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on Harmful Algal Blooms
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Reports of the
ICES/IOC Working Group on Harmful Algal Bloom Dynamics
2009 and 2010

31 March – 2 April 2009
El Rompido (Huelva), Spain
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Executive Summary

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics meeting for 2009 took place at the Laboratorio de Control de Calidad de los Recursos Pesqueros in Punta Umbria, Spain from 30 March to 2 April 2009. 22 Scientists representing 11 countries participated in the meeting.

Highlights

- Reviewed and updated JAMP monitoring guidelines for Chlorophyll for Advisory Committee to prepare ICES advice to OSPAR
- Reviewed the IOC HAEDAT and MONDAT databases and identified priorities and assigned timelines for completion of these databases.
- Joint day session with WGPBI to mutually inform the two working groups of the priorities in the study the environmental interactions regarding HABs dynamics and to support modelling aspect of HAB research.
- Formulated the justification of 2010 theme session of HABs in the Baltic
- Reviewed parameters for specific real time automated forecasting HABs systems within GOOS
- Presented 11 National reports on the occurrence of HABs in ICES area during 2008
- Prepared material for Steering Group on Climate Change
- Discussed and prepared a workplan towards the preparation of a Cooperative Research Report on HABs in the ICES area

New Findings

There were 8 presentations that described new findings made by the group and they are synopsized in this report. These reports are extremely useful means of disseminating ongoing projects and very recent developments. They often lead to productive collaborative arrangements between scientists meeting at the working group, and this was the case at this year’s working group.

The reports included:

- *Azadinium spinosum* gen. et sp. nov. (Dinophyceae) identified as a primary producer of azaspiracid toxins
- Dinophysis and Arcachon basin
- Climate impact on HAB
- Report of a major Cochlodinium bloom in the Arabian Gulf, Arabian Sea, and Gulf of Oman
- Characteristic profiles of Ciguatera toxins in different strains of Gambierdiscus toxicus
- Diversity and toxicity of Alexandrium in Scottish waters
- Thematic network on toxic phytoplankton and biotoxins: REDIBAL
- Summary of Phytoplankton QC Scheme
Welcome and opening of the Meeting

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics meeting for 2009 was hosted by the Laboratorio de Control de Calidad de los Recursos Pesqueros in Punta Umbria, Spain from 30 March to 2 April 2009. On behalf of the Laboratory the Director, Luz Mamán Menédez, opened the meeting and welcomed the participants to Punta Umbria (Huelva). The agenda was agreed and Eileen Bresnan and Jennifer Martin were elected as joint rapporteurs. Individual sessions also had session leaders and editing rapporteurs appointed to share the workload.

22 Scientists representing 11 countries participated in the meeting. 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. This proved to be a valuable tool to speed up the work and make exchange of information more efficiently. Over the course of the 4 day meeting the group made presentations addressing the terms of reference and prepared documents to service requests from ICES and OSPAR, 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 and its linkages to HAB-MAP. As coordinators 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. In 2009 there were no attendees from outside the ICES area.

WGHABD facilitates interaction between scientists working in diverse areas of HAB science and monitoring and provides a useful forum for interchange of useful terms of reference on various approaches to HAB research. The present working group was established in 1994 following a study group on the Dynamics of Algal Blooms, established two years earlier; however its origins go back further into the 1980s and evolved from other study groups within ICES. The group 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.

In the opening session the chair, Joe Silke (Ireland) gave a summary of the presentation of the WGHABD 2008 report to the parent Oceanographic Committee (OCC) at the ASC meeting in Halifax, Canada. The report was very well received and feedback indicated the report was well organised, informative and the meeting was well attended. The participants then introduced themselves and gave a short review of their scientific activities.

