll fluorescence showed peaks at 30-45 m depth. Water samples collected from these depths had abundances of *K. mikimotoi* of approximately 300 cells L⁻¹. No harmful effects were reported.

Abundances of algae producing toxins accumulating in shellfish were below the warning level most of the time. *Alexandrium pseudogonyaulax* was observed in July and August. Maximum abundance was 5000 cells per Litre. Although this species is on the IOC HAB checklist it has not been shown to be toxic in the Kattegat-Skagerrak area. *Dinophysis* was observed in abundances above the warning level in August. At this time DST in blue mussels was above the regulatory level in some cases. The species of interest are mainly *Alexandrium* spp. (Paralytic Shellfish Toxin, PST-producers), *Dinophysis* spp. (Diarrhetic Shellfish Toxin, DST producers), *Protoceratium reticulatum* (Yessotoxin, YTX producer), *Azadinium spinosum* (Azaspiracidic Shellfish Poisoning, AZT-producer) and *Pseudo-nitzschia* spp. (Amnesic Shellfish Toxins, AST producers).

In blue mussels DST was observed above the regulatory level in a few samples in January-February and in September to November. In one sample in March LC-MS screening for PST indicated presence of PST in blue mussels. AZT and AST were not recorded at levels above the regulatory limits in blue mussels (*Mytilus edulis*), oysters (*Ostrea edule*) or in cockles (*Cerastoderma edule*).

3.2.10 UK national report 2012

Marine Scotland Science (MSS), Scottish Association for Marine Science (SAMS), Agri-Food and Biosciences Institute (AFBI), Centre for Environment, Fisheries and Aquaculture Science (Cefas).

Paralytic shellfish toxins

Alexandrium spp.

Alexandrium was recorded at all sites monitored in Scotland during 2012 and in 46% of the samples analysed. The largest recorded *Alexandrium* bloom during the year was observed on the east coast of the Isle of Lewis (Loch Erisort) on 18-Jun-12, with an abundance of 6,500 cells per litre, but this was not associated with a toxicity in shellfish. PSP toxins above the maximum permitted concentration in the Clyde (Arran: Lamlash Bay) in April, east coast (Dornoch Firth) in May, and on the east coast of the Isle of Harris (Loch Stockinish) in June. These events were all associated with elevated *Alexandrium* densities. In Northern Ireland, *Alexandrium* spp. were recorded in 2.2 % of samples and the maximum cell abundance (180 cells L⁻¹) was recorded in a sample from Carlingford Lough in July. PSP toxins in shellfish did not exceed the regulatory limit in 2012. In England and Wales, high cell densities of *Alexandrium* were observed in the south of England. The maximum cell concentration recorded was 25×10^6 cells L⁻¹ in a sample from the Yealm in July 2012 but PSP toxins in shellfish did not exceed the regulatory limit.

Amnesic shellfish toxins

Pseudo-nitzschia spp.

In Scotland, *Pseudo-nitzschia* cell counts exceeding 50,000 cells per litre (UK threshold level) were recorded in 11.5% of the samples analysed, with over 20% of the samples in June and July having greater than threshold cell densities. Many *Pseudo-nitzschia* blooms during summer were not associated with any accumulation of DA in shellfish. The largest recorded *Pseudo-nitzschia* bloom was observed in the Shetland Islands (Vaila Sound: east of Linga) on 11-Jul-12, with a density of more than two million cells per litre. Only one closure was enforced as a result of concentrations of DA in shellfish greater than 20mg Kg⁻¹. This was in Loch Spelve on the west coast where concentrations of 27 mg DA Kg⁻¹ were recorded. In Northern Ireland, *Pseudo-nitzschia* were present in 67.3 % of water samples received during the year. Belfast Lough was the only area where numbers breached the set trigger level of 150,000 cells L⁻¹. A *Pseudo-nitzschia* bloom during July-August in Belfast Lough was associated with levels of domoic acid in mussels that exceeded the regulatory limit and resulted in the closure of a number of shellfish beds in the lough. During this period a maximum abundance of 258,520 cells L⁻¹ was recorded in a water sample taken on the 16th July. This is the first documented case in Northern Ireland of the closure of shellfish beds due to the presence of domoic acid. In England and Wales *Pseudo-nitzschia* was recorded at 44 sites in the monitoring programme. DA was detected in shellfish from seven monitoring sites but concentrations never exceeded the regulatory limit.

Lipophilic shellfish toxins

Dinophysis spp.

In Scotland, *Dinophysis* was recorded occurred above UK threshold level (100 cells per litre) in more than 20% of all samples. The majority of *Dinophysis* blooms occurred between June and August, with 42% of the samples exceeding threshold counts in July. DSP toxicity was widespread between June and September with DSP toxins in shellfish reported above permitted levels in sites on the West Coast, (Arran: Lamlash Bay, Loch Melfort, Loch Leven, Loch Eishort, Loch Torridon, Loch Laxford, Western Isles (Loch Roag) and East Coast, (Dornoch Firth). The highest *Dinophysis* density observed during 2012 occurred in the Clyde estuary, (Arran: Lamlash Bay),

with a concentration of 2,760 cells per litre recorded on 11-Jun-12. Cells of *Dinophysis* were present continuously for five months in Lamlash Bay, from the start of weekly phytoplankton monitoring at the beginning of April 2012 through to early September. Closures of shellfish harvesting at this site as a result of high concentrations of DSP toxins lasted from June until October. In Northern Ireland, *Dinophysis* spp. were detected throughout the year (January –December). The maximum recorded cell abundance was 2,200 cells L⁻¹ in a sample taken from Belfast Lough on the 16th July. Okadaic acid was recorded in mussels from the lough during this period but levels were below the regulatory limit. Cells of *Prorocentrum lima* were present in 1.9% of samples with a maximum abundance of 22,620 cells L⁻¹ recorded in a sample from Lough Foyle in January. No lipophilic toxins were detected at that time. In England and Wales, *Dinophysis* was observed at sites along the south and west coastline and at two sites on the east coast. Okadaic acid was detected in shellfish but never above the closure limit.

Prorocentrum reticulatum* and *Lingulodinium polyedrum

In Scotland, *Prorocentrum reticulatum* was recorded at low concentrations in 4.3% of samples, mostly between April and June. The highest concentration of *P. reticulatum* was observed on the east coast of Scotland at Stonehaven with a cell density of 540 cells L⁻¹. *Lingulodinium polyedrum* was recorded on only five occasions in 2012, occurring at a concentration of 20 cells L⁻¹. Concentrations of YTX above the closure limit of 1 mg YTX eq Kg⁻¹ was recorded in shellfish from Lamlash Bay in June and July and from Shetland in August. YTX was not reported in shellfish from Northern Ireland, England and Wales.

Azadinium

The causative organism for AZA is not routinely monitored in growing areas however concentrations of AZA in shellfish exceeded the EU regulatory limit at one site on the east coast of Scotland (Anstruther) and one on the West (Loch Bay). AZA toxins were recorded in the Northeast of England (Holy Island) but never above the regulatory limit. AZA toxins were not reported from Northern Ireland.

Other events

Karenia mikimotoi was observed in UK waters during 2012, but no harmful impacts were associated with this species during the year. A foam event was observed in the village of Footdee in Aberdeen during September 2012. Strong winds during a severe storm blew copious amounts of foam on shore. Samples were examined but no causative organisms were observed. Information on this event can be found at <http://www.bbc.co.uk/news/uk-scotland-northeast-orkney-shetland-19727613>.

3.2.11 USA national report 2012

Presented by Don Anderson

PSP

On the US west coast, Alaska, Washington, Oregon and California all recorded PSP toxicity during 2012. Nine confirmed PSP cases occurred in Washington state and three cases occurred in Alaska. In all cases, shellfish were harvested from areas that were closed. PSP toxin levels were much higher in Washington state in 2012 than in 2011, with the highest recorded value being 10,304 µg detected in mussels near Kingston (Puget Sound). In California, PSP levels were high in winter, which is unusual.

New England experienced “normal” closures due to PSP – including eastern Maine, western Maine, New Hampshire and the south shore of Massachusetts.

New York state had closures due to PSP on the north side of eastern Long Island (Mattituck Creek / Mattituck Inlet). It was noted that this closure occurred approximately one month earlier than previous years. The winter was also significantly warmer than previous years.

Combined research efforts by scientists involved in the Gulf of Maine Toxicity (GOMTOX) project, funded by NOAA’s Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) program, and administered by the National Centers for Coastal Ocean Science (NCCOS), have led to enhanced understanding of toxic algal blooms on Georges Bank. This new information, coupled with an at-sea and dockside testing protocol developed through collaboration between GOMTOX and US Food and Drug Administration (FDA) investigators, has allowed fishers to harvest ocean quahogs and surf clams in these offshore waters for the first time in more than two decades.

The shellfish industry estimates the Georges Bank fishery can produce up to 1 million bushels of surf clams and ocean quahogs a year, valued \$10 – 15 million annually. An elevated area of the seabed between Cape Cod and Nova Scotia, Georges Bank is one of the best fishing grounds on Earth. But since 1990, it has been closed to harvesting of surf clams and ocean quahogs after HABs caused paralytic shellfish poisoning (PSP) that sickened fishers. For decades scientists speculated the blooms on Georges Bank were fueled by coastal blooms in the Gulf of Maine. More recent research by GOMTOX investigators, however, has shown that Georges Bank is home to a separate and distinct population of the toxic algae. Precisely why the blooms vary in severity has been much more difficult to determine, and has involved extensive seasonal sampling of water and sediments, study of coastal currents, environmental and oceanographic conditions, availability of nutrients, and the development of a computer program to model all of the variables.

In the three-year course of intensive study on Georges Bank since then, blooms have occurred every year, in concentrations that would typically lead to toxicities in coastal shellfish beds. Yet, a parallel effort by the fishing industry and federal testing labs to analyse shellfish samples from Georges Bank found the bivalves to be clean of toxins. So while toxins were produced at and near the surface, they were not delivered to the surf clams and ocean quahogs in the seabed in quantities sufficient to threaten human health.

But, thanks to an innovative screening protocol and regulatory structure developed collaboratively by the FDA, NOAA’s National Marine Fisheries Service, the fishing industry, and testing labs approved by the National Shellfish Sanitation Program, a system is now in place to monitor, test, and verify that clams harvested from Georges Bank are safe. The clams are checked by fishers at sea using the newly available test kit, and re-checked by regulators when the fishing vessels reach the dock. Combined with the weekly monitoring of shellfish beds along the coast during the bloom season to protect human health, these monitoring systems are extremely effective at keeping toxic shellfish off the market.

ASP

For the fifth year in a row, Washington State had very low levels of domoic acid with no closures reported. Oregon had no reports of domoic acid. Domoic acid was detect-

ed in shellfish east of Mount Desert Island, Maine, and, subsequently, the first-ever closure for ASP in Maine was issued in late summer.

