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

24–27 April 2012

Oban, Scotland, UK

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Contents

Executive Summary

The 2012 ICES-IOC Working Group on harmful algal bloom dynamics was held in Oban, Scotland, United Kingdom, on 24–27 April hosted by the Scottish Association for Marine Science (SAMS). The meeting was successful with 20 scientists from 12 countries attending. This includes participants from the IOC Member States Egypt, Kuwait and South Korea. In addition one person participated in part of the meeting using video conference. A full schedule of terms of reference were worked through and this report is a summary of the deliberations of the group.

There is an extensive overview on the impacts of HAB's on marine mammals and birds in the report. An overview on the use of Solid Phase Adsorption Toxin Tracking - a monitoring tool for marine biotoxins is also included. A new way of categorizing Paralytic Shellfish Poisoning outbreaks in the Gulf of Maine is presented. The reader will find information on the Harmful Algal Event Database (www.iode.org/haedat) and overviews of the HAB situation in Egypt and in the ROPME area (www.ropme.org), approximately the Gulf of Oman and the Persian Sea. There are severe HAB problems in both areas and they seem to be increasing.

Fish killing algae is addressed in a separate section of the report and plans for two workshops are also included. One in 2013 on HAB's in a changing world addressing e.g. climate change impacts on HAB's, and one in 2014 on new technology for observing HAB's in situ.

National Reports

The National Reports for 2011 were presented to the group on the status of HABs from all ICES countries that participated in this year's meeting (9), reports of presentations are given in this document. Year 2011 included some unusual Harmful Algal Bloom Events in the ICES region and blooms in new geographic locations.

During 2011, the testing of shellfish for the presence of lipophilic shellfish toxins changed from the mouse bioassay to chemical LC-MS methods during July in many European countries. Several countries have used both methods for a few years.

Canada reported the first documented occurrence of Diarrhetic Shellfish Poisoning on the West coast. Sixty persons became ill in British Columbia. The causative organism is likely to be dinoflagellates from the genus *Dinophysis*. Also Paralytic Shellfish Toxins (PST) was found in mussels (causative organism *Alexandrium* spp.) and salmon mortalities caused by *Heterosigma akashiwo* occurred in fish farms. On the East coast Paralytic Shellfish Toxins (PST) was high in some areas a large part of the year.

Denmark reported no DSP, ASP or PSP. An extreme spring bloom of the fish killing alga *Pseudochattonella* cf. *farcimen* delayed the release of trout to fish cages. There were a few reports of dead wild sea trout.

Ireland had minor problems from Amnesic Shellfish Toxins caused by the diatom genus *Pseudo-nitzschia*. Diarrhetic Shellfish Toxins in mussels caused closures of harvesting mainly in June and Aug.-Sep. Paralytic Shellfish Toxins were limited to Cork harbour where it occurred for a short period in June.

The Netherlands Toxin levels were below the regulatory limit for all marine biotoxins monitored. Trace levels of DST were observed. *Dinopysis acuminata* was observed in low abundances. Also *Pseudo-nitzschia* spp. were found in low concentrations.

Poland A short episode of toxic *Nodularia spumigena* was recorded 29–30 June in coastal waters. Accumulations of scums in coastal areas resulted in beach closure in Gdynia. The concentration of nodularin in two classes of blue mussels (*Mytilus trossulus*) was measured. The smaller mussels accumulated higher concentration of the toxin than bigger mussels. Also fin fish was investigated for nodularin content. Generally, round goby accumulated higher amounts of the toxin than flounder. In some fish muscles, the toxin content exceeded the tolerable daily intake value (TDI) for a human.

Spain Between May and November 2011, *Lyngbya majuscula*, a benthic filamentous toxigenic cyanobacteria, formed a bloom covering hundreds of square kilometers on the eastern coast of Fuerteventura Island. This is the first record of this type of bloom in the Canarias archipelago. Andalucia suffered severe DSP outbreaks on the Atlantic sites and PSP outbreaks on the Mediterranean sites during 2011. Five persons were affected by Ciguatera Fish Poisoning (CFP) in the Canary Islands. A combination of DSP and PSP outbreaks led to very lengthy harvesting closures in Galicia. Andalucia suffered severe DSP outbreaks on the Atlantic sites and PSP outbreaks on the Mediterranean sites during 2011.

Sweden Diarrhetic Shellfish Toxins were observed in high concentrations in blue mussels in autumn on the Swedish Skagerrak coast. This coincided with high abundances of the dinoflagellate *Dinophysis acuta*. The potential fish killer *Pseudochattonella farcimen* was abundant in March-April in the Kattegat but no harmful effects were observed. An unusual high biomass bloom of *Ceratium* spp. caused brown water in November in the Kattegat. In the Baltic proper the intensity of the cyanobacteria bloom was moderate and it was found off shore. In the Bothnian Sea both coastal and off shore blooms of cyanobacteria were observed.

UK (Northern Ireland) A large bloom of *Dinophysis* spp. occurred in Belfast during July and August causing high levels of DST in blue mussels (*Mytilus edulis*). In **England and Wales** PST was breaching the action levels on 14 occasions. DST above regulatory levels were recorded in 12 shellfish samples. In **Scotland** *Alexandrium* spp. was observed on several occasions. On two occasions there were closures because of PST. There were also closures because of DST.

USA ***PSP*** On the U.S. west coast, Alaska, Washington, Oregon and California all recorded PSP toxicity during 2011. Eight confirmed and 13 probable PSP cases occurred in Alaska. New England experienced "normal" closures due to PSP. Also New York state had closures due to PSP. Florida experienced *Pyrodinium bahamense* blooms on the west coast. ***AST*** California experienced closures due to domoic acid. ***NSP*** Florida and Texas experienced *Karenia brevis* blooms on both the east and west coasts. At one point during the bloom, discoloured water and dead fish could be found along over 250 miles of Gulf beach. ***DSP*** For the first time, DSP toxins were detected in Washington state. DSP toxins were also detected in New York state. ***Brown tide*** Long Island, NY experienced a significant brown tide bloom, which began in June and ended in July.

1 Welcome and opening of the Meeting

The 2012 ICES-IOC Working Group on harmful algal bloom dynamics was held in Oban, United Kingdom, on 24–27 April hosted by the Scottish Association for Marine Science (SAMS). The meeting was successful with 20 scientists from 12 countries attending. This includes participants from the IOC Member States Egypt, Kuwait and South Korea. In addition one person participated in part of the meeting using video conference. On behalf of the host and the venue local organisers Keith Davidson (SAMS) 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 recognised that this expert group meeting provides an excellent opportunity to meet and collectively address the terms of reference that we have set ourselves and have been passed to us through ICES and IOC. Both ICES and IOC have recognised 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.

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.

20 Scientists representing 12 countries participated in the meeting. In addition one person participated in part of the meeting using video conference. 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. One person from Egypt participated in the meeting to inform about and to discuss the harmful algal bloom situation in Egypt. Three participants from Kuwait representing the Regional Organization for the Protection of the Marine Environment (ROPME) participated in the meeting to learn about ICES work with Harmful Algal Blooms and to contribute their knowledge to WGHABD. Also one person from PICES participated to plan the joint IOC-ICES-PICES workshop on Harmful Algal Blooms in a Changing World (WKHABCW). The two South Korean participants presented the 15th International Conference on Harmful Algae(ICHA) to be held 29 October to 2 November 2012 and contributed with information on HAB's in South Korea.

The list of participants is presented in Annex 1. The meeting agenda is presented in Annex 2. The meeting was very successful and with a full agenda of challenging and diverse terms of reference. An ICES SharePoint site was made available before and during the meeting. Although not without problems, this proved to be a valuable tool to speed up the work and make exchange of information more efficient. 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 organiser 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.

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.

2 Adoption of the agenda

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

3 Terms of Reference for the 2012 meeting

At the 98th Statutory Meeting (2011), Gdansk, Poland, SCICOM Steering Group on Human Interactions on Ecosystems (SSGHIE) produced Resolutions 2011 Terms of References as follows :

The **ICES-IOC Working Group on Harmful Algal Bloom Dynamics** (WGHABD), chaired by Bengt Karlson, Sweden, will meet in Oban, Scotland, UK, 24–27 April 2012 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 2010;

c) 1) Quantify the occurrence of fish killing algal events in the ICES region[1];

2) Document gaps in understanding of the processes controlling the occurrence of fish killing algae and the factors that cause fish mortality;

d) Scope and plan a workshop focused on automated in-situ devices and imaging technology (including newer molecular methods) used for observing HABs and detecting toxins;

e) To collate and discuss data on macroalgal blooms and their impacts in the ICES region;

f) Report on the impacts of harmful algal blooms on marine mammals and birds relevant to the Marine Strategy Framework Directive objectives;

g) Discuss and evaluate how ICES can expand its science on eutrophication issues, especially in the coastal zone (e.g. suggest new EGs, WK or SGs);

h) Evaluate potential for collaboration with other EGs and other ICES initiatives in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings).

1 This could be linked to the ToR to look for trends in the occurrence of HABs and associated events. We might not be able to perform statistical analyses, but maps of the ices area showing when and where fish kills occurred might be interesting.

4 Term of Reference A

4.1 To report on new findings in the area of harmful algal bloom dynamics

4.1.1 Harmful Algal Event Database updates

Henrik Enevoldsen, IOC, reported on changes in the Harmful Algal Event Database. The database is hosted by the IOC at: http://www.iode.org/haedat

Here follows a few examples of new functionality of the web interface:

1) Google Maps

- The maps are automatically zoomed and centred depending on what they have to display;

- They can be moved around by clicking and dragging on them;
- They can be zoomed in by double clicking;
- Clicking on one of the markers refines the search to the relevant grid;
- Maps are also displayed when showing any event with location data;
- All events associated with a HAE area are displayed by doing an advanced search for that area.

2) Downloading the whole data base

Users can download the entire database from the 'Browse' page or their 'Options' page. NB: This only includes the fields that were previously downloadable.

3) Event data checking

An interface has been added under the 'Options' page for checking event data. The administrator can check all records, and national editors can check records from their country.

4.1.2 Use of Solid Phase Adsorption Toxin Tracking (SPATT) in Scotland: monitoring tool for marine biotoxins

Jean-Pierre Lacaze, Marine Scotland Science

Introduction

Recent findings (Mackenzie *et al.*, 2004) made by scientists from New Zealand showed that significant amounts of marine biotoxins were being released in the water column during blooms of toxin-producing microalgae. This observation led to the development of a passive sampling technique based on the ability of an adsorbent such as synthetic resin, activated charcoal or computationally designed polymer to adsorb the toxins dissolved in the water. This new passive sampling technique was called SPATT (Solid Phase Adsorption Toxin Tracking).

The combination of SPATT with analytical detection tools (e.g. LC–MS and ELISA assays) has the potential to provide a simple and sensitive means for monitoring the presence and temporal evolution of biotoxins in inshore waters.

Scientists at Marine Scotland Science (MSS) have been involved since 2005 in the development and use of SPATT. Laboratory trials using different types of adsorbents led to the adoption and subsequent utilisation in field monitoring of a synthetic resin (Sepabeads® SP-700, Mitsubishi Chemical Corporation) which demonstrated good adsorption capabilities towards diarrhetic shellfish poisoning (DSP) toxins and other lipophilic toxins such as yessotoxins (YTXs), pectenotoxins (PTXs), azaspiracids (AZAs) and spirolides (SPXs). Additionally, domoic acid (DA), which is the main toxin responsible for amnesic shellfish poisoning (ASP), was found to bind efficiently to the same resin.

The SPATT sampler in use at MSS consists of a nylon mesh bag of relatively small dimensions (15 x 5 cm) filled with ca. 12 g of SP-700 resin. The bag is two thirds closed with a non-releasable cable tie and a clip is used to seal the top which serves at the same time as an anchor point. The SPATT sampler is then simply attached to a mooring line few meters below the surface using a cable tie and is deployed on a weekly basis at the monitored location. Desorption of the toxins from the SP-700 resin is done in the laboratory using a washing step first (deionised water) followed by an elution step using either methanol (100 mL) for lipophilic toxins extraction or a combination of methanol:water (50:50 v/v, 100 mL) for domoic acid extraction.

MSS scientists have used SPATT bags since 2005 at Loch Ewe on the west coast of Scotland, and since 2011 at Scapa in Orkney and Scalloway in Shetland as part of an environmental monitoring programme. SPATT samplers were also deployed for an EU-funded project (WATER) at a couple of other locations on the west coast of Scotland, namely Loch Spelve and Loch Creran, during the summer period in 2009 and 2010. Finally, Basta Voe in Shetland and Loch Roag in the Western Isles are two other locations where SPATT bags have been deployed weekly since November 2011. The monitoring period is planned to last a full year with the main objective being the screening of dissolved AZA toxins. In addition to the deployment of SPATT bags, SP-700 resin was also used in small cartridges installed in an Aqua Monitor water autosampler (Envirotech Instruments LLC, Chesapeake, USA). Deployed regularly at Loch Ewe and in Shetland over the past few years for relatively short monitoring periods, it was demonstrated that passing 3.6L of seawater through the SPATT cartridges was sufficient to allow the adsorption of quantifiable amounts of toxins onto the resin.

Loch Ewe – SPATT & *Dinophysis sp.* – 2005–2012 monitoring

Loch Ewe was the location in Scotland where the first SPATT samplers were deployed on a weekly basis from 2005 for the monitoring of lipophilic toxins. As part of an integrated environmental monitoring programme, weekly phytoplankton samples were also collected. In June 2005, a couple of months after the start of the SPATT deployment, there was a bloom of *D. acuminata* (2500 cells.L^{-1}) which was quickly followed by an increase in DSP toxins (OA, DTXs) extracted from the SPATT samplers (max. ca. 700 ng DSP toxins.g^{-1} resin). A few weeks later, towards the end of July, a small bloom of unidentified *Dinophysis sp.* (350 cells.L^{-1}) was immediately followed by large amounts of DSP toxins extracted from the SPATT resin (~ 1µg DSP toxins.g^{-1}

resin). The occurrence of these *Dinophysis sp.* bloom events in 2005 led MSS to start in spring 2006 the deployment and collection of mussels (*Mytilus edulis*) on a weekly basis. However, no other large blooms of *Dinophysis sp.* were recorded since summer 2006 while the levels of DSP toxins did not go over 400 ng DSP toxins.g^{-1} resin. It is interesting to note that DSP toxins seem to be present in the water column all year long even during the winter period at very low levels but high enough to be detected by LC-MS.

Loch Ewe – SPATT & *Pseudo-nitzschia sp.* – 2008 monitoring

A bloom of *Pseudo-nitzschia sp.* reaching a maximum of 300 000 cells.L^{-1} occurred towards the end of September 2008. Levels of DA extracted from the SP-700 resin increased gradually during September and a maximum of 4.3 ng DA.g^{-1} resin was detected few days after the peak of *Pseudo-nitzschia sp.* had been reached. DA was also detected in the mussels flesh and the temporal evolution of DA concentration in shellfish and SPATT was found to be very similar.

Loch Ewe – SPATT & *AZA.* – 2005-2007 monitoring

Monitoring the presence of AZA was performed using SPATT between 2005–2007. Increased concentrations of AZAs were observed in SPATT during the late autumn-winter period when few phytoplankton cells were present in the water column. *Azadinium spinosum* had yet to be described during this study period. However phytoplankton samples corresponding to samples with increased concentration of AZA contained in general a low biomass of phytoplankton.

Loch Creran – SPATT, Lingulodinium polyedrum & Protoceratium reticulatum – 2010

As part of an INTERREG project, SPATT bags were weekly deployed in 2010 at Loch Creran on the west coast of Scotland and the toxin-producing phytoplankton community was also simultaneously monitored. Levels of YTXs extracted from the SPATT samplers started to raise from mid-June at the same time as the number of *Protoceratium reticulatum* cells in the water started to increase. The levels reached a maximum for YTXs (200 ng YTXs.g^{-1} of resin) and *P. reticulatum* (1500 cells.L^{-1}) during the first week of July. During this period, the concentration of another known YTX producer, *Lingulodinium polyedrum,* in the water column slightly increased (< 150 cells.L^{-1}), but this was not seen as being significant. It was reasonable to attribute the surge in YTX solely to the *P. reticulatum* bloom.

Later this summer in August, *L. polyedrum* levels started to increase and reached a maximum of 2000 cells. L^{-1} on the 30th of August. Levels of YTXs extracted from the resin increased also slightly reaching 25 ng YTXs.g^{-1} of resin. Although the *L. polyedrum* bloom reached higher cell numbers than the *P. reticulatum* event, the YTX toxicity recorded in the SPATT samplers deployed during the events was 8 fold lower during the *L. polyedrum* bloom. The toxin levels recorded in SPATTs during summer 2010 clearly demonstrate that YTX production by dinoflagellates at Loch Creran is very much dependant on the species type, with *P. reticulatum* exhibiting production of much larger quantities of YTXs than *L. polyedrum*.