A one day joint session with WGPBI was held during our meeting as in meeting out Terms of Reference (f). This session was jointly arranged following initiation by the WGHABD last year with an aim to mutually inform the two working groups of the priorities in the study the environmental interactions regarding HABs dynamics and to support modelling aspect of HAB research. As one of the strengths of the WGHABD is the interaction between monitoring programme managers, research scientists and data analysts this joint session was deemed appropriate to pursue. There are practical aspects of physical-biological interactions that can be developed jointly, for example, environmental data is often needed in modelling HAB events and sam-
pling could be aligned with local hydrography such as mixed layer depth, circulation patterns, frontal dynamics, etc. Historical data and time series data are also important in looking for historical occurrences and trends of HABs. Increase and decrease in population size is important to bloom dynamics and modelling HABs. The joint working group session was seen as a productive means to explore these areas and further follow up activities were identified including a theme session and further collaborations.

The other ToRs were discussed at the opening meeting and deemed relevant to dynamics and following review were adopted.

2 Adoption of the agenda

The group reviewed the agenda and this was adopted without any change.

3 Terms of Reference

At the 95th Statutory Meeting (2008), Halifax, Canada, the Council approved the WGHABD (2009) Terms of References as follows:

The ICES IOC Working Group on Harmful Algal Bloom Dynamics [WGHABD] (Chair: J. Silke, Ireland) will meet in El Rompido (Huelva) Spain from 30 March to 2 April 2009 to:

a) review and update of JAMP Eutrophication monitoring guidelines (OSPAR request no. 6, 2009)
b) review and report on the compilation of national practices across ICES areas for Harmful Algae and Phycotoxins monitoring and prioritize updating of the IOC-MONDAT Data Base.
c) with reference to modelling in the ICES region, review the state of knowledge of initiation, maintenance and senescence of cyanobacteria blooms, including transfer of toxins and effects on the foodweb.
d) discuss and formulate the description and justification for a thematic session on HABs in the Baltic Sea for the 2010 ASC.
e) identify the requirements for observing specific TPA and HAB species in near real time using automated techniques and produce forecasts of Harmful Algal Events using observations and models.
f) Wish to pursue by interdisciplinary work with WGPBI the development of joint ToRs and a joint WG sessions in 2009
g) discuss and report new findings that pertain to harmful algal bloom dynamics. Bring new findings in phytoplankton population dynamics models to the attention of WGHABD for discussion.
h) collate and assess National reports (Country Reps) and collect data for HAEDAT
i) review the UK’s DEFRA funded literature and data analysis on HABS and nutrient enrichment. Identify follow up activities.
j) review the publications in Journal of Sea Research from the ICES Workshop on Time-series Data Relevant to Eutrophication Ecological Quality Objectives (WKEUT)
contribute to ICES Climate Change position paper by reviewing current climate change effects in HABs events. Prepare draft/outline report for consideration of SGCC at spring meeting 2009.

4 Term of Reference A

4.1 Review and update of JAMP eutrophication and monitoring guidelines

4.1.1 Discussion

In the absence of a phytoplankton ecology group, OSPAR requested the WGHABD to provide advice on the JAMP eutrophication and monitoring guidelines. The group felt that OSPAR should also send their request to the Marine Chemistry for review and other phytoplankton experts. Nevertheless a subgroup was assembled and a revised document prepared and sent to Advisory Committee to prepare ICES advice to OSPAR related to the JAMP.

The group noted that this is a brochure for chlorophyll and perhaps a nutrient brochure should be a separate document. They expressed a number of concerns noting that: chlorophyll $a$ does not give a value for primary productivity; “chlorophyll” is being measured which can include “a”, “b”, and “c”; not only chlorophyll $a$; and there is the perception that the global change in climate is related to HABs. In some coastal waters, particularly in Europe, blooms are used to diagnose the undesirable consequence of nutrient enrichment and eutrophication. They discussed the fact that chlorophyll does not really measure the frequency of blooms and the frequency of sampling needs to be addressed. At minimum, sampling should be weekly or biweekly. If one is only sampling one station in one estuary it will be difficult to determine if the correct site is being sampled. Sampling frequency must also be often enough to resolve bloom events. The documents do not identify clearly what a bloom actually is and the WGHABD group felt that a clear definition was required – a bloom is a discrete event associated with a bloom of microalgae and an increase in cell abundance relative to a background level which may be zero, and low abundance or high, depending on the organism.

Concern was expressed as to why chlorophyll was being measured to implement guidelines for nutrient loads as suggested in the existing guideline.