NSP

Florida experienced *Karenia brevis* blooms on the west coast. The 2011 bloom continued into 2012 through March 12th) and the 2012 bloom began September 17th and is continuing through to 2013. Fish kills (multiple species) were attributed to the *Karenia* bloom, and respiratory problems in humans were also reported. Texas also experienced a bloom of *Karenia* during summer; fish kills were reported.

DSP

For the second year in a row, DSP toxins were detected in Washington state resulting in closures at 20 sites. A closure at Ruby Beach, WA was the first ever on the Pacific coast due to DSP toxins. New York state experienced its first closure due to DSP toxins, with closures on the north side of Long Island.

Brown tide

Once again, the south shore of Long Island, NY experienced a significant brown tide bloom, which began in May and ended in July. The *Aureococcus* bloom was very intense similar to 2011, reaching densities over two million cells per ml (normally blooms peak at one million cells per ml). This was the sixth year in a row with elevated *Aureococcus* concentrations, following a decade of very low levels. Before that, there was a decade of high concentrations, beginning in 1987. The Indian River and Mosquito Lagoons (east coast of Florida) also experienced brown tide in 2012 (mid-July to early October). The impacts of this bloom, due to *Aureoumbra lagunesis*, are still being evaluated with respect to losses of benthic life and seagrass beds, fish kills, etc.

3.3 ToR c) Develop and set up a new reporting format for producing major reports every three years

This topic was discussed but a detailed reporting format was not decided. After the WGHABD meeting IOC-IPHAB met in May 2013 and decided to produce global harmful algae status reports. This would be a task for the WGHABD for the ICES area. A reporting format could include the following:

- Maps presenting the distribution of HAB events based on contributions to the Harmful Algae Event Database, HAEDAT. This would be an update of the existing HAB-maps.
- Presentations of time-series of HAB events based on HAEDAT for different sea areas.
- Time-series data on abundance of HAB species for sea areas (often based on data from several countries).
- Time-series data on algal toxins in shellfish for sea areas often based on data from several countries.
- National reports should include reporting to HAEDAT
- Texts describing HAB events from the reporting period
- New findings
- Other topics

3.4 ToR d) Review progress regarding the entering of data onto the HAEDAT database, and how data can be extracted and utilized

The status of reporting to HAEDAT by ICES countries was presented by Henrik Enevoldsen as reflected in Table below.

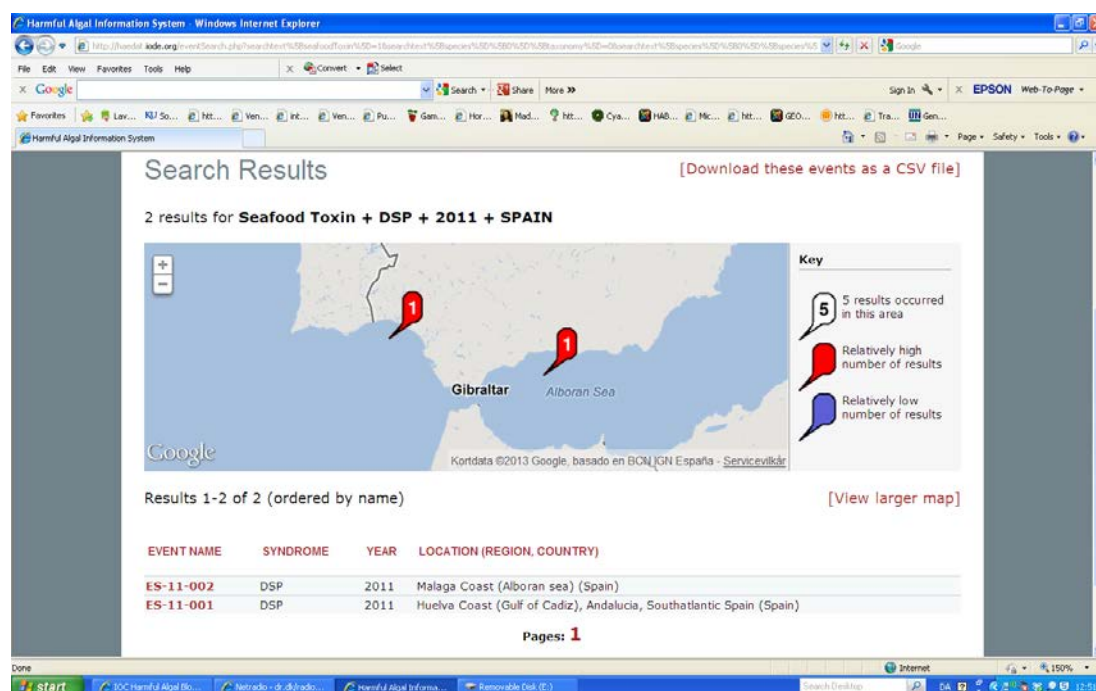
WGHABD discussed how countries can be motivated to complete input as this is a condition for starting to do any meaningful analysis of data including updated decadal maps. It was agreed that all those present at this year's WGHABD would make an effort to enter data and the Chair and IOC will follow-up with those not present (as indicated in the table).

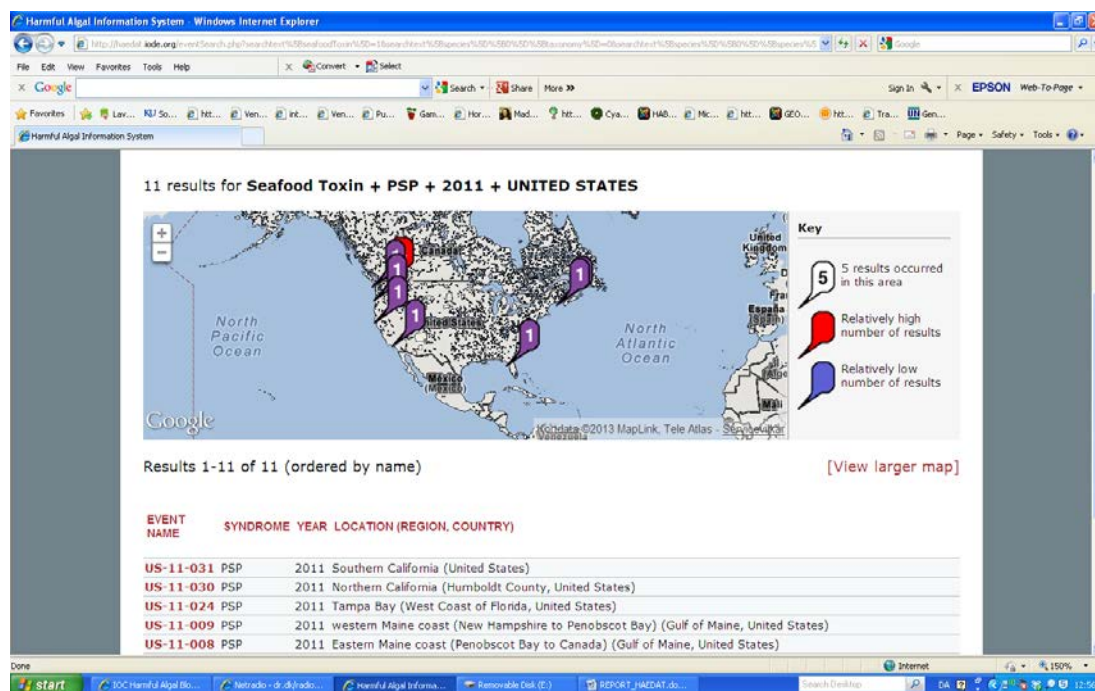
BY ICES COUNTRY	Most recent year reported	Note	Years missing ?	What can be done?
CANADA (482)	2012		0	OK
DENMARK (13)	2001		11	Reminder to Per Andersen (HE will offer to enter if PA compile)
ESTONIA (8)	2004		8	Reminder to Inga Lips
FAROE ISLANDS (4)	1990		22	Reminder to Eilif Gaard (HE will offer to enter if EG compile)
FINLAND (23)	2010		2	Reminder to Sirpa Lehtinen
FRANCE (729)	2009		3	Catherine Belin to complete
GERMANY (61)	2001	2010, 1 record	10	Allan Cembella et al to complete
ICELAND (6)	1994		18	?
IRELAND (208)	2010		2	Joe Silke to complete
LATVIA (25)	2004		8	Reminder to Maja Balode
NETHERLANDS (75)	2009		3	Marnix Poelman to complete
NORWAY (53)	2001		11	Torbjørn Johnsen to complete progressively
POLAND (30)	2010		2	Hannah Mazur to complete
PORTUGAL (406)	2012		0	ok
SPAIN (236)	2013		0	ok
SWEDEN (59)	2009	no data 2001-2008	11	Bengt Karlson to complete
UNITED KINGDOM (228)	2012		0	ok
UNITED STATES (579)	2011		1	ok

The WGHABD agreed that delivering data products and synthesis from HAEDAT is essential to its future, to motivation of data providers to continue providing data, and

for data submitters to stay committed. It was agreed that one important product would be 'telling the story' of HAB events for appropriate regions/countries and that each country responsible will outline for WGHABD 2014 the story to tell for their respective country (for the data available in HAEDAT for each country). Based on this the WGHABD will in 2014 decide on the outline of a 'synthesis story' about HAB events in the ICES area. These data product should include new decadal and other maps as previously delivered by the Ifremer team.

I was also agreed to include in the WGHABD reports extracts from HAEDAT as the reporting of events, including distribution maps, tables etc. to show the usage of HAEDAT. Example:





3.5 ToR e) Undertake time-series analysis of HAB species and associated events

3.5.1 Thirty years - *Alexandrium fundyense* cyst, bloom dynamics and shellfish toxicity in in the Bay of Fundy, eastern Canada

Jennifer L. Martin, Murielle M. LeGresley and Alex R. Hanke

Fisheries and Oceans Canada, Biological Station, 531 Brandy Cove Road, St Andrews, NB E5B 2L9 Canada.

Sediment and water samples were collected for *Alexandrium fundyense* spatial and temporal distribution and abundance at more than 120 locations throughout the Bay of Fundy during summers and winters of 1980-1984. These broad surveys have been repeated at various times through the past 30 years, with annual more regular sampling since 2004. In addition, *A. fundyense* abundance has been monitored at several locations within the Bay of Fundy at weekly intervals from April – November and monthly during the remaining months since 1988 (Figure 1). Paralytic Shellfish Poisoning (PSP) toxins in shellfish (notably *Mya arenaria*) have also been monitored at multiple locations in the Bay of Fundy since 1943. The datasets were examined to determine relationships and roles between overwintering resting cysts, bloom initiation, bloom decline, cell dispersal and *A. fundyense* motile populations and resulting shellfish toxicity since 1980. Cysts are widely dispersed throughout the Bay of Fundy in the offshore, inshore and intertidal zones with the largest deposits located in the offshore in silt/clay sediments to the east and north of Grand Manan Island at depths of 60-180 m. Results show that there is a constant stable source of cysts in the Bay of Fundy with highest concentrations of cysts (9,780 cysts•cm⁻³) observed in 2010 (Figure 2) and highest concentrations of *A. fundyense* motile cells (>18 million cells•L⁻¹) observed in 1980 (Figure 3).