Loch Creran – SPATT & *Alexandrium sp.* – 2010

Spirolides (SPXs) were also detected in SPATT during summer 2010 corresponding to a couple of increased levels of *Alexandrium sp.* occurring in July and August (60 cells.L^{-1}). The presence of two spirolides, namely desMethyl-C and 20-Methyl-G SPX, recovered in SPATT confirms the presence of *A. ostenfeldii* as the toxin producer. Results from the SPATT analysis show that 20-Methyl-G SPX is the dominant spirolide analogue produced by *A. ostenfeldii* at Loch Creran.

Conclusion

- The above SPATT samplers made of SP-700 resin demonstrate that this passive sampling technique is an efficient tool to monitor *in-situ* the presence of lipophilic toxins and domoic acid in the water column.
- SPATT is a simple and sensitive technique which targets directly the marine biotoxins.
- Extracts from SPATT are free of co-extracted compounds (proteins…) occurring in shellfish which is proving to be much friendly for LC-MS/MS analyses.
- This is a time integrated monitoring technique which provides a good simulation of biotoxins accumulation in shellfish.
- This technique has the potential to improve spatial and temporal sampling opportunity.
- Coupled to rapid testing techniques (ELISA, PP2A, lateral flow), SPATT can be a useful management tool for harvesters.
- Combining phytoplankton and SPATT monitoring is proving to be a very informative tool by providing a good indication of the actual toxicity of a bloom event and can provide valuable information about the dynamics of toxin producing blooms in areas where shellfish are not readily available for testing.

References

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4.1.3 Categorizing the severity of PSP outbreaks in the Gulf of Maine for forecasting and management

Don Anderson, Woods Hole Oceanographic Institution, USA

Development of forecasting systems for HABs has been a long-standing goal of HAB research and management. Significant progress has been made in this regard in the Gulf of Maine, where seasonal bloom forecasts are now being issued on an annual basis using cyst abundance maps and an *Alexandrium* population dynamics model. For the seasonal forecasts that we have issued since 2008, it has been a challenge to describe the severity of the bloom that is being predicted. Our approach to the forecasting (described in McGillicuddy *et al.* 2011) generates estimates of region-wide *Alexandrium* cell abundance for the forthcoming bloom season, but does not yet project toxicity and shellfish closures along the coast. Press releases issued to describe the forecasts have used bloom descriptors that are relatively general (e.g. "severe", "moderate", "moderately large") and that therefore do not provide the type of information that the general public and resource managers would like. We would like to provide information analogous to that given in severe storm forecasts such as those for hurricanes, which are designated Category 1–5 based on their projected wind speeds. Such information is of great value to those anticipating an outbreak, as the specifics of each category are known, and the extent of damage or the precautions necessary to avoid damage are clear.

After discussions with officials responsible for shellfish monitoring along the New England coast, we determined that the parameter that would be most useful in a forecast would be the extent of coastline that is closed due to PSP toxins. We therefore initiated a program to develop a set of classification categories that could be used to describe the severity of *Alexandrium* blooms within the region. This effort is described in detail in Kleindinst *et al.* (in prep), and is summarized as follows.

Historical data on shellfish closures were used to produce maps in which the areas that were closed to harvesting were indicated using a consistent set of straight-line segments. Examples of two years with widely differing levels of shellfish closures are shown in Figure 1. Digital mapping tools were used to measure the length of coastline closed each year from 1977 to the present. These distances were then clustered into 3 categories (0-199 km, 200 – 399, and 400 – 600 km). These categories are tentatively termed "Limited", "Moderate", and "Extensive". These terms were selected because they have a geographic connotation, whereas other terms such as "severe" do not. When future forecasts are issued, these descriptive terms will be used, and the implied length of coastline closures will be provided as well, but we will not specify a "category number". To our knowledge, this is the first effort to quantify or classify the severity of HAB outbreaks.

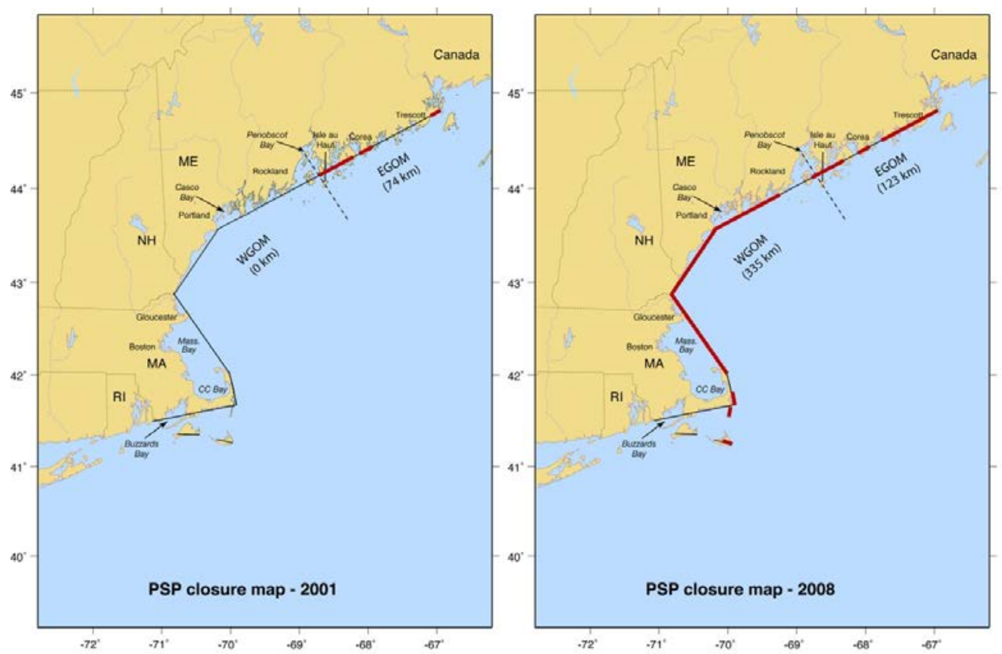

Figure 1. Example maps of varying closure levels due to PSP in the Gulf of Maine – A) 2001; B) 2008. With the new bloom severity classifiers, 2001 would be termed "Limited", and 2008 "Extensive".

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4.1.4 Prince 5 and Wolves Samplings (Bay of Fundy)

Martin, J.L., M.M. LeGresley, P.M. McCurdy, F.H. Page, J. Fife, K. Pauley and S. Scouten

Temperature and salinity sampling was initiated at a sampling location in the Bay of Fundy, Atlantic Canada, at Station Prince 5 in 1924 and continues today. A phytoplankton monitoring programme was initiated close to the Wolves Islands, Bay of Fundy (and not far from the Prince 5 site) in 1988 in response to a rapidly growing aquaculture industry and concerns about environmental impacts and harmful algal blooms (HABs). Results from early phytoplankton sampling work in the late 1970s and early 1980s on the paralytic shellfish poisoning (PSP) producing organism, *Alexandrium fundyense*, and its distributions in the Bay of Fundy determined that Prince 5 was not the best indicator site for *A. fundyense* population dynamics studies and sampling at the Wolves Islands gave a better representation of offshore phytoplankton populations and their transport to the inshore regions. As a result, the long term sampling site at the Wolves was initiated in 1988 and has been monitored regularly since.

Sampling at the Wolves site is at weekly intervals between April and late October resulting in 652 total visits from 1988–2011 whereas at Prince 5 samples are collected monthly resulting in 240 samplings during the same time period. Sampling at the Wolves includes phytoplankton species abundance, nutrients, secchi and CTD casts at the surface, 10 m, 25 m and 50 m; sampling from Prince 5 is at the surface, 10m, 25m, 50m and just above bottom (approximately 90 m). Analyses of phytoplankton from the Wolves are from each of the discrete depths every week during bloom periods whereas at Prince 5, 100 ml from each depth is integrated into one sample during the mid-month sampling. Phytoplankton samples are analysed from the Wolves at SABS using the Utermohl settling method and those from Prince 5 are done using the freeze transfer method. As the phytoplankton samples from the Wolves separate the surface, from those collected a depths, higher numbers are observed of some species that tend to concentrate in the surface layers whereas an integrated sampling may show higher numbers of species such as pennate diatoms that can concentrate in the deeper waters. It does not, however, give a greater indicator of total biomass.

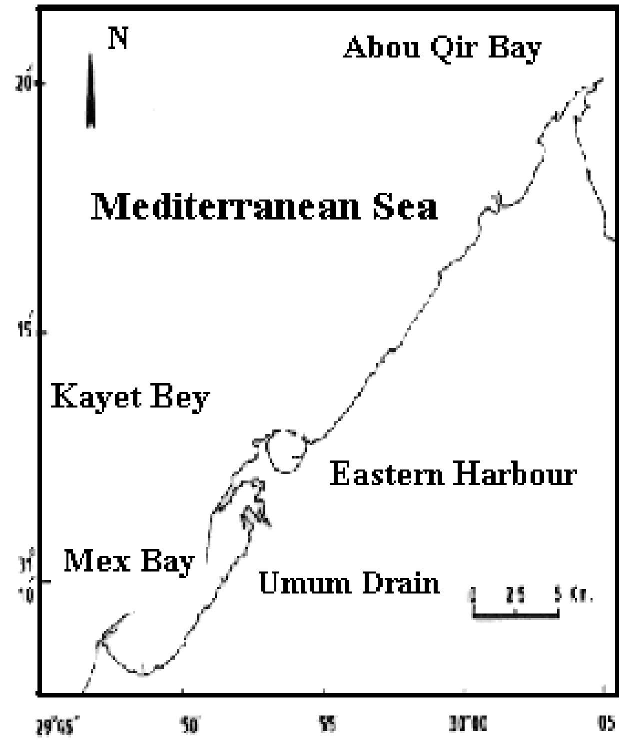
During 2003 and 2004, there was a comparison study done between surface samples collected between the 2 sites. Results from one sampling in 2003 showed 41 species at the Wolves and 19 at Prince 5. *A. fundyense* concentrations in the sample were 84,000 cells•L^{-1} at the Wolves and no *A. fundyense* observed at Prince 5. Another species, *Ditylum brightwellii* had 105 000 cells•L^{-1} at the Wolves and 41 000 cells•L^{-1} at Prince 5. Results from another sampling in 2004 showed 26 species at the Wolves and 20 at Prince 5. *A. fundyense* concentrations in that sample were 299 000 cells•L^{-1} at the Wolves and no *A. fundyense* observed at Prince 5; 89 000 cells•L^{-1} *Pseudo-nitzschia* spp chains of cells were observed at the Wolves whereas 2400 cells•L^{-1} were detected at Prince 5. Results from recent years (2008–2011) continue to show the same pattern.

Collection of samples at weekly intervals also gives a better indication of peak phytoplankton values as sampling monthly can often result in missed blooms or missing the magnitude of a particular bloom. The same can be said for temperature, salinity and nutrient values.

4.1.5 Overview of Harmful Algal Blooms in Egypt

Mikhail K. Samia

The first mention about red tide occurrence in Alexandria waters goes back to 1958, with the strong water discoloration caused by a new genus and new species, *Alexandrium minutum* Halim. This phenomenon received no attention until 1990s, when an intensive concern was paid to investigate environmental factors affecting red tide outbreaks. No formal monitoring program is in place in Egypt, the Eastern Harbor and the neighbouring coastal embayment were continuously monitored for red tides and heavy blooms.



The investigated area (Long 29°5′° E, Lat 31°10° N - Long. 30° 15′ E, Lat. 31° 25′ N) extends along the Egyptian Mediterranean coast of Alexandria for about 50 Km., including estuaries, harbors and semi-enclosed basins. It is subjected monthly to about $183x10^6m^3$ of untreated wastewaters from different land-based sources. The coastal water of Alexandria is highly eutrophic.

There are evidences for the distinct increased recurrent frequency of the red tide blooms in Alexandria coastal waters, their intensity, magnitude, and the number of harmful and harmless causative species.

Shellfish production is rare in Alexandria Coast, There are no data concerning toxic detection or analysis.

During the period from 1998–2010, 62 events of visible water discoloration at intermittent periods were recorded from late spring to early autumn, 41 of them were extensively studied. The blooms duration varied according to the nature of the blooms, and ambient conditions; about 5% of these events maintained for one day, 70–81% for three - five days, and 5–9% for more than a week. The bloom species (24 species) appeared mono-specifically or in combination. Fish and invertebrate mortality occurred 8 times during 1998–2010.

Heavy fish kills accompanied the last bloom of *A. minutum* in 1994. Since then, the species became insignificant; yet, no cases of toxicity have accompanied these abnormal blooms, although *A. minutum* is known to be PSP producing elsewhere. Occasional fish kills in the Eastern Harbor attributed to localized oxygen stress and/or gill clogging.

Blooms of *A. minutum* were replaced by others of several harmless/harmful species, mainly *Chattonella antiqua, Prorocentrum triestinum, P. minimum, Karenia mikimotoi, Alexandrium ostenfeldii, Gymnodenium catenatum.*

- *Prorocentrum triestinum*: last bloom was occurred on 16 August 2007 with a peak of 38.76x10^6 cells l^{-1} at 19.8–29.5^{o}C and Salinity 22.5–37.5. First bloom of *P. triestinum* was observed in 1996 associated with limited fish mortality.
- *Chattonella antiqua* forming monospecific bloom during late August /early September 2006. The species, caused mass fish mortalities and showed wide spatial distribution. Cell density at peak day in the different sites was:

- 23.13×10^6 cells l^{-1}	Chl *a* 88.5 µg l^{-1}	(Sept.1, Mex Bay)
- 4.12×10^6 cells l$^-$		(Sept. 4, Eastern Harbor)
- 1.82 ×10^6 cells l^{-1}		(Sept. 4, Montaza area)

Last massive mono-specific bloom of *C. antiqua* was recorded during 30 August – 2 September 2010. The species originated at Mex Bay distributed about 20 m. East along the coast, cell density at 13.1x10^6 cells l^{-1}. Fish mortalities accompanied this bloom. First appearance of *Chattonella antiqua* was in September 1998 (Eastern Harbor) with cell density of 0.54x10^6 cells l^{-1}.

- *Karenia mikimotoi* .The last bloom with peak of 1.32x10^6 cells l^{-1} in 11 August, 2007 at Kayet Bey Area the temperature at peak day was 28.5^{o}C and Salinity 34.5. First appearance of *Karenia mikimotoi* was in September/October 1998 and cell density range was 0.13x10^6 – 0.5x10^6 cells l^{-1}
- *Alexandrium ostenfeldii* showed its last bloom in 31 July 2007. The highest cell density 0.52x10^6 cells l^{-1} recorded at 28^{o}C and salinity 37.5. First appearance of *A. ostenfeldii* was in Mex Bay 1993, with 1.73x10^6 cells l^{-1}.
- *Gymnodinium catenatum* few cells were first found in 1992 and the last bloom was observed in August 1st 2006 at 1.12x10^6 cells l^{-1}, 28.2^{o}C and salinity 35.5.
- *Prorocentrum minimum* formed a monospecific bloom in 11 June 2007, 3.25x10^6 cells l^{-1} at 24^{o}C and salinity 36.5.

No harmful algal bloom was observed during 2011.

The newly recorded red tide diatom species include:

Chaetoceros pseudocurvisetus	2007 Oct. (6.7x10^6 cells l^{-1})
C. sociale	2000 Mar. (0.57x10^6 cells l^{-1})
	2000 Oct. (0.55x10^6–0.81x10^6 cells l^{-1})
	2007 Sep. (10.2x10^6 cells l^{-1})
Asterionella glacialis	1999 April (1.15x10^6 cells l^{-1})
	2000 Feb. (1.17x10^6 cells l^{-1})
Leptocylendrus mimimus	1999 Sept. (1.5x10^6 cells l^{-1})
Lithodesmium undulatum	1999 Nov. (1.55x10^6 cells l^{-1})
	2007 June (2.7x10^6 cells l^{-1})
Cyclotella nana	2000 Mar. (1.28x10^6 cells l^{-1})
	2007 July (10.8x10^6 cells l^{-1})
C. glomerata	2007 May (11.62 x10^6 cells l^{-1})
Nitzschia longissima	2007 October (2.21 x10^6 cells l^{-1})
Rhizosolenia delicatula	2000 March (3x10^6 cells l^{-1})
R. setigera	2006 May (13.39 x10^6 cells l^{-1})

R. fragilissima	2007 July (11x10^{6} cells l^{-1}) 2009 July (14.19x10^{6} cells l^{-1})
Euglena granulate	2007 May (1.5x10^{6} cells l^{-1}).

Skeletonema costatum was the major and dominant red tide species, highest cell density (255x10^{6} cells l^{-1}) was recorded during May 2005 (Mex Bay).

Expected red tide forming species (near future) as due to their progressive increased numbers include *Ceratium furca, Dinophysis acuminata, Prorocentrum sigmoides, Cochlodinium polykrikoides, Takayama sanguinea, Cochlodinium catenatum, Gymnodinum impudicum, Polykrikos schwartzii*, and *Protoperidinum steinii*.

Survey of epiphytic microalgae along the coast revealed benthic blooms of *Ostreopsis* spp. and *Oscillatoria* spp.

Harmful phytoplankton species in Alexandria waters (* invasive species)

**Alexandrium catenella*
Alexandrium minutum
**Alexandrium ostenfeldii*
**Chattonella antiqua*
Dinophysis accuminata
**Gymnodinium catenatum*
**Heterocapsa circularisquama*
**Heterosigma* sp.
**Karenia mikimotoi*
Prorocentrum minimum
P. triestinum
**Pseudonitzschia australis*
P. pungens
Skeletonema costatum

Incidents of massive invertebrate and fish mortality with red tide blooms

- October 1994, caused by *Alexandrium minutum* .
- August 1999 attributed to the first occurrence of *Gymnodinium mikimotoi*.
- May 2000, attributed to fish killer *Chattonella antique.*
- May to late October 2001 when 16 algal species (9 diatoms, 5 dinoflagellates, 1euglenophycean and 1 raphidophycean species) were responsible at 8 intermittent periods.
- During August 2004 and July/August 2005 as a direct impact of the occurrence of 6 toxic phytoplankton species (*A. ostenfeldii, G. catenatum, H. circularisquama, K. mikimotoi*, and *P. minimum*, and the raphidophycean *C. antique*).
- Late August /early September, 2006 and from 30 August to 2 September 2010, caused by *Chattonella antique.*

Egypt, in particular the National Institute of Oceanography and Fisheries (Alexandria), receives no any HAB monitoring program fund, all the work done about red tide phenomena is considered personally, and no formal, national monitoring program is established yet. There is a continuous need to inform health and fisheries authorities of the benefits of establishing monitoring programs. Training course on quantitative and qualitative analyses of toxin producing microalgae is deeply needed.

4.1.6 Significant algal blooms observed in the ROPME Sea Area (2005–2012)

Layla Al-Musawi, Kuwait

The Regional Organization for the Protection of the Marine Environment (ROPME) was established as the secretariat for implementing the "The Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution". The Convention defines the geographical coordinates of the ROPME Sea Ares (RSA) to be between16°39′N, 53°3′30″E; 16°00′N, 53°25′E; 17°00′N, 56°30′E; 20°30′N, 60°00′E; 25°04′N, 61°25′E, adding up to a surface area of 240 000 km^2. The RSA is further divided into the inner RSA (I-RSA) consists of the marine area west of 56°E longitude that extends along the NW/SE axis from the north boundary of the RSA to the north of Strait of Hormuz; the middle RSA (M-RSA) corresponds to the Sea of Oman. It is a strait connecting the Arab Sea with the Strait of Hormuz; and The outer RSA (O-RSA) is a segment of the Arabian Sea extending from Ra's Al-Had to the southern border of Oman.

Since 2003, ROPME has been implementing Real-Time Remote Sensing Monitoring of Algal Bloom in the RSA. The observed bloom is described as a 'large' bloom if it covers an area of tens of square kilometres, whereas it is described as 'massive' if it covers a surface larger than tens of square kilometres. Over the last years, the Monitoring has documented the frequency and extent of several incidents in the RSA. The following are examples of the most prominent events.

May 2005: Large algae bloom near Halul Island, Qatar, I-RSA. The prevailing species was *Trichodesmium erythraeum*. There were but a handful reports of limited fish kills.

October 2005: Red tide near coast of Oman, Masirah, Dawhat (O-RSA). The Focal Point confirmed massive fish kill and red tide involving: *Noctiluca scintillans, Prorocentrum micans, Trichodesmium erythraeum*.

March 2006: large algal bloom, Sea of Oman (M-RSA). There were no official reports regarding the species or incidents of fish kill.

April 2008: Surface algae bloom in coastal waters of Iran (Northern parts of I-RSA). There were no official reports regarding the species or incidents of fish kill.

April/May 2008: Surface algae bloom near UAE, Iran, and Qatar (I-RSA). There were no official reports regarding the species or incidents of fish kill.

October 2008: Red Tide phenomena, Masirah Bay, Coast of Oman (O-RSA). There were no official reports regarding the species or incidents of fish kill.

November/December 2008: Massive algal bloom, largest observed in ten years in the region. The species was reported to be *Cochlodinium polykrikoides*, causing fish kills throughout the RSA.

April 2009: Large algal bloom, Qatar (I-RSA). The species was reported to be *Trichodesmium erythraeum.*

January/February 2010: Large algal bloom Ras Jibsh, Masirah, Ras Mandrakah, Ras Al-Had, Oman (O-RSA). There were no official reports regarding the species or incidents of fish kill.

May 2010: Algae bloom, Qatar (I-RSA). There were no official reports regarding the species or incidents of fish kill.

August 2010: Large algal bloom, Strait of Hormoz. There were no official reports regarding the species or incidents of fish kill.

January 2011: Surface algae, Masirah, Ras Jibsh, Oman (O-RSA). The species was reported to be *Noctiluca scintillans*.

December 2011–April 2012: Massive Algal Bloom in both Inner and Outer RSA, with highest concentration around Masirah island. The species was reported to be *Noctiluca scintillans*.

April 2012: Surface algae around Qatar and Iran (I-RSA). The species was reported to be *Noctiluca scintillans*.

5 Term of Reference B

5.1 To deliver National Reports on harmful algal events and bloom dynamics for the year 2011

5.1.1 Canada National Report 2011

Jennifer Martin

West Coast

PSP

2011 was considered to be a "normal" year with shellfish closures as a result of elevated levels of PSP toxins. The highest level observed was 1334 μg/100 g STX equiv. on June 6 in *Mytilus edulis* in the lower Strait of Georgia with shellfish harvesting areas closed to harvesting from 6 May to 24 October.

DSP

The first documented occurrence of Diarrhetic Shellfish Poisoning occurred in British Columbia in 2011. Sixty people became ill following consumption of mussels collected 19 July – 2 August from Gorge Harbour, Cortes Island. A phytoplankton monitoring programme collecting samples for the salmonid aquaculture industry collected samples approximately 25 km away from the affected shellfish site and detected 24 000 *Dinophysis* spp. cells•L^{-1}. *Dinophysis acuminata* were the most abundant (82%), *D. acuta* (9%) and *D. fortii* (4%), and *D. rotundata* (5%)[1].

[1]Esenkulova, S. and N. Haigh. 2012. First Report of *Dinophysis* species causing Diarrhetic Shellfish Poisoning in British Columbia, Canada. Harmful Algal News. 45:12, pp 16-17.

ASP

No shellfish areas were closed due to unacceptable levels of DA in 2011.

Salmon mortalities in fish culture operations.

Heterosigma akashiwo was responsible for salmon mortalities in the Upper Strait of Georgia, British Columbia on June 23 when concentrations were 400 000 cells•L^{-1}. In Clayoquot Sound, Vancouver Island, *H. akashiwo* was observed at levels of 300 000 cells•L^{-1} on 12 September resulting in further mortalities. Interestingly, at a salmon farm at Jervis Island, Lower Strait of Georgia, concentrations of 22 million cells•L^{-1} were observed with no ill effects to the farmed salmon.

East Coast

PSP

2011 would be considered to be a "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 103,400 cells•L^{-1} and highest shellfish toxicity (3640 µg 100g STX equiv.) was detected in *Mytilus edulis* at Bocabec Bay. Although shellfish toxicity values only reached 849 µg 100g STX equiv. at Deadmans Harbour, the shellfish beds were closed throughout the year due to unacceptable levels of PSP toxins with low levels detected through the winter.

Mytilus edulis from the Atlantic coast of Nova Scotia (Mahone Bay) toxicity values reached levels of 1501 µg 100g STX equiv. and that area was closed from 10 June to 13 July.

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 2011.

DSP

No shellfish harvesting areas were closed due to unacceptable levels of DSP toxins in shellfish in 2011.

ASP

No shellfish harvesting areas were closed due to unacceptable levels of DA in shellfish in 2011.

Salmon Mortalities

There were no salmon mortalities at aquaculture operations on the east coast associated with HABs in 2011.

5.1.2 Denmark National Report 2011

Per Andersen (presented by Niels Daugbjerg)

Shellfish

No – DSP, ASP or PSP in 2011

No negative effects from the otherwise extensive *Pseudochattonella* bloom (see Figures 1–2) on shellfish stocks and no observed food safety impact either.

Responsible algal species present – but in low concentrations.

Toxin monitoring in 2011 involves routine analysis of algal toxins using chemical methods, while the MBA is no longer in use routinely.

Marine fish farms

An extreme major spring bloom of *Pseudochattonella* (probably *P. farcimen*) delayed the release of trout to fish cages in the coastal waters. No fish kills in aquaculture units during the bloom because no fish were in the sea yet. Reports of miserable traditional recreational sea trout fishing in the bloom period, and few reports of observations of dead sea trout. No other dead fish species observed during the bloom. No negative effects reported on birds and mammals either.

Other blooms

During the *Pseudochattonella* there were several reports from winter "swimmers" about brown water and very low visibility resulting in "no swim" situations. No report of negative effects on those who swam. No further blooms in the coastal waters with consequences on recreational use of the water. Few reports on blooms of cyanobacteria/blue-green algae in Danish lakes.

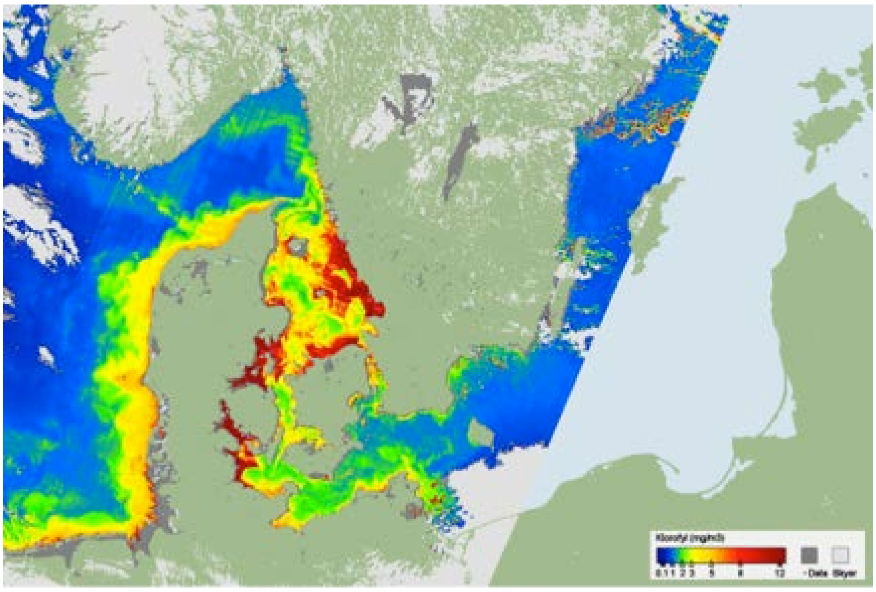


Figure 1. Bloom development based on chlorophyll (mg/m³) of *Pseudochattonella* in Danish waters 5 March 2011. (Source DMI).

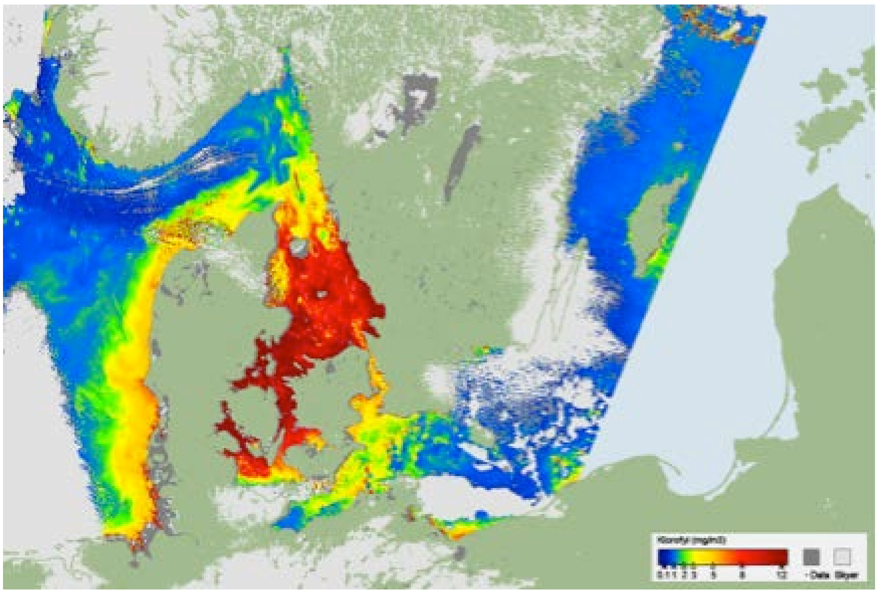


Figure 2. Bloom development based on chlorophyll (mg/m³) of *Pseudochattonella* in Danish waters 16 March 2011. (Source DMI).

5.1.3 Ireland National Report 2011

Joe Silke

During 2011 there were toxic events in shellfish from 4 different syndromes detected in shellfish analysed as part of the national monitoring programme. The causative species for these outbreaks were detected in waters at the time of the event, with the exception of Azaspiracid toxicity for which no obvious presence of *Azadinium* was noted in phytoplankton monitoring programme. Each of these outbreaks resulted in closures of shellfish production areas as detailed below.

ASP Summary

Domoic acid concentrations were typically observed to be <LOQ (Limit of Quantification) or <LOD (Limit of detection) in samples of species (except *P. maximus*) submitted in the early part of 2011 but *Pseudo-nitzschia spp.* were observed to increase, predominantly in the South West to a max concentration of > 169 000 cells/litre during week 18 (beginning of May). During this time, increases in the concentration of Domoic Acid were observed in samples of *M.edulis* submitted, where predominantly concentrations in samples submitted from Inner Bantry Bay were > regulatory levels. Quantifiable concentrations < regulatory level were observed in samples submitted from sites within Outer Bantry and Kenmare Bay. During weeks 19–20, levels of both *Pseudo-nitzschia seriata spp.* and Domoic Acid were observed to decrease, allowing for all previously affected sites to be assigned Open status during week 20. ASP concentrations were observed to decrease further in all affected areas during June to levels typically <LOD. All samples analysed have been typically <LOD / LOQ for the remainder of the year in all shellfish species apart from *Pectenidae* which usually contain persistent levels of Domoic acid in the non edible tissues. Molecular analysis was conducted on phytoplankton samples from the SW, where available. During the presence of ASP (Domoic Acid) producing species, *Pseudo-nitzschia australis* & *Pseudo-nitzschia delicatissma* was observed to be present in some of the samples.

AZP Summary

2011 was a year with little Azaspiracid, the site closures were mostly due to DSP toxins or a mixture of DSP and AZA toxins where DSP was predominanat. All samples analysed were observed to be below the regulatory level during January–August, typically <LOD/LOQ. In August one site within Bantry Bay was observed to contain levels just above regulatory threshold (0.17µg/g). All samples analysed were below the regulatory level during August–October, except for two sites within Bantry Bay, one in August & one in September, which subsequently decreased to concentrations below the regulatory level in October. All samples analysed were below the regulatory level during November 2011 – February 2012. Quantifiable conc.'s were decreased during November, where typically conc.'s were <0.1µg/g.

DSP Summary

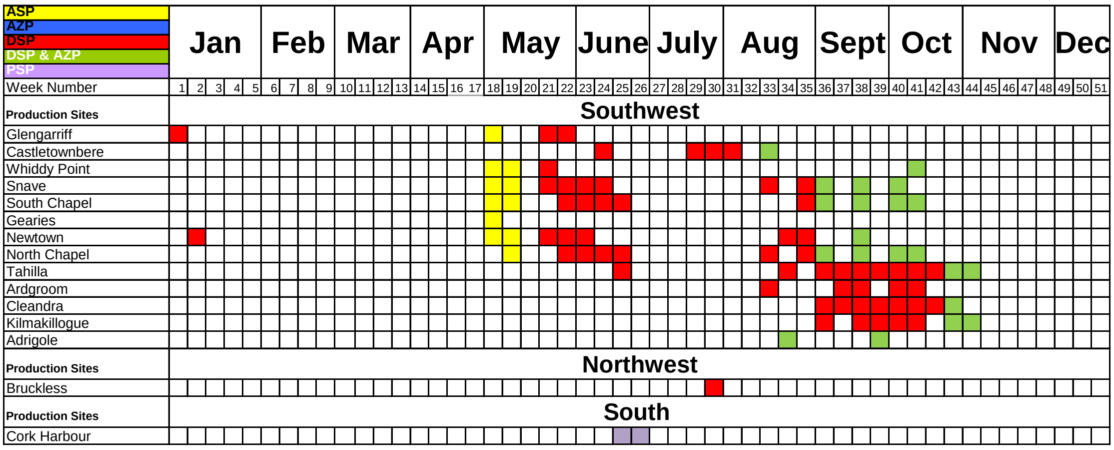
During early – mid January 2011, conc.'s of DSP toxins remaining from the 2010 toxicity outbreak decreased to below the regulatory level, with the majority of sites re-opening in Bantry, Dunmanus and Kenmare bays. By end of January 2011 all sites were on Open status.