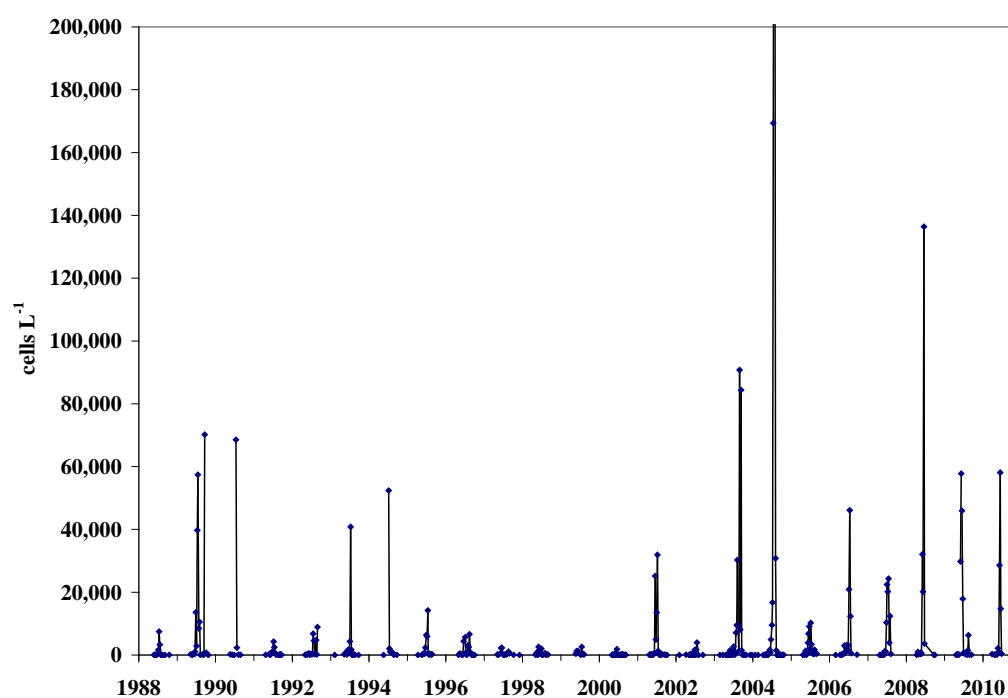


Figure 1. *Alexandrium fundyense* concentrations at the Wolves Islands (1988-2010). The highest concentration (3.19×10^5 cells \cdot L $^{-1}$) was observed in 2004.

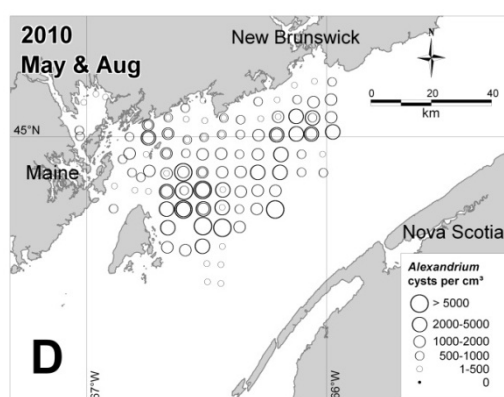


Figure 2. *A. fundyense* cyst concentrations in the Bay of Fundy in 2010.

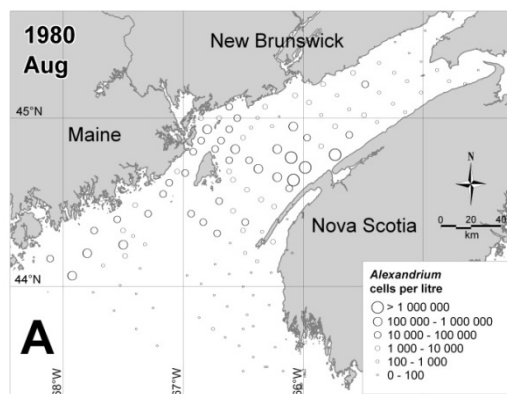


Figure 3. *Alexandrium fundyense* concentrations (1980) in the Bay of Fundy.

Interannual changes in abundance in *A. fundyense* populations showed a large variability of abundance between years; resting cysts were relatively constant and trends in *M. arenaria* toxicity showed large interannual variability (Figure 4). Results show that the offshore seed beds are constant in cyst density between most years and serve as an important source for the motile cells that form the major bloom initiations and resulting shellfish toxicity through the Bay of Fundy. There was no relationship found between densities of resting cysts. Summer motile cell concentrations and shellfish. Oceanographic influences and weather (wind) play an important role in *A. fundyense* cell dispersion to inshore shellfish harvesting areas.

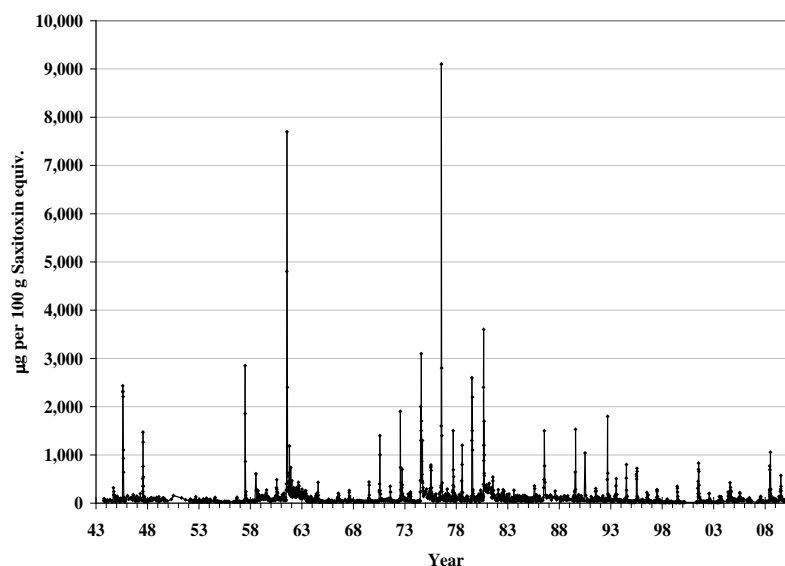


Figure 4. *Mya arenaria* shellfish toxicity at Lepreau Harbour (1943-2010).

3.5.2 Changes in the diversity of the dinoflagellate genus *Dinophysis* (Ehrenberg) in the Northwest North Sea

E. Bresnan¹, M. Edwards², R. Stern², S. L. Hughes¹, S. Fraser¹, D. G. Johns² and J. P. Lacaze¹.

¹Marine Scotland – Science

²Sir Alister Hardy Foundation of Ocean Science

The dinoflagellate genus *Dinophysis* (Ehrenberg) is a common component of summer dinoflagellate community in northern North Sea region. Variation in the distribution of *Dinophysis* in the North Sea has been shown on a decadal scale using data collected by the Continuous Plankton Recorder (CPR). Interannual variation has been observed in the diversity of this genus since coastal monitoring began in Scottish waters in the mid 1990s. *D. acuminata* dominated the *Dinophysis* population when monitoring began but was replaced by *D. acuta* as the dominant species during 2001. Widespread closures of shellfish harvesting areas were enforced as a result of DSP during this time. Since then, *D. acuta* has decreased in abundance and the *Dinophysis* population has become dominated by small, morphologically ambiguous cells requiring molecular techniques for identification. The *Dinophysis acuta* event occurred during a period when a negative salinity anomaly was observed in the Fair-Isle inflow into the North Sea. Examination of data from the Continuous Plankton Recorder (CPR) shows that previous negative salinity anomalies in the Fair Isle inflow have coincided with elevated observations of *Dinophysis* in the CPR transect in the northwestern North Sea including a period in the 1970s when high cell densities of *D. norvegica* were observed in the northeast coast of England. Molecular analysis has confirmed the identification of *D. acuminata* as the dominant species in present day *Dinophysis* blooms in Scottish waters.

3.5.3 Time-series of Azaspiracid HAB events in Ireland as an indicator of *Azadinium* distribution.

Presented by Joe Silke

Due to the short period of time between blooms of *A. spinosum* occurring and detection of Azaspiracids in shellfish, observations of AZA in shellfish would be considered a useful indicator for the temporal distribution of *Azadinium*. The temporal distribution of Azaspiracid observed from 11 years of Irish shellfish monitoring show some interesting patterns which gives us an indication of the temporal and spatial distribution of *A. spinosum*. Figure 1 shows a predominance of higher levels, more frequent occurrence and longer outbreaks in the south than the rest of the country. Interannual variability is also observed while most areas show some occurrence nearly every year, there are some years (e.g. 2002- 2003) when there is very little toxin observed anywhere. The evidence points towards an offshore factor controlling the levels observed within the bays where shellfish are produced which results in this intermittent occurrence. It is not known whether continuous periodic intoxication over winter or the inability of shellfish to depurate AZAs is responsible for extended winter toxicity as seen in several years from 2005 onwards particularly in southern locations.

A less frequent intoxication can also take place in early summer (May-June) but this tends to happen more intermittently. Toxin accumulation seems to oscillate during these events where toxicity increases and decreases creating a yo-yo effect over a number of weeks suggesting that shellfish is not getting intoxicated in a single incident from *A. spinosum*, but rather in consecutive waves over time perhaps from offshore pulses of toxic plankton being advected inshore by coastal processes. This is also observed in other species in Irish waters including *Dinophysis* sp. which was

shown to impact inshore shellfisheries in the southwest when oceanographic factors result in intrusions of offshore water containing high cell counts (Raine et al. 2010). Physical circulating forces during summer and wind driven exchange in a thermally stratified water column allows for phytoplankton species in the water mass to be transported into the bays in the Southwest of Ireland. This could go some way towards explaining how harmful phytoplankton that are growing in the shelf waters around the Southwest coast of Ireland can penetrate into the bays and concentrate in coastal locations. This wind driven HAB events in the Southwest coast could be used as a proxy for the movement, temporal and spatial distribution of *Azadinium* around the coast, as the inshore coastal current move clockwise around the Irish coast. Other recent information gathered in offshore water during the month of August suggests that offshore populations of *A.spinosum* observed to occur in moderately stratified water in the Celtic Sea may pool there and await oceanographic currents to either dissipate the bloom, or to concentrate them into a highly toxic front that can be transported into the shellfish production areas in the Southwestern bays of Ireland. The offshore presence of *Azadinium* is suggested also in earlier observations of *Azospira* present in offshore locations during the month of July (Figure 2).

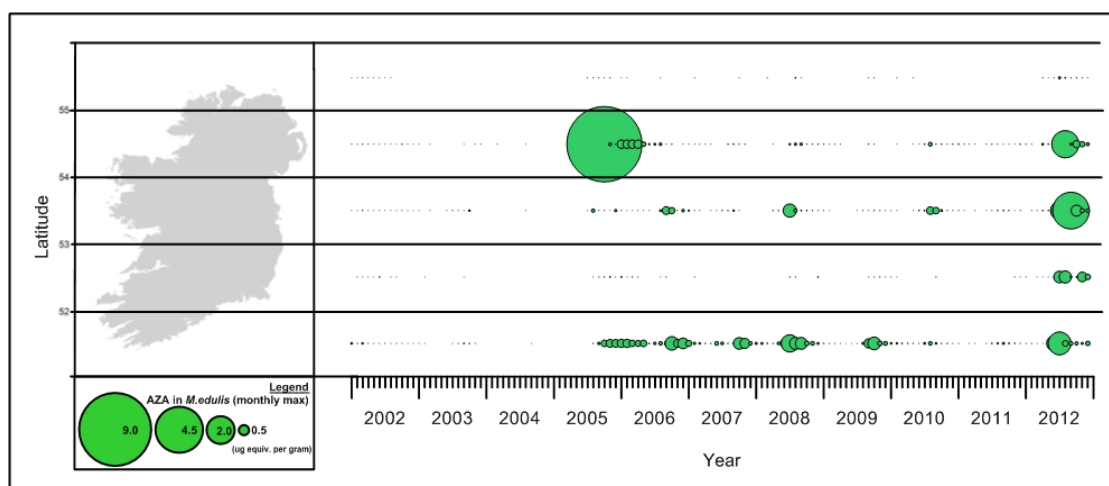


Fig 1: Distribution and concentration of Azaspiracid toxins (AZA1 $\mu\text{g eq.g}^{-1}$) in Irish farmed mussels (*Mytilus* sp.) between 2002 and 2012.

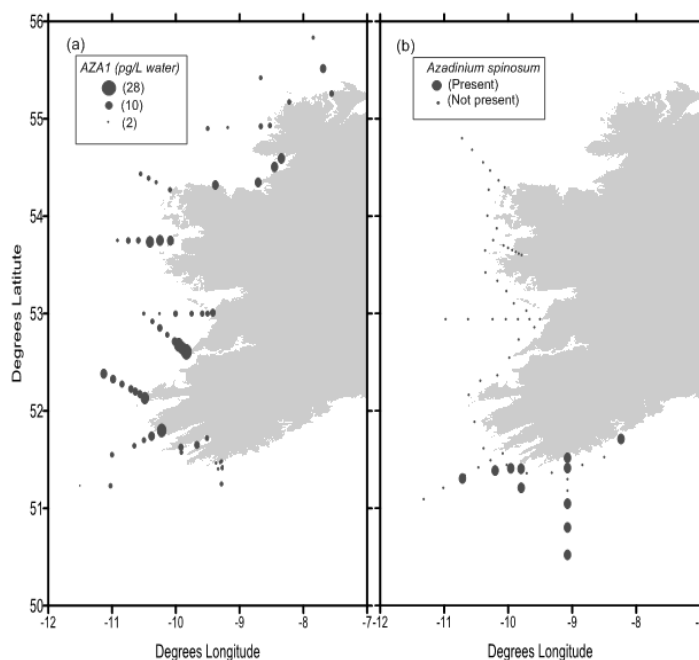


Fig 2 (a) distribution of Azaspiracid from filtered seawater samples collected in offshore samples around Ireland (August 2004) (b) presence of *Azadinium spinosum* (detected by PCR) in offshore samples (August 2012)

3.5.4 Time-series of *Dinophysis* and DST in blue mussels in Sweden

Presented by Bengt Karlson

Extracts from a report in Swedish presenting time-series data on phytoplankton. Swedish national and regional monitoring programs was presented together with data on Diarrhetic Shellfish Toxins in blue mussels from the National Food Administration and other sources.

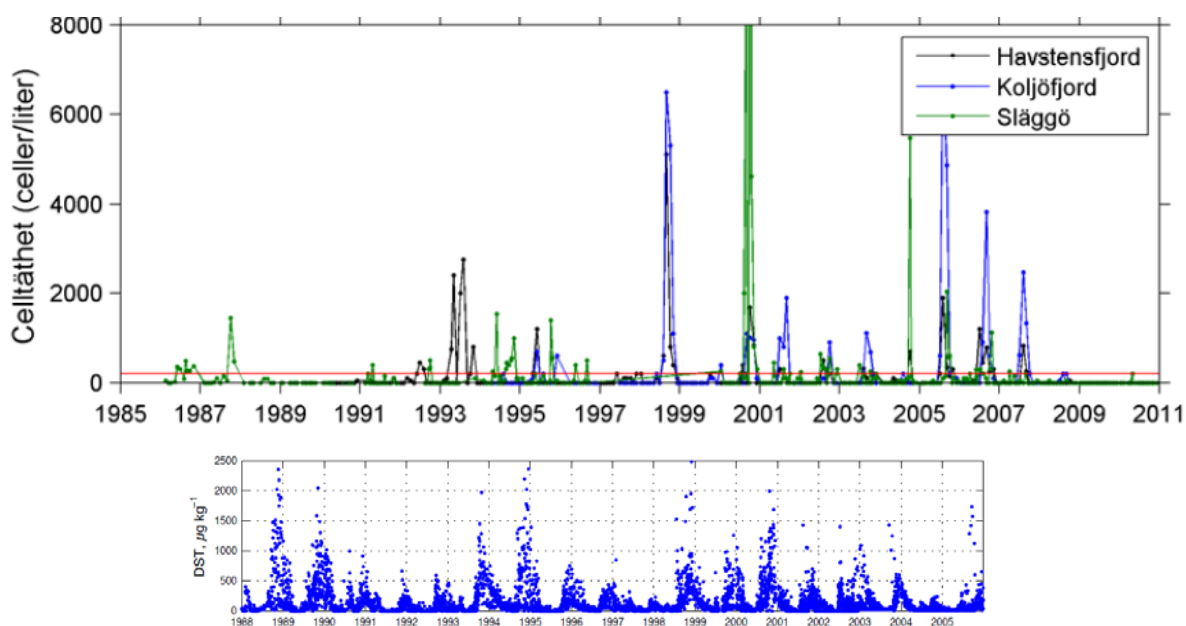


Figure 1 Top: Abundance (cells per Litre) of *Dinophysis acuta* at three stations along the Swedish Skagerrak coast. Bottom: Concentrations of Diarrhetic Shellfish Toxins in all samples from the Swedish West coast.

Reference:

Karlson, B., Rehnstam-Holm, A-S and Loo, L-O, (2007), Temporal and spatial distribution of diarrhetic shellfish toxins in blue mussels, *Mytilus edulis* (L.), at the Swedish west coast, NE Atlantic, years 1988-2005 Swedish Meteorological and Hydrological Institute, Reports Oceanography, no.35, 78 pp.

3.5.5 ToR f) Review state-of-the-art and ongoing research and managerial activities related to emerging benthic HABs in ICES countries

Beatriz Reguera, IEO, Vigo, Spain

1. BACKGROUND

HAB events caused by benthic dinoflagellates of the genera *Gambierdiscus* (Ciguatera Fish Poisoning) and *Ostreopsis* (palytoxins) have been known for long in tropical and subtropical regions of the Atlantic, Pacific and Indian oceans. Nevertheless, problems associated with species of these genera have emerged in European countries in the 2000's raising concern about their potential relation with climate change. Health authorities and food safety agencies from temperate latitudes were not prepared to control the occurrence of these benthic HAB's toxins in seafood and marine aerosols, or even to recognize the symptoms in affected consumers. This concern has contributed to the establishment in 2010 of a new SCOR-IOC GEOHAB *Core Research Project on HABs in Benthic Systems* (GEOHAB 2012; Zingone et al. 2012) and triggered the celebration in April 2011 of a conference dedicated to *Ostreopsis* (ICOD = *International Conference on Ostreopsis Developments*) during the meeting of the French Phycological Society (SPF) in Villefranche-sur-Mer (Lemée et al. 2012).

Ciguatera in a broad sense may include a complex mixture of at least three groups of lipophilic toxins produced by more than three different genera (*Gambierdiscus*, *Ostreopsis*, *Prorocentrum*, *Amphidinium*) of benthic dinoflagellates co-occurring in the same tropical-subtropical habitat (Morton et al. 1992, 1997). Nowadays we know that, concerning benthic HABs, ciguatera toxins in a strict sense (ciguatoxins, maitotoxins) are produced only by species of the genus *Gambierdiscus*; palytoxins and its analogs by *Ostreopsis* spp.; and okadaic acid and its congeners (diarrhetic shellfish toxins) by benthic species of *Prorocentrum*.

1.1 Ciguatera Fish Poisoning (CFP)

Ciguatera is a seafood poisoning caused by eating tropical coral reef fish that act as carriers of the ciguatera toxins (CTX) (Yasumoto, 2005). Ciguatera Fish Poisoning (CFP) is endemic in tropical areas within the Atlantic Ocean (in particular in the Caribbean Sea), the Indian Ocean, and in the Pacific (in particular in Polynesian islands) (Lewis, 2001). The term "ciguatera" comes from "cigua", the name given in Cuba to a carnivorous snail (*Livona picta*) identified by popular wisdom as an important source of ciguatera symptoms. Although descriptions of fish intoxications presumably caused by ciguatoxins exist since pre-Christian times, the first detailed report of CFP dates back from 1774 and was provided by a surgeon's mate of Captain Cook's South Pacific exploration aboard the HMS *Resolution* when the crew was intoxicated after eating fish in New Caledonia (Lehane, 1999).

CFP is by far the most extended non-bacterial seafood borne intoxication (Lehane and Lewis, 2000) and mainly affects coastal populations from developing countries where artisanal fisheries constitute an important part of their staple food. Toxins are produced by benthic microalgae which live attached to seaweeds or other substratum and are transmitted to humans through herbivorous and carnivorous fish. At the moment, there is not a realistic, cost-effective way to monitor CTXs in seafood and the only possible prevention is to avoid consumption of risk species from risk areas. More than 50,000 cases are reported every year but it is assumed that less than 10% of them are communicated to the health authorities. Symptoms of the intoxication are used to diagnose and distinguish CFP from other seafood intoxications. However, the confirmation of cases of CFP relies upon the detection of CTXs in the remaining meal

or within the plasma of patients (Bottein, 2007). Therefore, it is important to have adequate CTX quantification methods to diagnose CFP cases and moreover, to prevent intoxications through the analysis of consumable fish (see review of methods in Cailaud et al., 2010). In tropical Pacific regions, such as the French Polynesia, where research and management of ciguatera started since the 60's, the ciguatera risk assessment programme is based on two main activities (i) epidemiological survey of marine biotoxin intoxications throughout the islands and (ii) the microalgal toxin-based field monitoring in the lagoons, complemented with awareness education of the local population. In this way, identification of the risk species but above all of the risk areas (probably related with development of more toxic strains) have been identified (Darius et al., 2007).