DSP concentration above regulatory level returned in samples of *M. edulis* submitted from the inner parts of Bantry Bay during the last week of May 2011, where the toxins were mainly a mixture of both Okadiac Acid and Okadiac Acid esters, where in small no. of samples, smaller concentrations of DTX-2 esters were present. This intoxification occurred at the same time the no.s of *Dinophysis spp.* cells were increasing in these sites. For the remainder of the country, concentrations were typically <LOD & <LOQ, where in Kenmare, a couple of sites had quantifiable concentrations < regulatory level. These levels remained in sites within Bantry & Kenmare Bays during June 2011, but conc.'s were observed to decrease to below the regulatory level in all these sites toward the end of June. DSP levels were observed to increase again within these bays from the end of July /beginning of August, resulting in further closures from mid-Aug. The toxin composition was observed to be a mixture of Okadaic Acid and its esters, and DTX-2. In the northern part of Ireland (County Donegal) DSP concentrations just above the regulatory level were observed for a short period during July in McSwynes Bay.

Concentrations above the regulatory level continued in samples of *M. edulis* submitted from sites within Bantry & Kenmare Bays during September 2011, conc.'s decreased to below the regulatory level in a number of these sites, mainly in Bantry during October, however a number of sites within Kenmare remained above the regulatory level as late as early November. DSP concentrations above the regulatory level remained in samples of *M. edulis* submitted from sites within Kenmare Bay during November 2011, conc.'s decreased to below the regulatory level in these sites during November onwards, with all sites on Open status.

PSP Summary

Similar to previous years, PSP was limited to Cork Harbour for one short episode in June. *Alexandrium minutum* was detected outside of Cork but shellfish tested from these areas were all negative for PSP toxins. In 2011 the method for analysis of PS toxins switched from Bioassay to HPLC chemical methods using the Lawrence Method. All samples analysed for PSP during January–June, have been < regulatory level via ELISA and HPLC analysis. PSP concentrations were above the regulatory level during the end of June for a 2 week period, in samples of *M.edulis* from Cork Harbour where the highest conc. observed was 164.8µg/100g STXdiHCl equiv.'s. Quantifiable concentrations below the regulatory level were observed in samples of *C.gigas* from Cork Harbour, 53.7 µg/100g STXdiHCl equiv.'s. All other samples analysed have been typically <LOD / LOQ. All samples analysed following this outbreak were typically <LOD /LOQ. All samples analysed have been typically n.d. /LOQ, where from October onwards there was only one occurrence of *Alexandrium spp.* cells being observed.



5.1.4 The Netherlands National Report 2011

Ainhoa Blanco

During 2011 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.

Dinophysis acuminata was detected in lake Grevelingen during the second half of May at concentrations ranging from 130 to 290 cells/L in the surface samples and ranging from 120 to 170 cells/L in bottom samples. Samples from the north area in the North Sea revealed during the last week of august a *D. acuminata* concentration of 380 cells/L. Concentrations during the following week were below detection limit. In the mid-section of the Wadden Sea, *D.acuminata* concentrations above threshold level were found during the last half of August. Week 33 presented the highest concentrations of 330 cells/L. Concentrations of this species decreased during the following two weeks to 140 cells/L and presented values below detection limit by mid-September. Concentration under the threshold limit for this species (100 cells/L) were reported for the Veerse Meer in September and for the Oosterschelde in November.

Pseudo-nitzschia sp. were found in all the location areas from July up to October, nevertheless, all the measured concentrations were well below the threshold limit of 500 000 cells/L. The highest concentrations for this species, 83 000 cells/L were recorded at the beginning of October in the lake Grevelingen. Concentrations in the Wadden Sea reached the highest value, 46 000 cells/L in September.

In some cases *D. rotundata* was reported in the north and middle areas of the Wadden Sea but always at very low concentrations.

All sites were also sampled for marine biotoxins, and analysed with LC-MS/MS. 2-3 times trace levels of DSP were found, but always below the report limit of 20μg OA-eq/kg (regulatory limit is 160μg OA-eq/kg).

5.1.5 Poland National Report 2011

Hanna Mazur-Marzec

The occurrence of toxin-producing *Nodularia spumigena.*

In years 2008–2010, monitoring of toxic cyanobacteria was conducted using FerryBox system which operated in the Baltic Sea between Gdynia (Poland) and Karlskrona (Sweden). The data collected during the project showed the decline in the average cyanobacterial biomass measured in July in subsequent years (from 107.3 μgC L^{-1} in 2008 to 9.2 μgC L^{-1} in 2010). The peak value of the biomass occurred in weeks 27–28, i.e. earlier than it was previously reported (week 29–30).

In 2011, only sampling in Polish coastal waters was performed. A short episode of the toxic *Nodularia spumigena* bloom (189 204 μgC L^{-1}) was recorded in week 26 (29/30 June). Accumulation of scums in coastal areas resulted in beach closure in Gdynia.

The concentration of nodularin (NOD) in two classes of blue mussels (*Mytilus trossulus*) was measured. The smaller mussels with the shell length (L) shorter than 2 cm accumulated higher concentration of the toxin (816.5±1196.8 ng/g d.w.) than bigger mussel (L> 3 cm; 254.4±248.1 ng/g d.w.). This tendency was statistically significant in Kolmogorow-Smirnov nonparametric test ($p<0.05$).

A month after the peak of *N. spumigena* bloom, on 29 July, the toxin concentration in flounder (*Platichthys flesus*) muscles and liver was 13.6 ng g^{-1} and 191.8 ng g^{-1}, respectively. NOD accumulation in round goby (*Neogobius melanostomus*) caught during the most intensive *N. spumigena* bloom (30 June), reached 257.7±151.2 ng NOD g^{-1} in muscles and 23.6±7.0 ng NOD g^{-1} in liver. A month later, on 29 July, round goby muscles and liver contained 347.3±564.2 ng NOD g^{-1} and 920.9±1769.1 ng NOD g^{-1}, respectively. Generally, round goby accumulated higher amounts of the toxin than flounder. In some fish muscles, the toxin content exceeded the tolerable daily intake value (TDI) for a human.

5.1.6 Spain National Report 2011

Beatriz Reguera

Andalucia suffered severe DSP outbreaks on the Atlantic sites and PSP outbreaks on the Mediterranean sites during 2011. This was an uneventful year in Catalonia, where the impact of toxins in shellfish exploitations was minimal. Five persons were affected by CFP in the Canary Islands. A combination of DSP and PSP outbreaks led to very lengthy harvesting closures in Galicia.

Andalucia

DSP**:** A *Dinophysis acuminata* event in March in the Atlantic coast off Huelva (max. 30 680 cell L^{-1}) led to closures of the whole production area. On the Mediterranean coast, a bloom of *D. acuminata* was detected from late June to early July off Málaga (max. 4120 cell L^{-1}). and was associated with positive results for lipophilic toxins in shellfish.

PSP: *Gymnodinium catenatum* spread through the whole Mediterranean coast of Andalucia (Cádiz to Almería). A first bloom appeared in July off Málaga (max. 15 000 cell L^{-1}), and a more intense one, from October to December, exhibited maximum densities (48 400 cell L^{-1}) and toxin levels in shellfish off Cádiz .

ASP: *Pseudo-nitzschia* spp. detected all year round with different peaks and troughs, but domoic acid in shellfish kept below detection levels.

The monitoring of toxin producing phytoplankton of classified production areas in Andalucia is conducted by the "Laboratorio de Control de Calidad de Recursos Pesqueros". This laboratory was accredited in 2011 by the Spanish National Accreditation Entity (ENAC) under ISO 17025 for the analysis of phytoplankton using the Utermöhl method (LE1796)."

https://ws128.juntadeandalucia.es/agriculturaypesca/moluweb/

Canary Islands

Cyanobacteria. Between May and November 2011, *Lyngbya majuscula*, a benthic filamentous toxigenic cyanobacteria, formed a bloom covering hundreds of square kilometres at depths from 2 to 30 m on the eastern coast of Fuerteventura Island. This is the first record of this type of bloom in the Canarias archipelago.

Ciguatera. On 26 June 2011, the Food Safety Department of the Canary Island Government (Sección de Seguridad Alimentaria, Dirección General de Salud Pública) reported five cases (members of the same family) of ciguatera poisoning after recreational fishing and consumption of "medregal", a large carnivore (*Seriola rivoliana*) caught at Fuerteventura coast. On 29 September, a 29.3-kg *Seriola rivoliana* specimen was tested positive after using a commercial ciguatoxin kit (IUSA); this was verified by the European Community Laboratory of Marine Biotoxines in Vigo, Spain.

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

Catalonia

IRTA Monitoring

DSP During 2011 there was only one closure due to presence of biotoxins. The production area L'Escala-Roses-Cadaqués was closed after detection of DSP/lipophilic toxins (EU Standard Operating Procedure SOP, 5) over the regulatory level in *Donax trunculus* in December; the causative species was not confirmed. *Dinophysis sacculus* and other *Dinophysis* species were present in low abundances in the Ebro delta bays reaching alert levels in May and at the end of the year.

PSP *Alexandrium minutum* reached alert levels in shellfish growing areas of the Ebro delta and in the open coast in abundances of $2 \cdot 10^3$ cell L^{-1} but all samples analyzed by the AOAC method for PSP bioassay were below the regulatory limit.

ASP *Pseudo-nitzschia* spp. were present in high abundances with a maximum ($5 \cdot 10^3$ cell L^{-1}) in October, all results of the shellfish samples analyzed for domoic acid were <LOQ.

The monitoring of toxin producing phytoplankton of classified production areas is conducted by IRTA (Research and Technology Institute for Agriculture and Food). IRTA was accredited in 2011 by the Spanish National Accreditation Entity (ENAC) under ISO 17025 for the analysis of phytoplankton using the Utermöhl method (LE1796). http://www.irta.cat/ca-ES/RIT/A/A3/Pagines/A31.aspx

ICM (CSIC) Monitoring

Benthic HABs: Dense blooms of *Ostreopsis* spp. in the hot spot of Sant Andreu de Llavaneres in summer (end of June to early October): maxima of $9.6 \cdot 10^6$ cell L^{-1}in the water column and $71 \cdot 10^6$ cell/g macroalgae (w.w.) in early July. The Catalan Water Agency (ACA) warned Council and health authorities; warning posters were displayed in the affected beaches; information was disseminated by the press. There were no reports of respiratory and skin irritations from the public in the exposed area.

Toxigenic HABs out of shellfish production areas. Dense blooms of *A. minutum* in different harbors with no shellfish exploitations (Estartit, Arenys de Mar, Vilanova y la Geltrú, Cambrils) with a max. of $5.4 \cdot 10^6$ cell L^{-1} in Cambrils. Moderate to high densities of *Dinophysis sacculus* in Estartit, Arenys de Mar, Port de Barcelona, Vilanova y la Geltrú and Tarragona harbours (max. $5.9 \cdot 10^4$ cell L-1) and high densities ($\geq 5 \cdot 10^5$ cell L^{-1}) of *Pseudo-nitzschia* spp. in Arenys de Mar, Vilanova y la Geltrú, Port de Tarragona and l'Ametlla, as well as in several beaches throughout the Catalan coast. In June, a proliferation ($8.2 \cdot 10^4$ cell L^{-1}) of a raphydophyte (*Chattonella* sp.) was observed in the mouth of the Muga river.

Monitoring of potentially harmful microalgae for the Catalan Environmental Authorities (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

DSP. *Dinophysis acuminata* bloomed in three separated pulses. From late April to late July caused closures due to lipophilic toxins in raft mussels in the Northern (Ria de Ares) and Southern Rías (Muros, Pontevedra and outer reaches of Vigo and Arousa). This event also caused closures of infaunal molluscs in coastal areas (O Burgo , Cariño, Ortigueira Cedeira, O Vicedo, O Barqueiro, Celeiro and Ribadeo). The maximum detected was 4680 cells L^{-1} on the surface at station P2, the usual hot spot in Ria de Pontevedra, on 30 May. *D. caudata* was co-occuring with *D. acuminata*, with a maximum of 2320 cell L^{-1} in the same spot the preceding week. A second more intensive bloom lasted from the end of August through September (max. 15 240 cell L^{-1} in Ria de Pontevedra, st. P5, on 29 August. Lipophilic toxins caused closures of all Galician mussel production areas except small internal production zones in the Rías of Arousa and Vigo. They also caused closures on infaunal shellfish in Ferrol, O Burgo, Baldaio, Corme, Corcubión, Finisterre, Muros and internal areas of Arosa and Pontevedra. The latest proliferation of *D. acuminata* developed during November and December, again causing closures in the Northern (R. Ares) and the Southern (Muros, Pontevedra, outer reaches of Vigo and Arousa) Rías with a maximum of 1520 cell L^{-1} in Ria de Pontevedra (st. P5) on 7 November. Overlapping of closures during the second and third outbreak led to uninterrupted closures in Ria de Pontevedra from mid-August to late December.

ASP. A brief bloom of *Pseudo-nitzschia* cf. *australis* from late April to mid-May caused closures of raft mussels in Baiona (Vigo) and in the Rias of Muros (max. 651 915 cell L^{-1} on 26 April and 58.5 ppm DA on 27 April at st. M1 in Muros), Pontevedra, Vigo, and infaunal molluscs of the four Southern Rias (Muros, Arosa, Pontevedra and Vigo) and coastal areas (Viveiro, Celeiro, O Barqueiro, Corme, Corcubión-Finisterre).

Another short event of *Pseudo-nitzschia* cf. *australis* in August caused mussel harvesting closures in Corme (max. 129 ppm DA on 23 August) and in raft and infaunal molluscs in all Ría de Muros (max. 601 425 cell L^{-1}). Finally, an episode of *Pseudo-nitzschia* spp. in October led to mussel harvesting closures in the Rias of Muros (south) and Ares (north) (max. 283 635 cell L^{-1} and 22.2 ppm DA on 6 October). Precautionary closures were established for infaunal molluscs of Muros, O Burgo, Corcubión, Fisterra, but toxins did not exceed the regulatory levels. Scallops (*Pecten maximus*) contained DA above regulatory levels all year round. Restricted harvesting with evisceration (according to EU Directive 2002/226/EC) was implemented.

PSP *In situ* growth of *Gymnodinium catenatum* detected in June in Ria de Pontevedra (max 1360 cell L^{-1} at st. P4 on 18 July) and produced a short-term closure in July (st. Portonovo B). This bloom spread to all production areas of Portonovo (Pontevedra) in August and September. During October, closures affected the whole Ria de Pontevedra and during November and December the Ria de Muros, middle and outer reaches of Arousa, all Ría de Pontevedra and outer reaches of Ria de Vigo. In Ria de Pontevedra, infaunal molluscs were also affected. Maximum values were 51 800 cell L^{-1} on 31 October at the surface and 22 200 µg equiv STX di.HCl/Kg on 25 November both at st. P2 in Pontevedra.

Alexandrium minutum in situ growth produced closures of infaunal molluscs in Ría de Camariñas (north) in May. Maximum values were 1360 µg equiv STX di.HCl/Kg and 11 872 cell L^{-1} on 9 May. *A. minutum in situ* growth in the estuary of Baiona (R. Vigo), caused closures of raft mussels in June and uninterrupted closures of infaunal shellfish from May to October. Max. 7900 µg equiv STX di.HCl/Kg on 2 May and 268 707 cell L^{-1} on 23 May.

Red tides were observed of *Noctiluca scintillans* in the very touristic area of Sanxenxo R. Pontevedra); *Lingulodinium polyedra* in Ria de Ares in August and *Myrionecta rubra* in May in the Atlantic Islands Natural Park within the Ria de Vigo.

The monitoring of toxin producing phytoplankton and phycotoxins of classified production areas in Galicia is conducted by the accredited INTECMAR (www.intecmar.org)

5.1.7 Sweden National Report 2011

Bengt Karlson

Skagerrak, Kattegat and the Sound (Öresund)

Commercial harvesting of shellfish in only carried out along the Skagerrak coast. Analysis of algal toxins in shellfish were made using chemical methods only from 1 July 2011. During the first six months both mouse bioassays and chemical methods were used.

In oysters(*Ostrea edulis*) and cockles (*Cerastoderma edule*) concentrations of algal toxins above the regulatory level were not detected. Results regarding blue mussels (*Mytilus edulis*) are found below.

DST

Concentrations of Diarrhetic Shellfish Toxins (DST) above the regulatory limit were detected from late August to end of year in blue mussels collected at the Swedish Skagerrak coast (Figure 1) causing closures of harvesting of wild and farmed mussels in some areas. This coincided with a return of high abundances of *Dinophysis acuta*. DST levels have been low 2007–2010 when the *D. acuta* abundances were low.

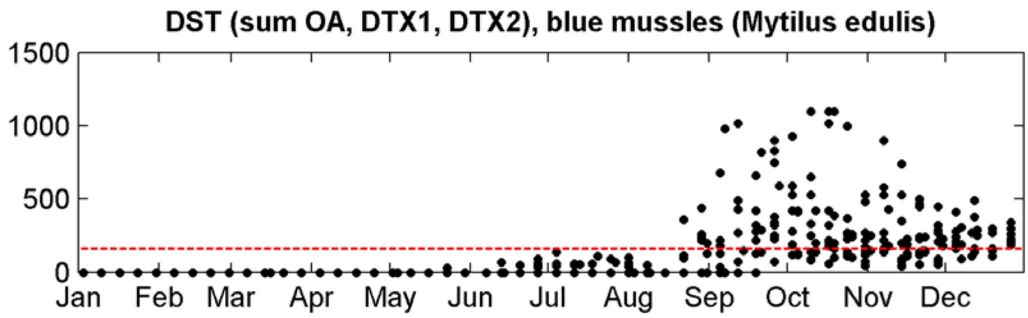


Figure 1. Concentrations of DST in blue mussels along the Swedish Skagerrak coast in 2011. Data from the Swedish National Food Agency.

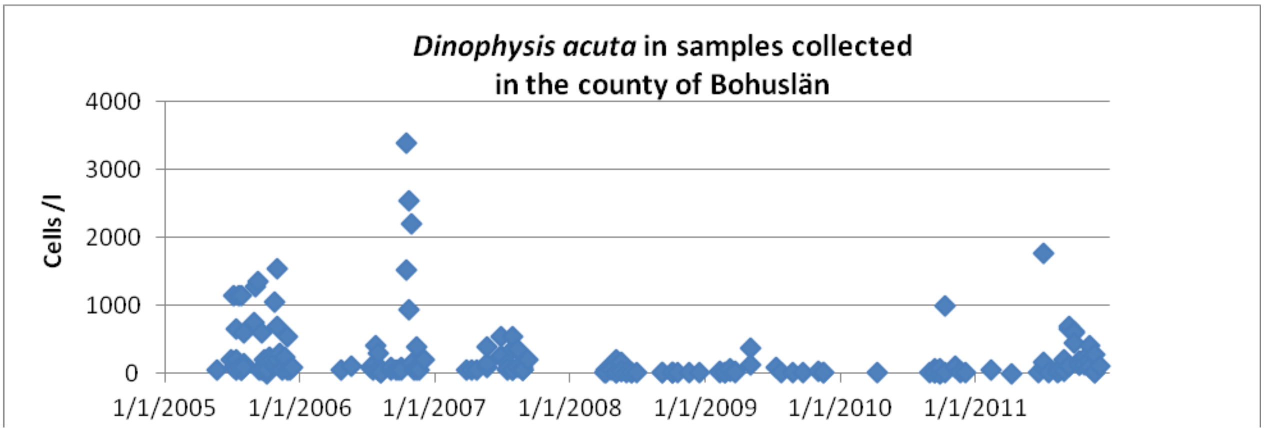


Figure 2. Abundances of *Dinophysis acuta* in water samples collected along the Swedish Skagerrak coast 2005–2011 from the Swedish National Food Agency monitoring programme. Values below detection limit are not shown.

PST, AST, and AZT

Concentrations of Paralytic Shellfish Toxins (PST), Amnesic Shellfish Toxins (AST) and Azaspiracidic Shellfish Toxins (AZT) above the regulatory limit were not detected. *Alexandrium* spp.were observed in the area on several occasions.

YTX

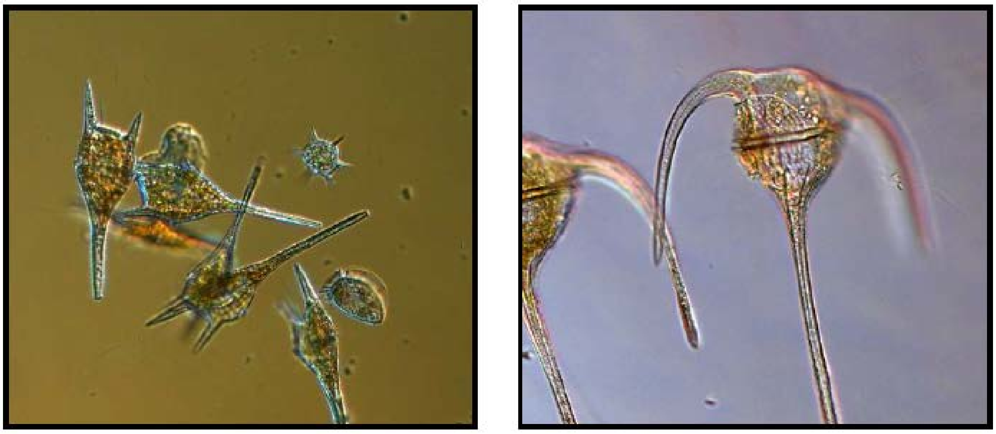
Yessotoxins (YTX) above the regulatory limit were detected in blue mussels in a few samples in May and June.

Fish killing algae

Pseudochattonella farcimen were observed along the Kattegat coast in March and April but no harmful effects were observed. *Chrysochromulina* sp. was found in bloom concentrations in May/June in the Sound, the Kattegat and in the Skagerrak but no harmful effects were observed. *Heterosigma* sp. was observed in the Sound and also *Karlodinium veneficum* but no harmful effects were detected.

Unusual bloom of *Ceratium* spp.

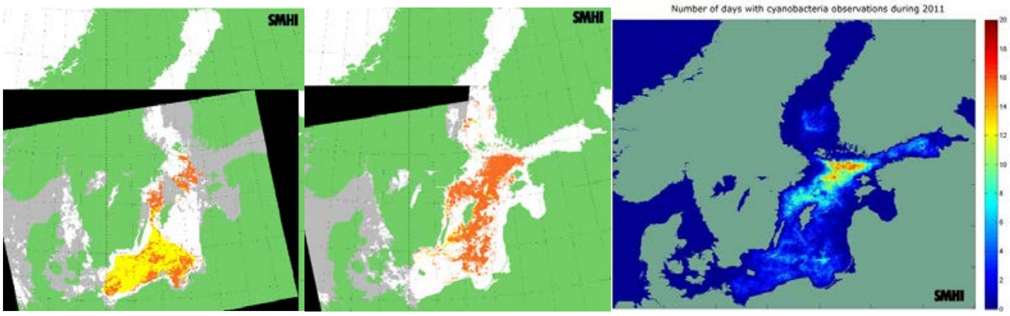
In November–December 2011 brown water was observed along the Swedish West coast at several locations. High biomass blooms this late in the growing season are unusual. In the Kungsbacka fjord, South of Gothenburg the chl. a. concentration was approximately 80 μg L^{-1} which is extremely high for the area. Microscope analysis of water samples revealed that *Ceratium fusus, C. furca* and *C. tripos were the dominant organisms.* No harmful effects were observed.



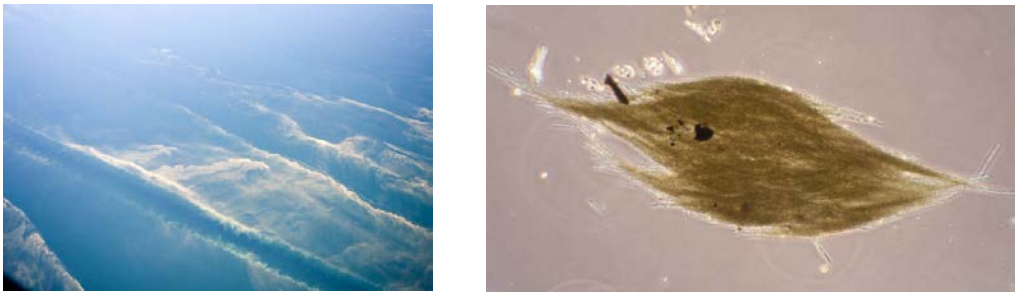
Left: *Ceratium* spp. Right:*Ceratium tripos*. Photos by Ann-Turi Skjevik.

The Baltic proper

In May and also later in the year *Chrysochromulina* spp. was found in high abundances but no harmful effects were observed. The cyanobacteria bloom was unusually long with a start in late June and end in the beginning of September. The intensity was moderate and the bloom was mostly off shore. In July the toxic species *Nodularia spumigena* was common. The non-toxic species *Aphanizomenon flos-aquae* was dominating during a cruise in late July and is likely to have been the most important component of the surface accumulations forming nuisance blooms.



Surface accumulations of cyanobacteria (orange is strong and yellow weak/sub surface). Left: 19 July, middle: 4 August, right: number of days with surface accumulations of cyanobacteria observed in satellite images (Hansson and Öberg, Baltic Algae Watch System, SMHI).



Left: Surface accumulations of cyanobacteria near the island of Bornholm. 1 August 2011.Photo by the Swedish coast guard. Right: *Aphanizomenon flos aquae*. Photo Ann-Turi Skjevik.

The Gulf of Bothnia

In late June there was a report of a bloom of the cyanobacteria *Anabaena lemmermannii,* in the Ostnäsfjärden near the town of Umeå. *Nodularia spumigena* was a small part of the total biomass. The bloom continued all summer in this shallow and protected area. In the Bothnian Sea cyanobacteria blooms along the coast were reported in the end of July. In August also off shore blooms were observed in the Bothnian Sea. Source of information: The information Centre for the Gulf of Bothnia.

Cyanobacteria in the Ostnäsfjärden. Photo: Karin Ahlman-Toyama.

5.1.8 United Kingdom National Report 2011

Eileen Bresnan *et al.*

During 2011, the testing of shellfish for the presence of lipophilic shellfish toxins changed from the mouse bioassay to LC-MS methods during July.

Northern Ireland

In 2011, twenty six sites were sampled routinely on a fortnightly basis from N. Ireland sea loughs and coastal waters and a total of 627 samples analysed. *Alexandrium* spp. were recorded in 2.4 % of samples and the maximum cell abundance (60 cells L^{-1}) was recorded in a sample from Belfast Lough in April. PSP toxins in shellfish did not exceed the regulatory limit during 2011.

Dinophysis spp. were present in 23 % of water samples. A large bloom of *Dinophysis* spp. occurred in Belfast Lough during July and August (maximum abundance of 15,660 cells L^{-1} was recorded on 31 July). This is the largest cell density of *Dinophysis* recorded in this region since monitoring began. Lipophilic shellfish toxins were detected in *Mytilus edulis* during this period as part of the statutory testing programme reaching a maximum concentration of 625 μg OA g^{-1}. As a result a number of shellfish beds were closed in the lough for a period of six weeks. As in previous years the most abundant species was *D.acuminata* with only low numbers of *D.acuta*, *D.norvegica* and *D.rotundata* counted.

Pseudo-nitzschia spp. were present in 65 % of water samples received and reached a maximum abundance of 264 640 cells L^{-1} in a sample from Dundrum Bay in late August. Toxicity due to domoic acid was confined to samples of whole scallops (*Pecten maximus*) from Strangford Lough.

England and Wales

During 2011, a total of 54 production areas were monitored routinely in England and Wales.

Alexandrium spp. were recorded in 22 of the 54 sampled areas, and in 134 of the 1130 samples collected. Highest concentrations were found in the Yealm where it occurred from May to October, reaching a maximum density of 675 000 cells L^{-1} on 14 September. The greatest frequency of *Alexandrium spp* occurred in the Fal estuary (Cornwall) where a concentration of 300 000 cells L^{-1} was reported at the end of June, and it persisted from May to October. PSP toxins breached action levels on 14 occasions (the highest number for a decade). These samples (all mussels) were collected from Milford Haven (Wales) and the Fal and the Fowey estuaries (SW England) between June and August 2011 when they coincided with the presence of *Alexandrium spp* at all three locations.

Dinophysis spp. were observed on 53 occasions, most frequently in the Fowey where they occurred between May and August when the maximum concentration of 1900 cells L^{-1} was recorded from that area. The maximum concentration of over 2000 cells L^{-1} was recorded from a sample collected from St Austell Bay (Cornwall) also in August. Lipophilic toxins above regulatory limits were recorded from 12 shellfish samples These were recorded by mouse bio-assay in 2 samples from the Burry Inlet (south Wales) and 2 from Butley Creek (Suffolk). They were also recorded by LC-MS from samples collected in St Austell Bay (where they coincided with the occurrence of *Dinophysis spp*.) and Swansea Bay.

Pseudo-nitzchia spp. (ASP) were found in 419 samples from 31 production areas. Highest cell densities were observed in the south-west of England and south Wales. Peak concentration reached 1.9 million cells L^{-1} in the Fowey in June. Once again there were no closures of shellfish production due to the presence of ASP toxins.

Scotland

The dinoflagellate *Alexandrium* spp. was present in over 33% of the total samples analyzed. It was most frequently observed between April and June, occurring in almost 42% of all samples analyzed during these months in the south west, west coast and Shetland Islands. There were two closures as a result of high concentrations of PSP toxins in shellfish tissue in Loch Laxford (north west) and Loch Eishort (Skye). The highest *Alexandrium* cell density recorded in the whole of Scotland in 2011 occurred in Loch Creran. The bloom was present in Loch Creran for a continuous period of eleven weeks from 30 March until 8 June, reaching a maximum cell density of 9680 cells L^{-1} on 11 May. PSP toxicity was not reported in shellfish from this region during this time. The bloom appeared to be dominated by the non-toxic *Alexandrium tamutum*.

The dinoflagellate *Dinophysis* spp. was present in 52% of the samples analysed throughout the year. *Dinophysis acuminata* was the most commonly observed species. *Dinophysis* was first recorded in the south west of Scotland in March and reached a maximum abundance of 900 cells L^{-1}. The densest *Dinophysis* bloom observed in the south west reached a peak abundance of 1400 cells L^{-1} on 7 June in nearby Loch Striven, and lipophilic toxins were detected in mussels in both Loch Fyne and Loch Striven. A bloom in August and September in Loch Melfort resulted in OA/DTX toxins reported above permitted levels in mid September. *Dinophysis* was present in the water column in Loch Scridain (west coast) throughout most of the period from mid April to late September. Associated OA/DTX toxins were reported above permitted levels from July into September in common mussels from this site. The highest *Dinophysis* density observed in the whole of Scotland in 2011 occurred in Loch Beag (Highland), with a peak abundance of 3820 cells L^{-1} litre recorded on 30 August. *Dinophysis* was frequently observed in Loch Eishort (Skye). OA/DTX toxins were reported above regulatory limit in *Mytilus edulis* for several weeks in September, following a bloom peak of 400 cells L^{-1} on 29 August at this site. *Dinophysis* was most abundant around the Shetland isles in late June, July and August, with OA/DTX toxins below regulatory limits in shellfish frequently being reported during this period. In the Western Isles, *Dinophysis* were frequently observed in Loch Roag during July, August and September. OA/DTX toxins were detected above regulatory limits on several occasions at this site.

The diatom *Pseudo-nitzschia* spp. was present in over 91% of all samples analyzed during 2011. The earliest bloom of *Pseudo-nitzschia* in 2011was observed on the east coast at Dornoch Firth, where a cell count of 80 845 cells L^{-1} was recorded on 22 March. Spring blooms also occurred at sites in the south west of Scotland and around Shetland. The densest *Pseudo-nitzschia* bloom for the whole of Scotland in 2011 was observed in Shetland at Dales Voe in mid August, with a maximum cell count of 837 637 cells L^{-1} recorded on 16 August. *Pseudo-nitzschia* blooms were widespread around the whole of Shetland throughout July and August and into September and were prolonged in some areas .There were no closures of shellfish harvesting areas during 2011 as a result of high ASP toxin concentrations.

The dinoflagellate *Prorocentrum lima* was observed in relatively low numbers, but was present in approximately 21% of the samples analyzed during the year. The maximum density observed for Scotland in 2011 was recorded at Kyle of Tongue, (north mainland coast) with a concentration of 1780 cells L^{-1} on 31 August.

Prorocentrum minimum was present in over 50% of the samples analyzed, although blooms were not particularly dense. The densest bloom of *Prorocentrum minimum* around the Scottish coast in 2011 was observed in Olna Firth (Shetland Isles) on the 21 June where a maximum abundance of 346 558 cells per litre was recorded. *Protoceratium reticulatum* was recorded at low concentrations in approximately 8% of the samples analyzed during 2011. It was most abundant at Loch Fyne in the south west of Scotland with the largest recorded concentration for 2011 of 2160 cells $L^{-1.}$ *Lingulodinium polyedrum* was observed in Loch Creran and West Loch Tarbert in the south west of Scotland during 2011. The maximum concentration recorded was 280 cells L^{-1}.

The potentially problematic species *Karenia mikimotoi* was most frequently observed in August and September. Blooms during 2011 were not particularly dense, although a bloom of 975 689 cells per litre was detected in Loch Eishort (Skye) in late August.