In a risk assessment study carried out in Puerto Rico between 1997 and 1998, Tosteson (IOCARIBE-ANCA, 1998) estimated an incidence of 18000 cases per year of CFP in a population of 3.5 million (i.e. 51 cases per 10,000 population per year). This author calculated a loss of 8 to 10 million dollars per year due to: i) loss in revenue to the fishers and distributors when there is an outbreak of ciguatera and potential consumers at least momentarily cease to purchase fish; ii) medical costs incurred by those persons poisoned and iii) the resulting loss of income due to the interruption of employment among poisoned consumers. According to Tester et al. (2009, 2010), between 1996 and 2006, highest rates of CFP in the Caribbean were 34 and 59 per 10,000 population per year in Antigua-Barbuda and Montserrat (Lesser Antilles) and these rates represented an increased incidence of CFP as compared with reports from the 1980's. In Canada, Todd (1997) estimated there could be as many as 300 cases of ciguatera poisoning each year, either from tourists visiting tropical areas or from imported tropical fish consumed in Canada. Assuming that each of these cases costs \$4,000, the total annual cost could be as high as \$ 1,236,000.

Interest for CFP in Europe increased in parallel with increased tourist activities in tropical regions and reports from European hospitals (from France, Spain, the Netherlands, Germany, and Italy) about citizens who suffered CFP symptoms during their holidays or upon their return from the tropics. Nevertheless, reports in recent years indicated that CFP was present in areas of Africa close to Europe and in the Macaronesia islands (Azores, Canary, Cape Verde and Madeira Islands). In 2004, CFP was first confirmed after consumption of flesh from fish caught in the Canary Islands (Pérez-Arellano et al., 2005), the presence of CTXs was also suspected in fish from Madeira in 2007 and 2008 (Gouveia et al., 2009), and for the first time a new toxic species of this genus, *Gambierdiscus eccentricus*, was reported from the Canary Islands in 2004 (Fraga et al., 2011). In all these cases, affected consumers had eaten large (up to 60 kg) Carangidae fish of the genus *Seriola*. In addition, dinoflagellates of the genus *Gambierdiscus* have been recorded in the Mediterranean Sea since 2003 (Aligizaki and Nikolaidis, 2008). All these reports from the 2000's have raised the concern about a possible spreading of CFP causing *Gambierdiscus* species to subtropical regions from which they had never been reported before.

In parallel, an extensive revision of the six already described species of *Gambierdiscus*, based upon morphological and phylogenetic analysis, led to the description of four new species, i.e. *G. caribaeus*, *G. carolinianus*, *G. carpenteri*, and *G. ruetzleri*, in the Caribbean and southern Atlantic US area (Litaker et al., 2009). It was also proposed that the original species, *G. toxicus* (Adachi and Fukuyo, 1979) may in fact include multiple species.

Incidences of CFP, according to the most recent mapping of this syndrome, are now distributed between parallels 35°N and 35°S. A problem identified by the GEOHAB CRP was the heterogeneity of macroalgal substrata where benthic HABs occur and hence, the difficulties to obtain comparable data of dinoflagellates abundance between regions. This led this group of experts to recommend a standard artificial substrata to be deployed and recollected in the study areas (GEOHAB 2012).

1.2 *Ostreopsis* events

Dinoflagellates of the genus *Ostreopsis* have been cited in the western Mediterranean coast in the last century (Meunier, 1919; Halim, 1960), but it was not until the early 2000's when harmful events, causing dermatitis and respiratory problems, were reported from the Mediterranean Seas in Italian, Spanish, Greek, French, Tunisian and Algerian coastal areas and linked for the first time with proliferations of *Ostreopsis* (*O. cf. ovata* and *O. cf. siamensis*) (Illoul et al., 2012; Mangialajo et al., 2012; Sansoni et al., 2003; Vila et al., 2008). Phylogeographical considerations on the genus *Ostreopsis* showed that *O. cf. ovata* is widely dispersed throughout tropical and warm temperate coastal areas and that in the North Atlantic/Mediterranean region it represents a panmictic population that is highly divergent from Indo-Pacific populations (Penna et al., 2012).

Six *Ostreopsis* species have been reported as responsible for toxic events, of which three have been shown to produce potent toxin analogues of palytoxin, which are complex, high molecular weight, and water-soluble polyalcohols (Riobó and Franco, 2011). After the discovery of ovatoxin-*a* in Mediterranean strains of *O. cf. ovata* (Ciminiello et al., 2008), five more ovatoxin types and two mascarenotoxins were detected for this species (revised in GEOHAB, 2012). Strains of *Ostreopsis cf. ovata* isolated from the French Mediterranean coast were identified with molecular methods and their toxins analysed by LC-MS. They contained ovatoxin-*a* (OVTX-*a*) (up to 55 pg.cell⁻¹) as their major toxin component and small amounts of palytoxin (PLTX) (max. of 2.5 pg.cell⁻¹) (Sechet et al. 2012).

Palytoxin like substances were found in plankton samples collected in summers 2005 and 2006 along the coasts of the Ligurian Sea when up to 200 people were hospitalized presenting cough, dyspnoea, sore throat, rhinorrhea, fever, headache, lacrimation, nausea/vomiting and dermatitis (Ciminiello et al., 2006; Durando et al., 2007). Interestingly, other intense *Ostreopsis* blooms have occurred in the same and other Mediterranean areas in summer, without any report of similar syndromes (Durando et al., 2007; Tubaro et al., 2011).

So far, demonstrations of the presence of PLTs in the aerosol during *Ostreopsis* blooms, or that the symptoms occasionally reported were actually caused by PLTs are weak (Tubaro et al., 2011). It is a priority to investigate the complex biological and environmental interactions that modulate the toxic outbreaks during the co-occurrence of intense blooms in calm waters followed by persistent onshore winds (GEOHAB, 2012). Further, it can not be discarded that other substances different from PLT are the actual bioactive compounds in the toxic aerosols.

Aligizaki et al. (2008) reported the presence of p-PLT contamination of shellfish (33.3 to 97.0 mg p-PLT · kg⁻¹ tissue) by natural populations of *Ostreopsis* in the Eastern Mediterranean Sea. This represents, so far, the only report on the presence of putative palytoxin-like compounds (p-PLT) in shellfish.

The deleterious effects of *Ostreopsis* cf. *ovata* blooms on the meiofauna (metazoans 40 µm to 1 mm in size) inhabiting the very common brown macroalga *Halopteris scoparia* were studied in shallow coastal lagoons along the French and Italian Mediterranean coasts. Changes in the community structure were associated with high abundances of *Ostreopsis*; the most affected organisms were the *nauplii* suggesting a negative impact on harpacticoid copepod reproduction (Guidi-Guilvard et al., 2012). Invertebrate mass mortalities linked to *O. ovata* blooms have to be interpreted with caution, because other causes, such as oxygen depletion or high seawater temperature have to be considered. Faimali et al. (in press) carried out an ecotoxicological screening to investigate the toxic effects of different concentrations of *O. ovata* (cultured in the laboratory and sampled in the field during blooms) on crustaceans and fish larvae. They found that *Artemia salina* was the most sensitive species even at concentrations below the “Environmental Alarm Threshold” set by the Italian Ministry of Health. 2011

1.3 European Union Regulations

European Union regulations state that “Fishery products containing biotoxins such as ciguatoxins or other toxins dangerous to human health” (EU, 2008), and regulations EC 853/2004 (EU, 1986) and EC No 1021/2008 (EU, 2008) control imports of fish species from genera well known to be associated with different kinds of ichthyosarcotoxins (“fishery products derived from poisonous fish of the following families are not placed on the market: Tetraodontidae, Molidae, Diodontidae and Canthigasteridae”). European regulations give neither indications about a reference analysis method for CTXs, nor about regulatory safety limits in fisheries products. This lack of specification should not be interpreted as a lack of interest, but as a reflection of the difficulties that laboratories dealing with ciguatera have encountered during the last decades regarding the definition and standardization of CTX analytical methods and establishment of safety limits. Even in laboratories with advanced LC-MS equipments the lack of CTXs standards hinders the possibility of analysing complex matrices with a growing number of described congeners. The European Food Safety Authority (EFSA) is currently completing a mandate to issue a scientific opinion on ciguatoxins (Mandate M2006-0060 on Emerging toxins-ciguatoxins) in response to a question raised by the European Commission (DG-SANCO). National regulations specifically addressing CFP do exist in some EU countries with overseas territories in ciguatera endemic areas. For example, in French Polynesia, groupers, snappers, barracuda and surgeonfish are banned for sale (Bagnis, 1992).

2. ONGOING RESEACRH AND MANAGEMENT OF BENTHIC HABS IN ICES COUNTRIES

2.1 Research and Management of Benthic HABs in Spain

2.1.1 *Ostreopsis* blooms research and management in northern in Catalonia

(Magda Vila, Marine Biology and Oceanography Department, ICM-CSIC, Barcelona. magda@icm.csic.es)

Ostreopsis blooms have been studied intensively during two years (2009-2010) in Sant Andreu de Llavaneres beach (NW Mediterranean Sea), a hot spot for toxic aerosol events in the Catalan coast, in the framework of the EBITOX project. *Ostreopsis* abundances in seawater and epiphytic on macrophytes have been monitored monthly during winter and weekly or biweekly during the blooming period, and quantified by

light microscopy (Vila et al., in prep.). During the two years of study palytoxin-like compounds (PLTX) have been analysed in the microepiphytic assemblages (Riobó et al., in prep.). At specific times the quantifications have also been done by qPCR assay (Casabianca et al., in press).

It is suspected that bacterial populations associated to *Ostreopsis* in the natural assemblages could contribute to the bloom toxicity. Thus, bacterioplankton and epiphytic bacteria assemblages have been characterized during the two sampling years of the project.

Ostreopsis showed a marked seasonality, being detected from July to mid-November. Molecular tools (PCR) revealed that the bloom was clearly dominated by *O. cf. ovata*, although *O. cf. siamensis* was detected in some occasions. The epiphytic *O. cf. ovata* bloom maintained concentrations above 10^5 cells·g⁻¹ w.w. during the hot season, forming a brown mucilage that coated the benthic community of macrophyte. Usual *Ostreopsis* abundances in the water column during the bloom season ranged between 10^3 to 10^4 cells·L⁻¹; however, numbers above 10^5 cells·L⁻¹ were sporadically recorded.

High Volume Air Pump samplers were installed in order to monitor the marine aerosol in the beach. The presence of *Ostreopsis* in the aerosol filters was investigated using both Scanning Electron Microscopy and molecular tools (PCR); the potential presence of PLTX was tested by LC-FLD and haemolytic assay. In the aerosols, SEM observations revealed the presence of some marine microalgae (mainly diatoms), whereas the presence of *Ostreopsis* was unclear using SEM; however, molecular assays revealed the presence of *O. cf. ovata*. In particular, qPCR assays estimated *O. cf. ovata* abundances up to 100 cells per filter during an outbreak in summer 2010 (Casabianca et al., in press). These concentrations are below the detection limit of the existing PLT quantification tools. In contrast, PLT ranged between 0.1 and 1.2 pg/cell in the microepiphytic assemblages.

Data to determine the relationship between *Ostreopsis* concentrations, health disturbing symptoms and meteorology are currently being analysed. The characterization of the bacterioplankton revealed that the highest abundances of planktonic bacteria coincided with the *Ostreopsis* bloom period. In turn, epiphytic bacteria assemblages (on macrophytes) were significantly more active than during periods when *Ostreopsis* was not present. In addition, epiphytic bacteria were significantly more diverse and more active than bacteria in seawater. DGGE gel-based sequential analyses detected the presence of several bacterial strains that could contain tetrodotoxin (e.g. *Vibrio*) (Borrull et al., in prep.). Following this relevant observation, huge amounts of epiphytic bacteria have been concentrated and processed to analyse the potential presence of certain toxins which may contribute to the toxicity of the *Ostreopsis* blooms. Analyses are in progress.

The aforementioned study has been financed by the Spanish national project EBITOX: "Study of biological and toxinological characteristics of benthic dinoflagellates posing a risk to human health" (CTQ2008-06754-C04-04). PI: J.M. Franco (Unidad Asociada IIM-CSIC and IEO-Vigo). A. Penna (Biomolecular Department, Urbino University, Italy) and M.M. Sala (Marine Biology and Oceanography Department, ICM-CSIC, Barcelona) have participated as external collaborators of this project.

Management: As part of the cooperation between the EBITOX research project and the water quality monitoring program, ICM-CSIC scientists involved in the project contact the ACA (Catalan Water Agency) whenever *Ostreopsis* concentration reaches $\sim 10^5$ cells·g⁻¹ w.w. macroalgae or $\sim 10^4$ cells·L⁻¹ in seawater at Llanvaneres. This thresh-

old is based on empirical results suggesting that at those concentrations health problems in humans can occur if the wind is blowing landwards (Vila et al. 2012).

2.1.2 Benthic HABs detection and research in southern Catalonia

(Pablo de la Iglesia, IRTA, Tarragona. Pablo.delaIglesia@irta.cat)

Research conducted to address emerging toxins and/or benthic HABs have been developed within the framework of several projects. The exposure to regulated and non-regulated (emerging) toxins have been assessed by a national project in samples from the shellfish harvesting areas and also from retail markets and expedition centres (Project INIA, RTA2009-00127-00-00). Benthic HABs, such as *Ostreopsis* spp. in the Ebro Delta surrounding area (NW Mediterranean Sea) have been also the subject of study in another project. Population dynamics in the environment as well as laboratory experiments with some microalgae isolates are still in progress, and some conclusions are expected regarding the impact of benthic blooms on sea urchins populations, aquaculture and human health (project JACUMAR). Emerging toxins with special focus on food safety and human health will be covered in a EU-context through the 7th framework KBBE.2012.2.4-01 project “ECsafeSEAFOOD” (Grant agreement No 311820), together with other seafood contaminants. Other related activities dealing with HABs and microalgae are the exploitation of remote sensing and modelling as early warning tools against HABs by the “Purga de Mar” project, (INNPACTO, IPT-2011-1707-310000), and the use of diatoms as nano-structured supports in the design of novel biotechnologies (DIANA project, MINECO, BIO2011-26311)

2.1.3 *Ostreopsis* distribution in the Atlantic coast of Iberia

(Enma Orive, Plant Biology and Ecology Department, University of the Basque Country, emma.orive@ehu.es)

The distribution of *Ostreopsis* cf. *siamensis* and *Ostreopsis* cf. *ovata* in the Atlantic coasts of Iberia have been studied by a group in the University of the Basque Country (David et al., 2012). They found that temperature ranges observed in the study area could not explain the species distribution but presumably the length of the warm period was the key factor. Their hypothesis is that for *Ostreopsis* to be present in a certain area three continuous months with SST above 19.5°C may be necessary. The morphological and phylogenetical characterization of *Ostreopsis* species in the same region has been studied by the same group (David et al., accepted).

2.1.4 *Ciguatera* and other Benthic HABs in the Canary Islands

(Carolina Pérez, Banco Español de Algas BEA, Gran Canaria. cpe-rez@marinebiotechnology.org)

CFP outbreaks have occurred several years during the last decade in some (Lanzarote, Fuerteventura) of the Canary Islands. In all cases, the affected consumers had eaten “medregal” (*Seriola rivoliana*) caught either from sport or artisanal fishers, and served in local restaurants of these highly touristic area. The outbreaks had a strong socio-economic impact and affected local fish sales in an alarmed population with not much information on the problem. Following the last outbreak in Lanzarote (April 2012) local authorities prohibited the consumption of *Seriola* specimens larger than 15 kg and warned the population that all big fish have to be analysed by the Food Safety Department. To carry out these analyses, the fish needs to be frozen awaiting for the results of the analyses from samples sent to the capital of the archipelago (Gran Canaria), or even to the EU Reference Laboratory on Marine Biotoxins in Vigo.

Between May and November 2011, *Lyngbya majuscula*, a toxic benthic filamentous marine cyanobacterium that may cause dermatitis and other skin irritations, formed a bloom covering hundreds of square kilometres at a depth of 2-30 m off the east coast of Fuerteventura Island, Spain. This is the first record of this type of bloom in the Canary Islands. It was identified by BEA reported to the locally authorities.

2.2 Benthic HABs in Portugal

(Teresa Moita, IPMA, Lisbonne, Portugal tmoita@ipma.pt)

2.2.1 Mainland Portugal

As a consequence of the spreading of *Ostreopsis* blooms in the western Mediterranean Sea, a sampling programme was initiated in mainland Portuguese coastal waters aiming at the early detection of *Ostreopsis* and other benthic HAB species. The first surveys were carried out in 2007 (S coast) and 2008 (S and SW), and from all the samples analysed, specimens were only detected in Sines (SW) and identified as *Ostreopsis* cf. *siemensis* (Amorim *et al.* 2010). Later benthic surveys identified the same species further north (David *et al.* 2012). Toxin profiles of the Atlantic strains were investigated and *O.* cf. *siemensis* seem to present a much lower risk to human health than *O.* cf. *ovata*. (Ciminello *et al.* 2013).

In September 2011, mucilaginous filaments were observed in seawater of D. Ana beach (Lagos coast, south Portugal). Genetic analyses of isolates revealed the bloom was due to the outbreak of *Ostreopsis* cf. *ovata* that reached 5.5×10^3 cells L⁻¹ in seawater samples, although concentrations remained lower (up to 320 cells L⁻¹) in adjacent areas (David *et al.*, 2012). Local authorities closed several beaches for bathing for 5 days once informed about the bloom occurrence and model predictions for its transport. Only one case of respiratory and skin irritation was reported.

2.2.2 Azores and Madeira islands

Ostreopsis species were identified in the Azores archipelago (36-39°N, 25-31°W), at São Miguel island, during a summer survey carried out in 2008 (Silva *et al.*, 2010). The averaged SST was above 21°C around the island. The morphological analysis of the species suggested the presence of *O. heptagona*, *O.* cf. *siamensis* and *O.* cf. *ovata* that were present in seawater samples in small numbers (maximum 90 cells L⁻¹).

In Madeira island, *Ostreopsis* was detected for the first time in 2002 (Fraga, 2005), and the species identified was *Ostreopsis* cf. *ovata* (Penna *et al.*, 2010). Further south, in Savage Islands, the genus was detected in seawater, in low concentrations (700 cells L⁻¹), only in summer 2008. A recent study on seaweeds around Madeira island revealed a maximum of 12,639 cells g⁻¹ w.w. on *Corallina*/turf (Kaufmann and Böhm-Beck, 2013).

The above mentioned samples, collected at Savage Islands in 2008, were in fact sent to IPMA for HAB species identification after a severe incident of ciguatera-like intoxication affecting several fishers who consumed a big fish of *Seriola* sp. caught around the islands. At that time, despite the presence of *Ostreopsis*, no cells of *Gambierdiscus* were identified in seawater. Ever since, several CFP like episodes were reported almost every year and several ciguatoxins were detected from *Seriola* spp. caught in Savage Islands and Madeira (Vale, 2010; Boada, 2010). Since 2010, the regional authorities have banned the sale of *Seriola* spp. specimens greater than 10kg. Only in 2012, for the first time, Kaufmann and Böhm-Beck (2013) were able to identify *Gambierdiscus* sp. in seaweeds of Madeira. The identification of the species is under study.

2.3 Research and management of Ciguatera Fish Poisoning in the US.

(Information provided by Pat Tester and D.M. Anderson)

There are two ongoing research projects in the US.

“Species and Strain Differences in the Toxicity of Caribbean *Gambierdiscus* Species: Implications for Ciguatera Fish Poisoning in the Caribbean” (pat.test@noaa.gov). Ciguatera fish poisoning (CFP) is caused by the bioaccumulation of toxins, produced by tropical dinoflagellates in the genus *Gambierdiscus* when these toxins enter the marine food via herbivorous and then carnivorous fish. Globally, CFP causes more human illness than all other harmful algal bloom species combined. Despite this, relatively little is known about the variety of toxins produced by different *Gambierdiscus* species and the overall differences in toxicity among and between species. This is crucial information for understanding the variability of CFP incidences and how they may differ seasonally and spatially, even from the Atlantic to the Pacific. For example, ciguatoxins (CTXs) isolated from Atlantic and Pacific fish are structurally different. It has been proposed that these differences are due to the production of different toxin precursors by the resident *Gambierdiscus* species. Supporting evidence of this hypothesis comes from a recent study that confirmed distributional differences in *Gambierdiscus* species found in each basin. These differences may also account for why CFP symptoms tend to vary between the two regions. For example in the Pacific, *G. polynesiensis* is generally far more toxic on a per cell basis than other co-occurring species. If this is also true for the Caribbean, then it may be possible to assess CFP potential by monitoring these key species. We hypothesize that relatively few *Gambierdiscus* species are highly toxic and that they contribute disproportionately to the flux of toxins that enter the food chain. If this hypothesis is correct, species composition will affect the severity and frequency of CFP occurrences in an area. Given the importance of understanding the toxicity of individual *Gambierdiscus* species, the primary goals of this proposal are to:

- Establish the relative per cell toxicity of the five known Caribbean *Gambierdiscus* species and *Gambierdiscus* ribotype II using genetically characterized clones already established in the Tester (NOAA) Lab culture collection.
- Screen Caribbean *Gambierdiscus* species using the receptor binding bioassay to determine if *Gambierdiscus* ribotype 2 is more toxic than the other Caribbean species.
- Measure differences in hemolytic activity among Caribbean *Gambierdiscus* species as an indicator of MTX and CTX toxicity.
- Characterize and compare the toxins produced by Caribbean isolates of *G. caribaeus* from both the Caribbean and Pacific to determine if they produce different or similar toxin suites.
- Assess the extent to which CTX toxicity varies within a species and whether per cell toxicity varies systematically with latitude or geographic region.