5.1.9 United States of America National Report

Don Anderson

PSP. On the U.S. west coast, Alaska, Washington, Oregon and California all recorded PSP toxicity during 2011. Eight confirmed and 13 probable PSP cases occurred in Alaska. This represents a considerable increase in the numbers reported in recent years (≤10 cases annually since 1998.) This was an active epidemiological investigation that uncovered poisoning cases that might not otherwise have been reported, indicating that the overall burden of PSP in Alaska likely is underestimated through standard reporting. However, saxitoxin levels were higher in shellfish during 2011 than in previous years, indicating that the increase in the number of cases might not have been entirely a surveillance artifact.

Alaska saw record high toxin scores – 30 000 µg STX per 100 g in baby mussels harvested from Rotary Beach in Ketchikan. Commercially harvested shellfish are tested for saxitoxin in Alaska are considered safe for human consumption but shellfish collected by persons for their own use are not. Because shellfish harvesting is an important cultural tradition and shellfish are an important subsistence food source for many Alaska Natives and other Alaska residents, not everyone follows the public health recommendation to avoid eating shellfish from non-commercial sources. Furthermore, transient fish-processing workers in Alaska might e unaware of the potential danger of eating untested Alaskan shellfish because they are unfamiliar with PSP and might have limited English literacy.

During the investigation, SOE epidemiologists posted signs at beaches on Metlakatla and in the community to warn residents about he PSP risks associated with consuming non-commercially harvested shellfish. The warnings were printed in English, Tagalog, Russian, Spanish, and Korean. The Ketchikan Public Health Center and the Alaska Department of Fish and Game posted similar signs throughout Ketchikan and surrounding areas. Additionally, the Alaska Department of Health and Social Services issued press releases and conducted media interviews to inform the public about the outbreaks and the need to avoid non-commercial harvesting of shellfish.

Compared with 2010, Washington had a less significant PSP year with no one site exceeding 1000 microgram. Closures took place in Puget Sound, the Strait of Juan de Fuca and the Olympic Peninsula. An automatic annual shellfish closure is put in place between April and 31 October for the outside Washington coast. Both Oregon and California experienced relatively light years.

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

New York state had closures due to PSP on the north side of Long Island (Northport Bay, Huntington Bay and Lloyd harbour) as well as all of Shinnecock Bay on the south side of the island.

Florida experienced *Pyrodinium bahamense* blooms on the west coast (Tampa Bay). The bloom lasted approximately 2 months but did not reach the lower levels of the Bay where harvesting is permitted. The maximum cell concentration was 600K cells/L. The Indian River lagoon bloom lasted for approximately 5.5 months with a maximum cell count of just under 1 million cells/L.

ASP. California experienced closures due to domoic acid – levels reached 387 μg / g offshore of Santa Barbara. Once again, Washington State had very low levels of domoic acid with no closures reported. Oregon had no reports of domoic acid. Domoic acid was detected in shellfish east of Mount Desert Island, Maine, but below action levels.

NSP. Florida experienced *Karenia brevis* blooms on both the east and west coasts. Both blooms started in the fall and continued through the end of the year. Texas experienced a bloom of *Karenia* initially detected by the Imaging FlowCytobot in July. The bloom continued into 2012. Mortalities included coyotes, domestic dogs, redhead ducks, shovelers, red knots, double-crested cormorants, fish and ghost shrimp. At one point during the bloom, discoloured water and dead fish could be found along over 250 miles of Gulf beach, from San Luis Pass to the Rio Grande. Presumably this bloom extended into Mexico though we have no information to confirm this.

DSP. For the first time, DSP toxins were detected in Washington state causing four commercial closures in the Olympic Peninsula and Strait of Juan de Fuca. Sequim Bay experienced commercial and recreation closures due to DSP with 3 human illnesses reported. The highest DSP toxin level recorded was 1.60 μg per gram of shellfish tissue. DSP toxins (1.25 μg per g) were also detected in New York state – (Northport Harbor on Long Island).

Brown tide. Once again, the south shore of Long Island, NY experienced a significant brown tide bloom, which began in June and ended in July. The bloom was very intense compared to prior years, reaching densities over two million cells per ml (normally blooms peak at one million cells per ml). This was the fifth 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.

6 Term of Reference C

6.1 C1 Quantify the occurrence of fish killing algal events in the ICES region

Background

In recognition of concerns over the impact of fish killing marine micro-algae on society, economic interests and the sustainability of food supplies (especially aquaculture), the IOC Intergovernmental Panel on Harmful Algal blooms (IPHAB) established a task team (Resolution IPHAB-X.7) on fish killing marine micro-algae. The task team (A. Cembella, Germany (Co-chair), R. Gowen, UK (Co-chair), P. Hess, France, and M. Wells, USA (and PICES) was given the following terms of reference:

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

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

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

At the request of IPHAB, the ICES-IOC Working Group on Harmful Algal Bloom Dynamics was asked to address the issue and identify research needs at its April 2012 meeting in Oban, Scotland. The terms or reference for WGHABD were:

i) Quantify the occurrence of fish killing algal events in the ICES area;

ii) Document gaps in understanding of the processes controlling the occurrence of fish killing algae and the factors that cause fish mortality.

WGHABD Discussion

R. Gowen introduced the topic and presented a proposal for delivering the tasks set by IPHAB. N. Daubjerg presented details of a 5 year Danish programme (HABFISH, Harmful Algal Blooms and Fish Kills) and highlighted some of key issues associated with icthyotoxic microalgae.

The WG agreed that the occurrence of fish killing algae (microalgae that are capable of killing fish (and other marine organisms) through the production of toxins, physical damage to tissues such as gills or by causing indirect asphyxiation) is a serious problem in ICES member states and globally. Below there are examples of the species that have been associated with mortalities of fish in some ICES member states and Egypt. The WG identified a need for a detailed assessment of the scale of the problem and the identification of key knowledge gaps. For example, why fish die when exposed to icthyotoxic algae. There have been few studies of icthyotoxic algae under controlled conditions and mechanisms of action are in many cases unknown. The WG concluded that a joint ICES/IOC/PICES meeting would be an appropriate venue to quantify the scale of problems caused by fish killing algae at the global scale.

It was noted that a theme session on fish killing algae has been proposed for the 15th International Conference on Harmful Algae (ICHA) to be held in the Republic of Korea in 2012 would provide a valuable forum for discussion.

WGHABD agreed the following actions:

i) Forward this WGHABD summary to M Wells (PICES) to help inform discussion of fish killing microalgae at PICES;

ii) To prepare a report documenting the occurrence of fish killing algal events in the ICES area, gaps in understanding of the processes controlling the occurrence of fish killing algae and the factors that cause fish mortality. The report will be based on a review of the literature and prepared by R. Gowen, A. Cembella, N. Daubjerg and K. Davidson and presented for discussion at the 2013 WGHABD meeting and the XI session of IPHAB in 2013.

Here follows a summary of fish killing algae events and information on fish killing species in six ICES countries and in Egypt.

6.1.1 Denmark

Contribution from Denmark regarding fish kills and fish killing algal species -the last five years perspective

Niels Daugbjerg (n.daugbjerg@bio.ku.dk)

Denmark has for a number of years witnessed recurrent blooms in the same marine regions. In this respect the most significant bloom being *Pseudochattonella farcimen*. *Pseudochattonella* was first recorded in 1998 and seems to have been increasing in cell numbers every year since then. Blooms of *Pseudochattonella* peaks late winter/early spring (March) when the water temperature is very low (i.e. 1–3 °C). The record high number of cells per litre is 70 millions (in 2011). Other water samples contained cell concentrations are 22 million cells/l. No caged fish died due to this bloom - the fish were not yet put into the nets at sea. However, their "release" to the nets at sea was delayed by 1–2 weeks. In 2011 there are a few reports mostly from line fishermen on dead trout floating along the coast. No other dead fish species, or effects on sea birds and marine mammals were noted.

In 1998 when the bloom forming *Pseudochattonella* was first recorded in Scandinavian waters 1100 tons of farmed salmon along the Norwegian coast died.

Denmark also has occasional blooms of other fish killing algal species but dead fish along the coast or in nets have not been recorded due to these.

An extensive bloom of *Chrysochromulina polylepis* in 1988, which killed 800 tons of trout, salmon and cod has never reappeared in Scandinavian waters.

List of fish killing algae recorded in Danish waters:

Dinophyceae: *Alexandrium tamarense*, *Karlodinium veneficum*, *Karlodinium* spp., *Karenia mikimotoi*, *Pfiesteria piscicida* and *Pseudofiesteria shumwayae*

Haptophyceae: *Prymnesium parvum* and *Chrysochromulina polylepis*

Dictyochophyceae: *Pseudochattonella farcimen* and *Dictyocha speculum*

Raphidophyceae: *Fibrocapsa japonica*

6.1.2 Egypt

Fish killing algal species during the last five years in Alexandria, Egypt

Mikhail K. Samia

There are evidences for the distinct increased recurrent frequency of the red tide blooms in Alexandria coastal waters, their intensity, magnitude, and the number of harmful and harmless causative species.

1- *Prorocentrum minimum* formed a monospecific bloom in 11 June 2007, 3.25×10^6 cells l^{-1} at 24°C and salinity 36.5
2- *Prorocentrum triestinum*: last bloom was occurred on 16 August 2007

With a peak of 38.76×10^6 cells l^{-1} at 19.8-29.5°C and Salinity 22.5–37.5

3- *Chattonella antiqua* forming monospecific bloom during late August /early September, 2006. The species, caused mass fish mortalities and showed wide spatial distribution. Cell density at peak day in the different sites was:

- 23.13×10^6 cells l^{-1}, Chl *a* 88.5 μg l^{-1} (Sept. 1, Mex Bay)
- 4.12×10^6 cells l^{-1} (Sept. 4, Eastern Harbor)

- 1.82×10^6 cells l^{-1} (Sept. 4, Montaza area)

Last massive mono-specific bloom of *C. antiqua* was recorded during 30 August – 2 September 2010. The species originated at Mex Bay distributed about 20m. East along the coast, cell density at 13.1×10^6 cells l^{-1}. Fish mortalities accompanied this bloom.

4- *Karenia mikimotoi* .The last bloom with peak of 1.32×10^6 cells l^{-1} on 11 August 2007 at Kayet Bey Area the temperature at peak day was 28.5°C and Salinity 34.5

5- *Alexandrium ostenfeldii* showed its last bloom on 31 July 2007. The highest cell density 0.52×10^6 cells l^{-1} recorded at 28°C and salinity 37.5

6- *Gymnodinium catenatum;* the last bloom was observed in August 1st 2006 at 1.12×10^6 cells l^{-1}, 28.2°C and salinity 35.5

7- *Prorocentrum sigmoides* Max. Density 0.15x106 cells l-1 in August 2007

8- *Alexandrium catenella* attained 0.135×10^6 cells l^{-1} on August 2007

9- *Heterosigma* sp. reached 160×10^3 cells l^{-1} on 22 August 2007

6.1.3 Ireland

Fish Kills associated with phytoplankton in Ireland

Joe Silke

A number of species have been associated with mass mortalities of both caged farmed fish and wild fish in Ireland. The most notable events were a series of mortalities in farmed salmon and sea trout in the 1970s which resulted in the collapse of this aquaculture activity in sea farms along the south coast of Ireland. The industry relocated to sites along the western and northern coast of Ireland. The species associated with this was a small flagellate initially referred to as "Flagellate x" but later tentatively identified as *Heterosigma akashiwo.*Between 1980 and 200 intermittent booms resulted in fish kills on these salmon farms caused by *Gyrodinium aureolum* which was later renamed *Karenia mikimotoi.* The most recent mortality from *Karenia mikimotoi* in Ireland was in 2005 when an extensive bloom persisted through the months from May until August with resulting mortalities in benthic invertebrates and wild and farmed fish and shellfish. Reports of dead lugworms, crabs, flatfish and dogfish were obtained from local fishermen in Donegal. In addition there were reports of an absence of prawns in the Donegal bay area. These mortalities and avoidance of the bloom are consistent with *Karenia* blooms of this scale and were observed previously during similar bloom events of this species. Satellite images of the bloom showed the extent of the bloom along the coast and up to approx 100 km offshore. The origin of these populations on the Irish Shelf remained uncertain, until current measurements revealed the presence of a clockwise coastal flow (the Irish Coastal Current (ICC) and its association with the transportation of large dinoflagellate communities from the northern Celtic Sea towards shelf waters adjacent to the bays of southwestern Ireland (Raine and McMahon, 1998). This paper also proposed that under easterly or northeasterly wind conditions, a westward flow of up to 10–16 cm s-1 would cause these blooms to be advected around the coast towards the bays of southwest Ireland within a period of 3–5 days and then subsequently transported into the bays of the region following a resumption of the prevailing west or southwesterly winds. Conversely, when easterlies and northeasterlies are absent and winds blow from the west or southwest the inshore coastal current is restrained which in turn limits the alongshore westwards advection of K. mikimotoi populations.

There have also been problems with irritant species such as *Chaetoceros* in particular the species with strong setae which result in fish producing excessive mucilage on the gills in response to them. The dinoflagellate *Prorocentrum balticum* has also been implicated in a fish kill along the northern coast of Ireland

6.1.4 Poland

Hanna Mazur-Marzek

In the last ten years, only two fish kill events were recorded. On 31 July 2004, dead fish were found in water and on beaches of the Gulf of Gdańsk. In young forms of *Ammodytes tobianus* the concentration of nodularin (NOD) was 1.6–2.8 μg/g. That year, a record bloom of nodularin-producing cyanobacteria *Nodularia spumigena* was recorded. In seston, 25 mg NOD/L was measured.

The second incident of fish kill was recorded in Puck Bay off Kuźnica (Hel Peninsula, southern Baltic Proper) on 28 June 2005. It was accompanied by the presence of increased number of *Anabaena lammermannii* (potentially toxic). Single filaments of toxin producing *Nodularia spumigena* were also present in phytoplankton.

6.1.5 Spain

Beatriz Reguera

Heterosigma akashiwo (Y.Hada) Y.Hada ex Y.Hara & M.Chihara, 1967

Heterosigma akashiwo is often present in shellfish growing areas in the Galician Rías (NW Spain) where it may become dominant during autumn downwelling (Crespo *et al.*, 2006). Blooms of this species occasionally precede blooms of *G. catenatum* (Fraga *et al.*, 1984), but have never been associated with negative impacts within the region, where fish aquaculture is not a major activity. Nevertheless, blooms of *H. akashiwo* do pose a threat to the growing finfish aquaculture initiatives in the Algarve coast (southern Portugal) where fish kills at farm sites have been attributed to this species (T. Moita, pers. comm.).

Crespo, B.G., Figueiras, F.G., Porras, P., Teixeira, I.G., 2006. Downwelling and dominance of autochthonous dinoflagellates in the NW Iberian margin: the example of the Ria de Vigo. Harmful Algae 5, 770–781.

Fraga, S. Mariño, J., Bravo, I., Miranda, A., Campos, M.J., Sánchez, F.J., Costas, E., Cabanas, J.M., Blanco, J. 1984. Red tides and shellfish poisoning in Galicia (NW Spain). International Council for the Exploration of the Sea. Special meeting on the causes, dynamics and effects of exceptional Marine Blooms and related events, C:5, 10 pp.

Karenia mikimotoi (=Gyrodinium aureolum, Gyrodinium nagasakiense)

In the Galician coast, dense blooms of *Karenia*, probably *K. mikimotoi*, are known to be the cause of conspicuous green discolourations of the water, with reported blooms in 1989 of up to 200 μg chl a 1^{-1} (Jiménez *et al.*, 1992), but have never been associated with any harmful impacts.

Jiménez, C., Niell, F.X., Figueiras, F.G., Clavero, V., Algarra, P., Buela, J., 1992. Green mass aggregations of Gyrodinium cf aureolum Hulburt in the Ria of Pontevedra (Northwest Spain). Journal of Plankton Research 14, 705–720.

Karlodinium veneficum (Ballantine, 1956) J. Larsen, 2000

Karlodinium armiger Bergholtz, Daugbjerg & Moestrup, 2005

Combined blooms of *K. veneficum* and *K. arminger* cause fish mortalities and led to the collapse of fish aquaculture in Alfacs Bay, Delta del Ebro (a river delta region, south of Barcelona, the main aquaculture site in Catalonia).

Bergholtz T., Daugbjerg N., Moestrup Ø. & Fernández-Tejedor M. 2005. On the identity of *Karlodinium veneficum* and the description of *Karlodinium armiger* sp. nov. (Dinophyceae), based on light and electron microscopy, nuclear-encoded LSU rDNA, and pigment composition. J. Phycol. 42: 170-193.

Daugbjerg N., Hansen G., Larsen J. & Moestrup Ø. 2000. Phylogeny of some of the major genera of dinoflagellates based on ultrastructure and partial LSU rDNA sequence data, including the erection of three new genera of unarmoured dinoflagellates. Phycologia 39: 302-317.

6.1.6 Sweden

Bengt Karlson

Documented fish kills in Swedish coastal waters are very few. This is likely not because of absence of fish killing algae but because of the smallness of the fish farming industry. The following species are of concern.

Pseudochattonella

This genus belongs to the Dictyochophyceae. The first bloom occurred in 1998 and at this time the name *Chattonella* aff. v*erruculosa* was used. The name *Verrucophora* was used for a short time but *Pseudochattonella* is the current name. *Pseudochattonella farcimen* is the species causing problems in spring.