Progress to date:

Detailed studies were undertaken using the hemolytic assay (Holland et al. 2013). Extensive fractionation studies were conducted to ensure the water soluble matitotoxin (MTX) and lipid soluble ciguatoxin fractions were being completely separated. The resulting protocol now provides a clean separation of the toxin types. This allows characterization of the variations in hemolytic activity (HA) from the CTX and MTX fractions extracted from six *Gambierdiscus* species found in the Caribbean. The results

from testing 56 isolates indicate that certain species had significantly greater HA than others. All species tested showed measurable HA with the exception of *G. carolinianus* isolates collected off the coast of North Carolina, USA. Experiments using specific inhibitors, hydrophilic and hydrophobic cell extracts, and heat treatments were all consistent with the observed hemolytic activity being due to maitotoxins (MTXs), the large polyether toxins produced by *Gambierdiscus* species. Geographically dispersed isolates of *G. caribaeus* (n = 26) and *G. carolinianus* (n = 15) were examined to determine regional differences in HA. *Gambierdiscus carolinianus* isolates from the western Caribbean and Gulf of Mexico had tenfold higher HA than isolates from the eastern Caribbean and 100-fold higher HA than isolates obtained from the continental shelf off North Carolina, USA. Similarly, *G. caribaeus* isolates from the western Caribbean and Gulf of Mexico had twofold higher HA than isolates from the Eastern Caribbean. Intra specific variation in HA of isolates from the same region was less than 5%. Depending on the species, HA consistently increased by ~7 to 40% from mid log growth phase to late log phase, and then declined in mid stationary phase to levels below those observed in log phase growth. Increasing growth temperatures from 20 to 31 °C for *G. caribaeus* from different regions showed only a slight increase in HA between 20 and 27 °C. HA in the *G. carolinianus* isolates from different regions grown over the same 20 to 31 °C temperature range remained constant. These data suggest that growth temperature is not a significant factor in modulating the intra and inter specific differences in HA. The HA of various isolates measured repeatedly over a 2 year period remained constant, indicating the compounds responsible for haemolysis were constitutively produced and under strong genetic control. Depending on species, > 65 to 95% of the total HA was associated with the cell membranes. The variation in HA for a limited number of *Gambierdiscus* isolates tested from outside the Caribbean was similar to that found within the Caribbean. This suggests that variations in HA among *Gambierdiscus* species is similar worldwide.

Another ongoing study in the US called *CiguaHAB* (danderson@whoi.edu) has the following objectives: 1) To characterize *Gambierdiscus* population diversity and connectivity on regional and local scales; 2) to determine effects of environmental factors on the growth and toxicity of representative strains of *Gambierdiscus*; 3) to investigate *Gambierdiscus* population dynamics and the environmental conditions that contribute to blooms in several locations for the study region; 4) to investigate the fate of ciguatoxins, their precursors, and metabolites in the coral reef foodweb; and 5) to model the population dynamics and toxin production of *Gambierdiscus* under different environmental forcing, including those associated with natural and human-induced perturbations.

At the federal level, the US FDA has the most extensive ciguatera-related activities in the US, though there are some research and monitoring efforts in other agencies such as the National Oceanic and Atmospheric Administration (NOAA) and the Centres for Disease Control (CDC). FDA activities (including collaborative research) at the Gulf Coast Seafood Laboratory, Dauphin Island, Alabama, include the following:

Outbreak Response and Training

Goal: Assist and respond to outbreaks of CFP, evaluate incidence, and identify new regions of concern

- 1) Assist international, national (e.g. CDC), state, and regional health departments in outbreak response for ciguatera fish poisoning. Includes consultation and guidance on sampling and information gathering, analysis of fishmeal remnants for ciguatoxins, and fish species identification as need-

ed. These efforts involve several divisions within FDA including the Division of Seafood Science and Technology (GCSL), Division of Seafood Safety (policy and guidance), and trace back with FDA district offices and the Coordinated Outbreak Response and Evaluation (CORE) Network.

- 2) Fish import surveillance testing as needed following reports of outbreaks in new/emerging areas of concern
- 3) Provide agency, interagency, state, and international training on chemical methods for ciguatoxins

Methods and Standards:

Goal: Optimize recovery, streamline analysis and validate methods for CFP

- 1) Validate screening and confirmatory methods for the detection and quantification of ciguatoxins in fish, shellfish, crustaceans, and clinical samples.
- 2) Ouabain- veratridine dependent neuroblastoma cytotoxicity assay (sodium channel specific)
- 3) Liquid chromatography-tandem mass spectrometry methods
- 4) Develop and optimize chemical extraction and solid phase clean-up methods for ciguatoxins in seafood and clinical matrices
- 5) Isolate, purify, and produce ciguatoxin reference materials to support FDA regulatory and research analysis
- 6) Evaluate methods that are commercially available, develop new methods as technology and data becomes available

Prevalence of CFP and Distribution of Ciguatoxins

Goal: Gain better understanding on the prevalence and distribution of ciguatoxins in fish on a regional scale to prevent illness and inform relevant stakeholders

- 1) Prevalence of ciguatoxins in commercially relevant species
 - 1.1) Virgin Islands and Florida predatory reef fish
 - 1.2) Evaluate the potential human health risk associated with harvest and consumption of invasive species (e.g. lionfish)
 - 1.3) Flower Garden Banks National Marine Sanctuary with NOAA NMS (Emma Hickerson)
- 2) Perform fish market surveys to evaluate and identify risk and background exposure to ciguatoxins in endemic regions

Bioaccumulation and Trophic Transfer

Goal: Characterize the uptake, bioaccumulation, and elimination of ciguatoxin precursors, toxins, and metabolites within and between species

- 1) Ciguatoxin exposure experiments in model fish and reef species
- 2) Determine the tissue distribution of ciguatoxins in fish to determine best sampling practices
 - 2.1) Caribbean
 - 2.2) Pacific (collaboration)
- 3) LC-MS/MS profiling and metabolomics of benthic dinoflagellates and fish from multiple trophic levels

Biomarkers of exposure

Goal: Identify characteristic biomarkers of ciguatera exposure in fish and clinical samples to develop new methods, field, and diagnostic tests

- 1) Transcriptomics and proteomics of clinical samples from CFP exposed individuals from the US Virgin Islands
- 2) Proteomics and transcriptomics analysis of fish following incurred exposure to ciguaterins and assessment of toxic and non-toxic fish from a single species.

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3.6 ToR g) Finalize plans for Workshop on Automated Harmful Algal Bloom in situ Observation Systems

During the prior WGHABD meeting in Oban, the idea of holding a workshop on in situ, autonomous sensors for HAB cells and toxins was discussed. The original goal was to acquaint Working Group members with the new technologies, as well as with the realities of purchasing, maintaining, and operating them in HAB research and monitoring programs. The ideal place for such a meeting would be in Woods Hole, since the Anderson lab owns two of the major instruments that were to be evaluated – the Environmental Sample Processor (ESP) and the Imaging Flow Cytobot (IFCB).

The ESP is a submersible, robotic instrument that collects discrete water samples, concentrates micro-organisms or particles, extracts target molecules, and automates application of molecular probes to identify micro-organisms and gene products. Real-time detection chemistries rely on DNA probe and protein (antibody) arrays to detect target molecules such as the HAB toxin domoic acid. Potential applications of ESP are many, as corroborated in the short video found at <http://www.mbari.org/ESP/espdeepmovie.htm>. In comparison to the IFCB's output, ESP data products are much less information rich but far more definitive, giving species-specific abundance estimates of tens of target molecules for up to 44 time points during a single deployment. The limited number of time points is a constraint imposed by the system's array magazine.

The IFCB is an imaging flow cytometer that essentially acts as an automated, underwater microscope. It is able to analyse one 5-mL seawater sample every 20 minutes, taking up to 12 images s⁻¹ of phytoplankton cells ranging in length from 10 to 100 µm.

The instrument operates continuously during submerged deployments of 6 months or more. IFCB data are information rich; cell images can be used to identify different life cycle stages, estimate *in situ* division rates, and detect impacts from parasites and grazers.

A third instrument would also potentially be demonstrated – the FlowCAM. This is an integrated system for rapidly analysing particles in a fluid, combining the high speed automated capabilities of a particle analyser with the information derived from microscopic images. By acquiring and storing a digital image of each particle detected, different particle types in a heterogeneous sample can be automatically identified, differentiated and quantified. The FlowCAM is, however, not yet submersible, so it is used in benchtop applications.

After some discussion, it was clear that a workshop at Woods Hole in conjunction with the annual WGHABD meeting would not be feasible in the next several years, as the timing for that meeting coincides with two major field programs in the Anderson laboratory, both of which involve field deployments of the ESPs and the IFCB. Laboratory staff would be fully occupied with field activities, and would not have time for tutorials and demonstrations on the instruments. Furthermore, in mid April, the IFCB will already be deployed, and would thus not be available for demonstration, and the ESP will be on the verge of deployment, and thus will not be available for that purpose either. A meeting at a different time of the year was discussed, but would have been heavily constrained by the availability of travel funds for WG members.

The WG decided that it would be worthwhile to have a session of next year's meeting in which presentations are given on the details of use of these new instruments. D.M. Anderson would discuss the ESP and IFCB, and Allan Cembella the FlowCAM. Keth Davidson would arrange a presentation on the use of gliders and other autonomous vehicles for HAB monitoring. The talks would address the realities of buying, maintaining, calibrating, deploying, and communicating with these instruments for HAB studies. Where possible, video footage would be provided to demonstrate operational details. At the conclusion of these presentations, the WG would discuss the need for further information exchange, possibly in the form of a community-wide workshop involving more types of HAB sensors with participation of a broader cross section of the HAB community than is currently represented on the WGHABD.

3.7 ToR h) Quantify the scale of the problem associated with Fish Killing Algae in the ICES region

This work is underway but not completed. The item is suggested to be a term of reference for the 2014 WGHABD meeting.

4 Report from the ICES-PICES-IOC-SCOR Workshop on Harmful Algal Blooms in a Changing World WKHABCW

Bengt Karlson, one of the conveners of the workshop reported about results. A workshop report is available at ICES www.ices.dk An ICES-PICES-IOC scientific symposium on Climate change and Harmful Algal Blooms is planned for 2014 or 2015.

5 Proposed session for the 2014 ICES ASC - Harmful Algal Blooms in Aquaculture and Fisheries ecosystems: prediction and societal effects

After the WGHABD meeting an-mail discussion among the members led to a per capsulam decision to suggest a session for the ICES Annual Science Conference in 2014.

Conveners: Beatriz Reguera (Spain), Juan Blanco (Spain) Bengt Karlson (Sweden).