Effects on fish:

- The gills are damaged – mechanism unclear
- Symptoms similar to anoxia
- Wild: *Belone belone* (Garfish, Garpike)
- Farmed fish: *Salmo trutta* and *Salmo salar*

Bloom history

1998 April/May
First large bloom in the area observed in May along West coast of Denmark
Bloom spreads into the Skagerrak and the Kattegat
350 tonnes of salmon died in southern Norway
Wild fish (*Belone belone* Garfish, Garpike) also died

2000 April/May
Large bloom along Danish West coast, German bight to Skagen
No fish mortality observed

2001 March/April
Large bloom in the Kattegat and the Skagerrak directly after spring bloom
1100 tons of salmon died

2004 April/May
Bloom concentrations on the Danish West coast and also in the Kattegat
No fish mortality observed

2006 February/April
Bloom strongest in the Kattegatt
Fish farm with *Salmo trutta* on land in Denmark affected, ca 18 tonnes dead

2007–2011 Blooms in March-April direct after or together with the diatom spring bloom. In 2011 a major bloom was observed in the Belt Sea area (see Danish report).

Prymnesium polylepis (former name Chrysochromulina polylepis)

This species have been observed in bloom abundances in the Baltic proper during the last few years. No harmful effects have been reported. A major bloom of this species occurred in the Skagerrak-Kattegat area in 1988. In early May 1988 caged fish died in the Gullmar Fjord, Swedish Skagerrak coast Kattegat and the Skagerrak in May-June 1988. Subsurface populations were associated with the pycnocline. The bloom caused many mortalities of marine animals and macro algae.

Edvardsen, B., Eikrem, W., Throndsen, J., Sáez, A.G., Probert, I. & Medlin, L.K. 2011. Ribosomal DNA phylogenies and a morphological revision provide the basis for a revised taxonomy of the Prymnesiales (Haptophyta). *European Journal of Phycology* 46(3): 202-228.

Prymnesium/Chrysochromulina fish mortalities in Kyrkfjärden 1991 and 1992

In Kyrkfjärden, an area with restricted water exchange, fish kills were observed two years in a row. *Chrysochromulina kappa* nd *Prymnesium* sp. were observed in the water. The following species of fish were affected:

Freshwater bream *Abramis brama*
European perch *Perca fluviatilis*
Northern pike *Esox lucius*
Bleak *Alburnus alburnus*

Karenia mikimotoi

The name *Gyrodinium aureolum* has been used extensively in Scandinavia. That is another species. Last major bloom in Sweden was in autumn 1988. The last few years the species have been observed again. No harmful effects have been documented.

Karlodinium cf. veneficium

In June 2012 dead fish were observed near the town of Mönsterås in the western part of the Baltic proper. In a phytoplankton sample collected at the same place *Karlodinium* cf. *veneficium* was observed in high abundances.

Chaetoceros cf. concavicornis

This diatom has been observed in the Skagerrak and the Kattegat since year 2008. It is likely to b e and introduced species. The setae have spines that may cause damage to gills.

Noctiluca scintillans

Observations of red water and bioluminescence common along the Kattegat and Skagerrak coast but no fish mortalities have been reported.

6.1.7 United Kingdom

Summary by Richard Gowen

In the 1970s and early 1980s, blooms of an unidentified microflagellate (Flagellate X later tentatively identified as *Heterosigma akashiwo*) were held responsible for the mortalities of farmed salmon and trout on the west coast of Scotland. Blooms of *Karenia mikimotoi* have been associated with mortalities of marine organisms in coastal waters of the UK but reports of fish mortalities are mostly restricted to Scottish waters. In

1980, a bloom (20.0 x 10^6 cells L^{-1}) caused the deaths of farmed salmon in Loch Fyne and large blooms occurred in 1999, 2003 and 2006. The 2003 bloom (18.0 x 10^6 cells L^{-1}) around the Orkney and Shetland Islands was responsible for the deaths of 53 000 farmed fish from four sites in the Shetland Isles. The largest recent bloom (~10 million cells L^{-1}) was in 2006. A bloom of the dinoflagellate *Heterocapsa triqueta* (1.0 x 10^6 cells L^{-1}) was associated with substantial losses to fish farms in the Shetland Isles in May 2001 as did a *Gymnodinium* spp. bloom (~ 9 x 10^6 cells L^{-1}) in the Orkney and Shetland Islands in August of that year. Some species of *Chaetoceros* have been associated with mortalities of fish. A bloom consisting predominantly of *C. wighami* in Loch Torridon and a mixed bloom of *C. debile* and the silicoflagellate *Dictyocha speculum* were responsible for the deaths of farmed fish with a market value of several million pound.

Fish Killing organisms in Scottish waters

Keith Davidson

Recent instances of *Karenia mikimotoi*: Largest recent bloom (~10 million cells L^{-1}) was in 2006 that was first evident in Mull and then migrated round the coast in a Northerly direction, eventually being evident in Shetland and the East Coast. (Davidson *et al.* 2009). No farmed fish kills in 2006 (10 million though to be the threshold for kills and the bloom was just less than that) although "distress" reported, lots of benthic mortalities. Subsequently FSA and Crown Estate (*K. mikimotoi*) specific monitoring have indicated substantial blooms each year (I haven't really synthesised these data yet, but it would be easy to do so). No published data on fish kills, but anecdotal report of fish kills of fish being transported by a well boat.

Historical *K. mikimotoi*: the first reported fish kill in west Scotland waters attributed to a *K. mikimotoi* bloom was in Loch Fyne in 1980. Also occurred in Loch Striven, East Loch Tarbert and Loch Ewe. Few reports subsequently, but a bloom in Shetland in 2001? caused mortalities of farmed fish.

Other fish killers: Flagellate X in Lochs Striven and Fyne. Few reports of *Heterosigma* or *Chattonella* etc compared to Scandinavia and "similar" regions on W coast of US etc, an interesting point is why are there not more blooms in Scotland? (as raised by Smayda 2005 in his Scottish Government Review)

Davidson K, Miller PI, Wilding T, Shutler J, Bresnan E, Kennington K, Swan S (2009). A large and prolonged bloom of *Karenia mikimotoi* in Scottish waters in 2006. Harmful Algae 8:349-361 doi:10.1016/j.hal.2008.07.007

Smayda TJ (2005)Harmful Algal Bloom Communities in Scottish Coastal Waters: Relationship to Fish Farming and Regional Comparisons - A Review.

http://www.scotland.gov.uk/Publications/2006/02/03095327/2

6.1.8 USA

Mark Wells

Western Coastal USA Waters

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

Hershberger, P.K., J.E. Rensel, J.R. Postel, and F.B. Taub. 1997a. *Heterosigma* bloom and associated fish kill. Harmful Algae News 16:1 and 4.

Horner, R.A., D.L. Garrison, and F.G. Plumley. 1997. Harmful algal blooms and red tide problems on the U.S. West Coast. Limnol. Oceanogr. 42:1076-1088.

Horner, R.A. 1998. Harmful Algal Blooms in Puget Sound: General Perspective. 4th Puget Sound Research Conference, Seattle, WA, March 12-13, 1998.

Rensel, J.E., R. Horner, and J.R. Postel. 1989. Effects of phytoplankton blooms on salmon aquaculture in Puget Sound, Washington: initial research. Northwest Environ. J. 5: 53-69.

Rensel, J.E. 2007. Fish-Killing blooms of *Heterosigma akashiwo* in Puget Sound and Adjacent Waters. Prepared for National Oceanic and Atmospheric Administration Center for Sponsored Coastal Ocean Research (CSCOR). Rensel Associates Aquatic Sciences, Arlington, WA.

Rensel, J. E., R. Haigh, and T. J. Tynan. 2010. Fraser river sockeye salmon marine survival decline and harmful blooms of Heterosigma akashiwo. Harmful Algae 10:98-115.

6.2 C2 Document gaps in understanding of the processes controlling the occurrence of fish killing algae and the factors that cause fish mortality

This ToR was addressed as part of ToR C1. In addition a ToR for 2013 is proposed in which a more extensive report on fish killing algae is planned.

7 Term of reference D

7.1 Scope and plan a workshop focused on automated in-situ devices and imaging technology (including newer molecular methods) used for observing HABs and detecting toxins

Don Anderson led the discussion of the proposed **Workshop on Automated Harmful Algal Bloom in situ Observation Systems.** During the intercession, Anderson and WGHABD Chair Bengt Karlson had discussed the concept of the workshop, and prepared a tentative workshop outline.

The WG discussed the various options for a workshop, as well as the overall objective of such a meeting, and the target audience. The three main instruments for HAB research and monitoring that are being considered for remote or semi-automated deployment are:

1) The **Environmental Sample Processor (ESP)** - a submersible, robotic instrument that collects discrete water samples, concentrates microorganisms or particles, and automates application of molecular probes to identify target microorganisms and gene products (see video at http://www.mbari.org/esp/). Contextual sensors for light, salinity, chlorophyll, temperature, and turbidity complement the ESP's data on microbial abundance. The ESP is commercially available through McLane Laboratories, Inc in Falmouth MA.

2) The **Imaging Flow CytoBot (IFCB)** - an instrument that combines flow cytometric measurements with in-flow micrograph imaging to provide records of plankton species dynamics and behavior (see http://www.whoi.edu/main/imaging-flow-cytobot). The IFCB is not commercially available.

3) The **FlowCAM** - a benchtop instrument that automatically captures digital images of each particle as it passes by in a fluid stream and records up to 26 different measurements for each particle. See http://www.fluidimaging.com/products-benchtop.htm. The FLowCAM is commercially available.

It is of note that a number of the sensors that would potentially be of interest in the workshop (ESP, IFCB) are still very much in the development stage. They are also very complex, sensitive instruments, so a hands-on workshop to learn techniques would not be appropriate at this time. On the other hand, the WG felt there would be considerable value in holding a two-day working session in which detailed presentations are given by both the manufacturers and users of the instruments, so that both the promise and the realities of field and laboratory use can be explored. Other WG members felt that it might be more productive to have only users at the workshop, and to not include the salesmen or manufacturers. The discussion did not come to closure on this issue.

The target audience would be those conducting research and monitoring of HABs who might be interested in deploying automated sensors in their activities. The initial approach will be to have the workshop restricted to the members of the WGHABD, with a few invited users to provide real-world experience. With this approach, there would not be a need for major fund-raising efforts, as most WG members would already be travelling to the workshop site. Opening up the workshop to others would make it a much more expensive and complex activity, and this might raise expectations to unrealistic levels in terms of instrument use and training. This seems premature given that direct demonstrations of several of the instruments would not be likely, given the complexity of the instruments, and their limited availability (i.e. with the exception of the FlowCAM, the few instruments that exist are likely to be deployed or in use at the time of the workshop).

The decision was made to add a two-day workshop session onto the normal 3-day WGHABD session. This is not possible in 2013, so the workshop is tentatively scheduled for 2014, in Woods Hole. The choice of the venue and time reflects the availability of instruments and experienced personnel. Don Anderson has 6 ESPs in his lab at WHOI, and should be able to make one available for demonstrations. Likewise, the IFCB was developed at WHOI by Rob Olson and Heidi Sosik, and thus it is possible that an instrument will be available for inspection, and perhaps some trial runs, if the workshop is in Woods Hole. The FlowCAM is readily transportable, and can easily be brought to Woods Hole for demonstration purposes. A Term of Reference for WGHABD 2013 will be to discuss and plan the workshop details.

8 Term of Reference E

8.1 To collate and discuss data on macroalgal blooms and their impacts in the ICES region

This ToR was discussed by the group. The WGHABD main expertise is on blooms of harmful phytoplankton, i.e. microalgae. Thus this ToR was not fully addressed. WGHABD recommends that ICES establishes an expert group on macroalgae to address issues related to eutrophication and the formation of mats of filamentous macroalgae etc.

9 Term of Reference F

9.1 Report on the impacts of harmful algal blooms on marine mammals and birds relevant to the Marine Strategy Framework Directive objectives

Ailsa J. Hall, Sea Mammal Research Unit, University of St Andrews, St Andrews, Fife, UK, KY16 8LB

Harmful algal bloom (HAB) monitoring programmes currently underway in the UK focus on monitoring of shellfish growing areas in fulfilment of the EU regulation EC 854/2004 and its amendments. The Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC) requires member states ensure that their waters achieve 'Good Environmental Status (GES)' in line with prevailing oceanographic conditions by 2020. Eleven descriptors encompassing different aspects of the marine ecosystem are being used to describe GES. Further background information on these descriptors can be found on the ICES website at http://www.ices.dk/projects/projects.asp#MSFD. Descriptor 4, " Food Webs", uses top predators such as marine mammals and birds as indicators of the status of food webs however the impact of algal toxins on marine mammals in European waters has yet to be fully investigated.

In UK waters the algal toxins responsible for Paralytic Shellfish Poisoning (PSP), Diarrhetic Shellfish Poisoning (DSP) and Amnesic Shellfish Poisoning (ASP) have been detected in shellfish since routine monitoring began (Davidson and Bresnan, 2009). Historically, enforced closures of fishing areas due to high concentrations of toxins , such as ASP, have had a significant negative economic impact on the associated industries (Gallacher *et al.*, 2001). To date he main focus of research on the impacts algal toxins has been with a view to improving biotoxin monitoring programmes. These studies revealed how different species accumulate algal toxins with *Mytilus edulis* taking up and depurating the ASP toxin, domoic acid (DA), much more rapidly than *Pecten maximus* (Bresnan 2005). Little work has been performed to date on algal toxins throughout the marine food web. Examination of field samples from the Stonehaven monitoring site in the North East of Scotland (56º 57.8′ N, 02 º 06.2′ W) show that copepods can act as a vector for DA in the marine ecosystem. During 2008, DA concentration in copepods increased to 20ϱg DA. indiv-1 (Marine Scotland Science, unpublished data). To date, reports of the impacts of algal toxins on higher trophic levels in this region have been ad hoc. PSP toxins are suggested to be have been associated with mortalities of sea birds along the North East Coast of the UK (Ayres and Cullum, 1978). Okadiac acid, the toxin responsible for DSP was detected in dead sea birds from the North East Coast of Scotland in 2002 and DA in the tissue of a dead Minke whale in 2005 (Marine Scotland Science, unpublished data).

The impact of HABs on marine mammals and birds appears to have been increasing in recent years (Gulland and Hall, 2007) and although it is not known whether this is a function of increases in stranding reporting effort or in our ability to detect exposure to biotoxins in marine vertebrates, it is clear that HAB events are having a widespread effect on a variety of species and populations (Landsberg, 2002, Shumway *et al.*, 2003). Among the most notable events domoic acid (DA) toxicosis in California sea lions (*Zalophuscalifornianus*) associated with blooms of *Pseudo-nitzschia australis*, have been among the best reported (Gulland *et al.*, 2002). The first major episode was described in 1998 (Scholin *et al.*, 2000), and since then hundreds of stranded sea lions and birds (Work *et al.*, 1993; Fritz *et al.*, 1992) with neurological signs including seizures, head weaving, ataxia, depression and abnormal scratching have been observed along the coast of California particularly during major bloom events such as in 1998, 2000, 2007 and 2010 (Bargu *et al.*, 2010; Goldstein *et al.*, 2008). Acute, high DA exposure and ingestion of contaminated planktivorous fish prey results in these classical signs of amnesic shellfish poisoning and high exposure leads to coma and death in affected individuals. However chronic, repeated, lower exposure, particularly in animals that may have been previously exposed, induces epilepsy and hippocampal atrophy (Goldstein *et al.*, 2008). This has resulted in unusual behaviour and dramatic effects on the navigational abilities of affected individuals (Thomas *et al.*, 2010). Domoic acid has also affected bottlenose dolphins (*Tursiopstruncatus*) in the Gulf of Mexico (Schwacke *et al.*, 2010) where its occurrence in conjunction with both Dinophysis spp. and Prorocentrum spp. was found combined with DSP toxins in the stomachs of dead animals. In addition, populations of dolphins along the coast of Texas had evidence of exposure to *K. brevis* and brevetoxinas well, indicatingthat a complex of multiple HAB toxins were associated with this high mortality event (Fire *et al.*, 2011).

Large scale mortalities have also been associated with brevetoxin exposure in manatees (*Trichechusmanatuslatirostris*); (O'Shea *et al.*, 1991) as well as bottlenose dolphins (Mase *et al.*, 2000, Fire *et al.*, 2007, Twiner *et al.*, 2011). Both these species of Florida coastal marine mammalappear to be regularly exposed (Wetzel *et al.*, 2010) being affected on an almost annual basis with exposure via the aerosol as well as the ingestion route (Bossart *et al.*, 1998).

Among the other common marine biotoxins produced by HABs, saxitoxin appears to have been responsible for mass mortalities in marine mammals including in humpback whales (*Megapteranovaeangliae*) in the Gulf of Maine (Geraci *et al.*, 1989) and Mediterranean monk seals (*Monachusmonachus*) off the coast of Mauritania (Harwood, 1998, Reyero *et al.*, 1999). Evidence of exposure to saxitoxin has also recently been found among the endangered North Atlantic Right whales (*Eubalaenaglacialis*); (Doucette *et al.*, 2006; Leandro *et al.*, 2010) through detection of STX and its derivatives in the whale faeces collected at sea (Doucette *et al.*, 2012). Samples of zooplankton, particularly their main prey *Calanusfinmarchicus*, were also positive (Doucette *et al.*, 2006). And as was seen in some of the other marine mammal species listed above, these endangered cetaceans also appear to be affected by concurrent exposure to multiple toxins, particularly both STX and DA (Doucette *et al.*, 2012).

This example highlights one of the current concerns involving HABs and marine vertebrates, the potential impacts on endangered species and the implications for their conservation and management. For example, Bottein *et al.* (2011) recently reported finding ciguatoxins in the tissues of dead Hawaiian monk seals (*Monachusschauinslandi*), a highly endangered species with only approximately 500 individuals left in the population.

Thus, the most important issues involving assessing the impact of HABs and their toxins on marine vertebrates are (1) the consequences of multiple toxin exposures; (2) the effect of low level, chronic exposure; (3) the effect of repeated exposure, at high level during large blooms and then continued chronic exposure in between and (4) the conservation and management mitigation options when effects on highly endangered species are confirmed.

Within the ICES region the impact of HAB exposure on marine vertebrates has recently become a research priority for Scotland when widespread exposure to DA was found in harbour seals (*Phocavitulina*) captured and sampled around the coast of Scotland in 2008 and 2009 (Hall and Frame, 2010). Since around 1999 there has been a dramatic and rapid decline in the abundance of Scottish harbour seals including the populations in the Northern and Western Isles, the Outer Hebrides and the Scottish Southeast coast (Lonergan *et al.*, 2007). Assessing their exposure to biotoxins was one of a number of different factors being investigated as potential causes of the decline.

Since this discovery a further study of DA exposure from screening faecal samples collected from seal haulout sites (n=262) in 2010 found that many populations were exposed and that a high proportion of the samples collected from the Shetland and Southeast regions (up to 77%) were positive. Perhaps coincidentally, but certainly of some note, is that these are the two areas of greatest population decline (up to 60% decline over the last 10 years or so). However, it is likely that the reasons for the decrease in harbour seals are multifactorial and toxins may be one of a number of stressors involved. Levels measured in the excreta were low (between 1000 and 9000 pg/ml in urine from live captured animals and mostly between 1000 and 100 000 pg/g faeces up to a maximum of 400 000 pg/g in faeces from haulout sites, Hall *et al.* unpublished). Given that the time since exposure is unknown, interpretation of these results is difficult. It is unclear if this represents low, very recent exposure or higher less recent exposure. The half-life of DA reported in other mammals is short (although concentrations in faeces may persist for weeks) and the foraging trips of harbour seals before they return to haulout sites is between 1 and 4 days (Thompson *et al.*, 2001) so it is likely that these levels are recent, low level exposure.

In addition, a small number offaecal samples (n=10/57) largely collected from the Southeast region in the early spring were positive for saxitoxin. Samples of fish prey collected at the same time were also analysed and DA and STX was found in their viscera, particularly the demersal benthivores that are common harbour seal prey items.A number of samples from other marine mammals stranded around Scotland (for example urine and faeces from harbour porpoise (*Phocoenaphocoena*) and white sided dolphin (*Lagenorhynchusacutus*)) collected by the Scottish Marine Animal Stranding Scheme were screened. Three porpoise and one dolphin sample were positive for low levels of DA.

Under the EU's recent Marine Strategy Framework Directive (Directive 2008/56/EC) Member States are required to ensure the waters around their coasts comply to "good environmental status". The UK has agreed on two Marine Mammal Criteria as qualitative descriptors of relevance here. The first states that for "75–90% of the monitored species (which includes both species of seal in the UK, the grey seal and the harbour or common seal) there should be no significant contraction in the distribution" and the second states that for "75–90% of monitored species there should be no significant decrease in abundance". Clearly if there are underlying, natural reasons for population fluctuations this information is critical to allow the interpretation of population trends data. If the exposure of marine mammals to biotoxins is having an effect on the population dynamics then monitoring their exposure from continued sampling of faeces from haulout sites is recommended. This is a so-called pressure target that is still to be developed but it may be an essential aspect of determining the underlying prevailing oceanic conditions, factors that should be included when using marine mammal population indicators as measures of marine environmental status.

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10 Term of Reference G

10.1 Discuss and evaluate how ICES can expand its science on eutrophication issues, especially in the coastal zone (e.g. suggest new EGs, WK or SGs)

The WG discussed this ToR in the context of the occurrence of harmful algal blooms (HABs). The relationship between anthropogenic nutrient enrichment and the occurrence of HABs within the ICES area has been widely studied (Cadee and Hegeman 2002). This topic has already been reviewed by a number of members of the working group in peer reviewed publications (Anderson *et al.* 2008?, Gowen *et al.* in press) and the WG has already addressed this issue during previous meetings. The WGHABD meeting in 2007 reviewed the outcomes of the ICES Workshop 'Time-series Data relevant to Eutrophication Ecological Quality Objectives' [WKEUT] where the relationship between *Phaeocystis* and nutrients were discussed. The WG concluded that future ICES science on eutrophication issues should focus on elements other than HABs, for example see recommendation for the establishment of a study group on macroalgae.

11 Term of Reference H

11.1 Evaluate potential for collaboration with other EGs and other ICES initiatives in relation to the ICES Science Plan and report on how such co-operation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings)

A few of WGHABD members are also members of the Working Group on Phytoplankton and Microbial Ecology (WGPME). A closer cooperation with WGPME regarding software for producing graphs etc. showing time series of HAB events etc. would be beneficial to both groups. WGHABD has had back to back meetings with the Working Group on Physical-Biological and a joint theme session in 2010 ASC was a worthwhile outcome of this linkage. WGHABD and the Working Group on Zooplankton Ecology (WGZE) have had some cooperation but this should be further developed.

There is a potential for cooperation between WGHABD and aqua culture specialists since Harmful Algal Blooms affect both shellfish and finfish extensively. In WGHABD there is substantial expertise in this area.

12 Closing of the meeting

The Chair thanked the host from the Scottish Marine Association, and congratulated him on behalf of the working group. He also thanked the participants for their input, especially the rapporteurs, and closed the meeting on Friday, 11:00 hours.

Annex 1: List of participants

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Annex 2: Agenda

ICES - IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) 2012
Venue and dates: Oban, United Kingdom 24-27 April 2012
Report due by: 15 May 2011

Chair: Bengt Karlson, Sweden (bengt.karlson@smhi.se)
Professional secretary at ICES: Adi Kellermann
Support secretary at ICES: Maria Lifentseva (maria.lifentseva@ices.dk)

WGHABD has tasks defined in resolutions by the IOC-International Panel on Harmful Algal Blooms and by the ICES- SCICOM Steering Group on Human Interactions on Ecosystems

Background documents are available at:

http://groupnet.ices.dk/WGHABD2012/default.aspx

Note that minibus (and rental cars) from Oban to the meeting location at the Scottish Association for Marine (SAMS) leaves at 0830.

Monday, April 23, 2012

Informal get together from 9pm in the lounge bar of the Royal Hotel. Keith will explain logistics.

Tuesday, April 24, 2012

Time	ToR	Lead(s)	Item	Rapporteur
09:00-09:30		B. Karlson K. Davidson	Opening of Meeting, Logistics, Introductions, Adoption of the Agenda	
09:30-10:30	c IPHAB-X.7	R. Gowen N. Daugbjerg	1) Quantify the occurrence of fish killing algal events in the ICES region; 2) Document gaps in understanding of the processes controlling the occurrence of fish killing algae and the factors that cause fish mortality;	Joe Silke
10:30-11:00			Health Break	
11:00-11:15		B. Karlson H. Mazur	Follow up of session on HAB:s in the Baltic Sea at the ICES Annual Science Conference in Gdansk 2011	Hannah Mazur
11:15-12:30	b	All Participants	National reports	Poland, Ireland, United Kingdom, Canada
12:30-13:30			Lunch	
13:30-14:00	g		Discuss and evaluate how ICES can expand its science on eutrophication issues, especially in the coastal zone (e.g. suggest new EGs, WK or SGs);	Eileen Bresnan

14:00-14:30	h		Evaluate potential for collaboration with other EGs and other ICES initiatives in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings).	Eileen Bresnan
14:30-15:00			Discussion on proposed three year cycle in ICES reporting and on IOC-IPHAB resolutions and WGHABD activities	Eileen Bresnan
15:00-15:30			Health Break	
15:30-16:00			continued	
16:00-17:00	b	All participants	National reports	Denmark

Wednesday, April 25, 2012

Time	ToR	Lead	Item	Rapporteur
09:00-09:30		H. Enevoldsen	Status of the HAEDAT and HAIS (Harmful Algal Event Database and the Harmful Algae Information System)	Mark Wells
09:30-10:00	i	D. Anderson	Scope and plan a workshop focused on automated in-situ devices and imaging technology (including newer molecular methods) used for observing HABs and detecting toxins	Don Anderson
10:00-10:30		Samia K. Mikhail	Harmful Algal Blooms in Egypt	
10:30-11:00			Health Break	
11:00-12:00	IPHAB-X.7	M. Wells B. Karlson	Presentation of the planned ICES-IOC-PICES Science Workshop on HABs and Global Change WKHABCW	
12:00-12:30		Everyone	Tour of the laboratory facilities, culture collection etc.	
12:30-13:15			Lunch	
13:15-13:45	a	Everyone	New findings	Hanna Mazur
13:45-14:15	b	All Participants	National reports	USA
15:00-			Excursion	

17:00				
Evening		Authors of CRR	Finalizing the Cooperative Research Report on HAB:s in the ICES area	

Thursday, April 26, 2012

Time	ToR	Lead	Item	Rapporteur
09:00-10:30	f	A. Hall and Eileen Bresnan	Report on the impacts of harmful algal blooms on marine mammals and birds relevant to the Marine Strategy Framework Directive objectives;	Eileen Bresnan
10:30-11:00			Health Break	
11:00-11:30	g		continued	
11:30-12:30	a		New findings	
12:30-13:30			Lunch	
13:30-14:30	e		To collate and discuss data on macroalgal blooms and their impacts in the ICES region;	
14:30-15:00		Layla Al-Musawi	Building a regional network for research, monitoring and early warning of Harmful Algal Blooms in the ROPME sea area – a discussion on possibilities for collaboration with WGAHBD	
15:00-15:30			Health Break	
15:30-16:00			Decide on 2013 Meeting Location Draft 2012 Resolutions / ToRs Report writing	
16:00-17:00		Hak-Gyoon Kim	Presentation of 15th International Conference on Harmful Algae(ICHA)	
19:00-		Everyone	Group dinner (participant's expense)	

Friday, April 27, 2012

Time	ToR	Lead	Item	Rapporteur
09:00-10:30			Draft 2012 Resolutions / ToRs Report writing	
10:30-11:00			Health Break	
11:00-12:30			Complete Report Writing	
12:30			End of Meeting	

Annex 3: WGHABD draft resolution for the next meeting

The **ICES-IOC Working Group on Harmful Algal Bloom Dynamics** (WGHABD), chaired by B. Karlson, Sweden, will meet in Belfast, Northern Ireland, United Kingdom, 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) Discuss 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 utilised;

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

f) Review state of the art and on-going 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.

WGHABD will report by 15 May 2012 (via SSGHIE) for the attention of SCICOM.

Supporting information

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 amongst the members. This is an excellent forum to promote and discuss topics of relevance. There are obvious reasons to continue this topic as an on-going term of reference **Term of Reference b)** National Presentations and review occurrences of HABs in the ICES area, making use of the HAEDAT system. **Term of Reference c)** ICES has decided to go from yearly reports from expert/working groups to a new model with a major report every three years and interim reports in between. The working group will discuss this and implement a new reporting format adapted to the new model. The WGHABD-reporting to IOC-IPHAB is made every other year which must be taken into account. **Term of Reference d)** The HAEDAT system has been functional for the past three 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 demonstrated. The working group will assess:

	i) Status for upload of all records including 2012 ii) Status of quality assurance of HAEDAT records prior to 2002 iii) New maps and search functionality based on HAEDAT data iv) Potential for linkages to the data analysis system developed for WGZE and WGPME by T. O'Brien, NOAA. An example case study using *Dinophysis* will be used to demonstrate the potential products that can be obtained using the system. **Term of Reference e)** Many of the programmes to monitor the occurrence of harmful species of micro-algae and associated events in coastal waters of ICES member states have been running for a decade or more. The data from these programmes is a valuable source of data that can be used to identify trends in the occurrence of HAB species and HAB events. As part of the three year reporting cycle proposed by ICES, WGHABD will provide updates of the analysis of suitable time-series (one option is to use the same suite of programmes as developed for WGZE and WGPME by T. O'Brien, NOAA. **Term of Reference f)** The WG should discuss and plan the details of a *Workshop on Automated Harmful Algal Bloom in situ Observation Systems* to be held in conjunction with the meeting of the WGHABD in Woods Hole, MA (USA) in April 2014. **Term of Reference g)** Toxic outbreaks caused by benthic microalgae were traditionally associated with benthic dinoflagellates growing in tropical coral reef areas. In recent years there has been an increasing number of respiratory and skin irritation events caused by aerosolized toxins associated with *Ostreopsis* spp. in W Mediterranean beach resorts in France and Spain, and last year a bloom of *Ostreopsis* spp. (already cited in NW Atlantic archipelagos) were reported for the first time from the Algarve coast (SW Portugal). Likewise, Ciguatera Fish Poisoning (CFP) after ingestion of large carnivore species (bioaccumulation of toxins) have been reported in recent years in the Canary and Madeira archipelagos. There is a poor knowledge on the environmental conditions triggering *Ostreopsis* blooms, and the bad correlation between abundance (mats in the water column) and potencial risk for public health. Further, growing interest and activities in NE Atlantic countries should benefit from the managerial expertise developed in the US where intoxications from aerosolized toxins during *Karenia brevis* blooms and CFP constitute endemic problem in the Gulf of Mexico and Caribbean region. **Term of Reference h)** 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 April 2013.
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 organisations	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.

Annex 4: Recommendations

Proposed ICES/IOC/PICES workshop on "HABs in a Changing World"

WGHABD recommends that the ICES/IOC/PICES workshop on "HABs in a Changing World" should be held in 2013. IOC involvement will be through GEOHAB.

In 2011 the WGHABD proposed an ICES/IOC/PICES workshop on HABs in a changing world. This proposal was accepted by the IOC Intergovernmental Panel on Harmful Algal Blooms through Resolution IPHAB-X.6 April 2011, by the ICES ASC in September 2011 and by the PICES Harmful Algal Bloom group later in 2011. The original plan was to arrange the workshop in May 2012 but due to slow progress in raising funds for the workshop it has been moved to 2013. Support has now been found from a source in the USA (NOAA) and more financial support is sought. The workshop has two primary goals: (1). To assess the state of knowledge on HABs and Climate change, and (2) to identify the most critical research needs that can realistically be addressed over the next 5–10 years. The output will be a "review" paper (concept paper more appropriately) targeted for a broad audience in a high level journal. Topics will include 1) the impacts of projected changes in macro- and micro-nutrient distributions on HAB organisms; 2) climate effects on the ecology of HAB species and trophic interactions; 3) and climate effects on the physiology/toxicity of HAB organisms. In Phase I a smaller workshop of 10–12 persons is planned for March 2013. In Phase II, the broad topic areas identified by the workshop participants will serve as the foundation for sessions in an open science meeting to be held in 2014 or 2015, depending on funding. For Phase I the venue is planned to be Friday Harbor Laboratories near Seattle Workshop planning is done by co-chairs Mark Wells (PICES HAB-S), Raphael Kudela (GEOHAB SSC Chair) and Bengt Karlson (ICES-IOC WGHABD).

Establishment of an ICES expert group on macro algae

A conclusion from ToR e) is that WGHABD recommends ICES to establish an expert group on macroalgae, e.g. on issues related to eutrophication and the formation of mats of filamentous macro algae etc.

Annex 5: Group picture

ICES-IOC Working Group on Harmful Algal Bloom Dynamics

Scottish Marine Institute Oban, United Kingdom 2012

Participants of the WGHABD meeting in 2012. Left to right: Mark Wells, Jean-Pierre Lacaze, Joe Silke, Keith Davidson, Don Anderson, Jennifer Martin, Eileen Bresnan, Samia K. Mikhail, Ainhoa Blanco, Richard Gowen, Steve Milligan, Beatriz Reguera, Niels Daugbjerg, Hak-Gyoon Kim, Bengt Karlson, Ken Jones and Seong-An Choi. Missing from the photograph are Hanna Mazur-Marzec, Ailsa Hall, Peter Petrov and Layla al-Musawi.