Harmful Algal Blooms (HABs) represent a major hazard for the exploitation of coastal resources in ICES countries. Toxin producing HABs are recurrent phenomena leading to prolonged shellfish harvesting closures when algal toxins are accumulated in commercial bivalves and exceed regulatory levels. The most important syndromes are amnesic (ASP), diarrhetic (DSP), azaspiracidic (AZP) and paralytic (PSP) shellfish poisoning. DSP outbreaks caused by *Dinophysis* spp., previously unreported in the Atlantic coasts of USA, have emerged in the last years as a new hazard in various places in North America ranging from New York to the Gulf of Mexico as well as in Pacific coasts of Canada and northwest US. High biomass blooms of fish-killing HABs are noticed mainly in areas of intensive caged-fish aquaculture, e.g. in Scandinavia and Scotland. Emerging toxins from species of benthic HABs (*Gambierdiscus*, *Ostreopsis*) traditionally reported from tropical areas have caused isolated events of Ciguatera Fish Poisoning (CFP) in Macaronesia (Canary, Madeira Islands) and outbreaks of respiratory irritation in the Spanish and French Mediterranean coasts. Blooms of benthic HABs were recently (2011) reported in tourist resorts from the Algarve (southern Portugal). In the Baltic Sea, and recently also in the Canary Islands, blooms of cyanobacteria have resulted in surface scums, which were a nuisance when accumulated in bays and on beaches. Some species are toxic.

Improved monitoring and predictive capabilities constitute the main tools to prevent or mitigate the negative impacts of HABs in coastal commodities. Increased monitoring efforts, technological developments for in situ detection of harmful algae and new analytical tools for toxins, together with international programmes and projects promoting species-specific research in the last two decades have led to a considerable advance in our capabilities for early warning detection and for understanding of the mechanisms underlying initiation, maintenance and decay of the blooms. Additionally, the application of operational oceanography principles to forecast HAB events has improved the flow of information from research and monitoring agencies to the end-users (health and environmental authorities, shellfish growers, tourist industry). Some mitigation practises have started to be implemented in restricted areas, e.g. direct chemical treatment of ballast and semi-enclosed water bodies. A combination of information from in situ HAB management programs, remote sensing and derived information from models may be made to analyse HAB events and their trends within a broader framework in an effort to minimize societal impacts.

Focus of session

Advances in the ecology and oceanography of HABs in the ICES domain

Improvements in HAB forecasting – coupled physical-biological and toxin uptake-detoxification models.

HABs and their impact on wild fisheries and shellfisheries

Emerging benthic HABs and their toxins.

Advances in automated HAB observing systems, biosensors and toxin-detection methods.

Mitigation strategies

Supporting information for the end-users

Priority:

Scientific justification:	Fast growing research and technological issue due to its large socio-economic impact worldwide.
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Participants:	It is expected that responses to a call for contributions will reflect the wide interest and ongoing research and monitoring activities on this topic.
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Linkages to advisory committees:	SCICOM, SSGHIE
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Linkages to other committees or groups:	WGHABD, SGOA, WGIPEM, WGBOSV, WKHABCW, WGPME
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Linkages to other organizations:	IOC, SCOR, PICES, OSPARCOM, HELCOM
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6 Draft Resolutions

The ICES IOC Working Group on Harmful Algal Bloom Dynamics [WGHABD] (Chair B. Karlson, Sweden) will meet in IJmuiden, Netherlands, 29 April to 2 May 2014 to:

- a) To report on new findings in the area of harmful algal bloom dynamics
- b) To deliver National Reports on harmful algal events and bloom dynamics for the year 2013
- c) To summarize the harmful algal bloom events 1990-1999 and in 2000 to 2009 in the ICES region based on decadal maps using HAEDAT with a view to investigating if data are of a quality that allows interdecadal comparisons.
- d) To review progress regarding the entering of data onto the HAEDAT database., and review synthesis stories (HAEDAT entries from start to date) submitted in advance from each country with a view of drafting a 'synthesis story' about HAB events in the ICES area.
- e) The WG should report on Automated Harmful Algal Bloom in situ Observation Systems
- f) To finalize draft a review document quantifying on the scale nature and extent of the problems associated with fish killing algae in the ICES region.
- g) To review progress and advise the conveners on the planned session on Harmful Algal Blooms in Aquaculture and Fisheries ecosystems: prediction and societal effects at the 2014 ICES Annual Science Conference in La Coruna, Spain
- h) To 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) To contribute to the development of a Global Harmful Algal Bloom Status Report

WGHABD will report on the activities of 2014 by the 15 June 2014.

Priority	The activities of this group are fundamental to the work of the Oceanography Committee. The work is essential to the development and understanding of the effects of climate and man-induced variability and change in relation to the health of the ecosystem. The work of this ICES-/IOC WG is deemed high priority.
Scientific justification and relation to action plan	Action Plan No: 1.1, 1.2, 1.5, 1.7, 1.10, 1.11, 1.12, 2.3, 2.9, 3.2, 4.11, 5.10, 5.13, 5.16, 6.1, 6.2, 6.3, 6.4, 8.1, 8.2, 8.4. Term of Reference a) WGHABD is a useful forum to discuss and present new findings among the members. This is an excellent forum to promote and discuss topics of relevance. There are obvious reasons to continue

	<p>this topic as an ongoing term of reference</p> <p>Term of Reference b)</p> <p>National Presentations and review occurrences of HABs in the ICES area, making use of the HAEDAT system.</p> <p>Term of Reference c)</p> <p>The data on harmful algae events in the HAAEDAT database will be supplemented and used for the evaluation.</p> <p>Term of Reference d)</p> <p>The HAEDAT system has been functional for the past four years and WG members have nominated responsible representatives in each country for the entering of HAB events onto the system. The WG will review the status of the database and success of the continuing updating by participant countries. The mapping and search functionality will be used.</p> <p>Term of Reference e)</p> <p>The WGHABD should discuss the present status of in situ, autonomous instruments for HAB monitoring and management, and consider future actions, such as a larger community workshop or conference on this topic. The WG should also review the opportunities afforded by gliders and autonomous underwater vehicles to make measurements relevant to HAB detection.</p> <p>Term of Reference f)</p> <p>Harmful species of micro-algae have been associated with mortalities of farmed and wild fish and a broad variety of marine organisms. Aquaculture operations are particularly vulnerable and HABs pose a threat to the security of food supply from this sector in the ICES region and globally. During 2012-13, WGHABD will quantify the scale of the problem in ICES member states and prepare a review for discussion at the next WG meeting and presentation at the IOC intergovernmental panel on harmful algae in 2015.</p> <p>Term of Reference g)</p> <p>The session at the 2014 ICES ASC will be important for sharing new results among scientists, managers and also with fishery and aquaculture.</p> <p>Term of Reference h)</p> <p>Climate change will affect harmful algal blooms in many ways. The planned scientific symposium will be a way to promote the research area and to report new results.</p> <p>Term of Reference i)</p> <p>The IOC Intergovernmental Panel on Harmful Algal Blooms, IPHAB decided in 2013 to develop a Global HAB Status Report. It was decided that WGHABD should contribute to the development of the report. This will be a good opportunity to use available data, improve monitoring and reporting systems to report on the in-</p>
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	creasing problems with HAB's.
Resource Requirements	The research programs which provide the main input to this group are already underway, and resources 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 Advisory Committees	There are no obvious direct linkages with the advisory committees
Linkages to other committees or groups	WGHABD interacts with WGZE, WGPME, WGPBI.
Linkages to other organizations	The work of this group is undertaken in close collaboration with the IOC HAB Programme. IOC should be consulted regarding ToR or discontinuation of the WG prior to the ASC. There is a linkage to SCOR through the interactions of the IOC-SCOR GEOHAB Programme.
Secretariat marginal Costs	ICES

7 Recommendations

WGHABD recommends SCICOM to support the proposal of an ICES-PICES-IOC scientific symposium on Climate Change and Harmful Algal Blooms to be arranged in 2014 or 2015.

8 Closing of the meeting

The Chair thanked the host from the Agri Food and Biosciences Institute, and congratulated him on behalf of the working group. He also thanked the participants for their input especially the rapporteurs and closed the meeting.

Annex 1: List of participants

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Annex 2: Agenda

Tuesday, April 9, 2013 lte

Time	ToR	Lead(s)	Item
09:15-10:00		B. Karlson R. Gowen	Opening of Meeting, Logistics, Introductions, Adoption of the Agenda
10:00-10:30	d	H. Enevoldsen	Review progress regarding the entering of data onto the HAEDAT database, and how data can be extracted and utilized;
10:30-10:50			Health Break
10:50-11:30	h	R. Gowen	Quantify the scale of the problem associated with Fish Killing Algae in the ICES region.
11:30-12:30	c	B. Karlson	Develop and set up a new reporting format for producing major reports every three years
12:30-13:15			Lunch
13:15-15:00	b	All participants	National reports
15:00-15:30			Health Break
15:30-17:00	a	All participants	New findings/report writing
17:00			End of session

Wednesday, April 10, 2013

Time	ToR	Lead	Item
09:15-10:00	e	All Participants	Undertake time-series analyses of HAB species and associated events
10:00-10:30	g	D. Anderson	Status for plans on a workshop focused on automated HAB in-situ observation systems
10:30-10:50			Health Break
10:50-12:30	b	All Participants	National reports
12:30-13:15			Lunch
13:15-15:00		Authors	Excursion/Cooperative research report
15:00-15:30			
15:30-17:00			Excursion/report writing
19:00-		Everyone	Group dinner (participant's expense)

Thursday, April 11, 2013

Time	ToR	Lead	Item
09:15-10:00	f	B. Reguera	Review state-of-the-art and ongoing research and managerial activities related to emerging benthic HABs in ICES countries;
10:00-10:30	b		National reports
10:30-10:50			Health Break
10:50-11:30	b		National reports
11:30-12:30	a		New findings
12:30-13:15			Lunch

13:15-13:45		D. Anderson B. Karlson	Preliminary results from the ICES-PICES-IOC- GEOHAB Workshop on HABs and Global Change WKHABCW
13:45-15:00	c	B. Karlson	Develop and set up a new reporting format for producing major reports every three years
15:00-15:30			Health Break
15:30-17:00		B. Karlson	Decide on 2014 Meeting Location Draft 2014 Resolutions / ToRs Report writing
17:00			End of session

Friday, April 12, 2013

Time	ToR	Lead	Item
09:15-11:00			Draft 2013 Resolutions / ToRs Report writing
11:30			End of meeting

Annex 3: ICES-IOC Working Group on Harmful Algal Bloom Dynamics

Belfast, UK 2013



Participants of the WGHABD meeting in 2013. Left to right: Marnix Poelman, Allan Cembella, Theresa Moita, Don Anderson, Beatriz Reguera, Henrik Enevoldsen, Richard Gowen, Torbjorn Johnsen, Keith Davidson, Jennifer Martin, Joe Silke, Eileen Bresnan, Stephen Milligan, Bengt Karlson and Caroline Cusack.