The contribution from WGHABD was used in preparing the ICES advice to OSPAR related to the JAMP. This was one of many areas of advice prepared by various Expert Groups whose contributions were submitted to the Review Group and Advice Drafting Groups to ensure the quality of the advice. The draft advice is on the RG/ADGJAMP SharePoint site along with the notes from the ACOM meeting to approve the advice. There is still some editing that needs to be done; this will be finalized before June 4th when the advice will be transmitted to ICES. The advice will then be available on the ICES web site. The advisory committee Vice Chair extended his appreciation to WGHABD for their assistance in this task.
5 Term of Reference B

5.1 Review and report on the compilation of national practices across ICES areas for Harmful Algae and Phycotoxins monitoring and prioritize updating of the IOC-MONDAT Data Base

5.1.1 HAEDAT

Each record for a harmful algal event is recorded on a MONDAT form. It includes a questionnaire where various data and information pertaining to a harmful algal event are compiled for entry into the Harmful algal event database (HAEDAT). The on-line version of HAEDAT was ready for on-line input in October 2007, however reappearance of bugs were reported by users. However the system is now available and open for data input. Due to the development of the on-line database and the development problems, data input has not happened since 2001. There is quite a challenge for everyone now to include the data from 2001 and onwards.

There are developments on the technical end that allow users to publish their data and query it through the Internet. This system was demonstrated to WGHABD in 2006 in a near complete version. Unfortunately it has taken a long time to complete and end user testing has revealed a number of bugs. The finished version was presented.

There continues to be the problem that forms have not been input to the database since 2004. The possibility will be explored to see if the old MONDAT forms can be transposed for input into HAEDAT directly without entering each record again individually. Jennifer Martin followed up with IT personnel in Canada and found that it would be possible if the HAEDAT allowed the acceptance of a batch files. This will be followed up in the upcoming months.

It was noted that many countries do not use algal concentration for a trigger for opening and closing a harvesting area. Many countries use an algal event to trigger frequency of testing. However, there are a number of countries that use the mouse bioassay solely.

Data accessibility and associated difficulties within countries were discussed. Retrieval varies from open access to restricted access; some is categorized as sensitive, some countries have varying data collections for toxicity such as the US where some states have only paper records, others may have electronic but do not make the values available. Often phytoplankton data is more difficult to obtain as it can be research or volunteer based.

As there is no formal agreement as to where the data for input to HAEDAT comes from within member countries, in 2004, the group agreed that country representatives be assigned to compile the national reports for each country. The following year, 2005, ICES sent out letters to each member country, but did not receive a response. The WG will request that ICES resubmit the request to ICES delegates so that it is ready for the SCICOM meeting in May.

5.1.2 HAIS

The harmful algal information system (HAIS) was described. HAIS is a novel system which is being developed. The information includes current taxonomy names of Harmful Algae, biogeography of Harmful species, occurrence of HAB events (HAEDAT), etc. HAIS has potential to become a unique product. HAIS is developed within the joint framework of the IOC International Ocean Data Exchange Programme
(IODE) and IPHAB. A meeting held in Oostende in January 2008 discussed developing HAIS. Here it was discussed who the collaborating partners are, and what the related responsibilities in the development will be. The existing data sources which are proposed to be incorporated in HAIS are:

- Harmful Algal events, IOC ICES PICES (HAEDAT)
- Biogeography with ISSHA (HABMAP) and OBIS
- Taxonomy with WoRMS and EoL (Tax. Reference list)
- References with AFSA and OceanDoc
- Expert Directory with IODE (OceanExpert)
- Monitoring and management design with ICES (MONDAT)

The system was endorsed by WGHABD but really functional. Proper back up structures will be guaranteed, and easy access will be guaranteed. Data should be validated on a yearly basis in order to guarantee their quality. HAIS should be disseminated as the leading HAB information system, since the involvement, trust and achievements in the component databases, so far have been great.

The monitoring plans etc will be incorporated in the MONDAT databases. These are however not updated since 2001. However, the adaptation of the European Regulations, have resulted in changes since then. Therefore it is important to have access to the different methodologies used, the implications of results, and function of phytoplankton monitoring. At this moment not everyone has a proper view of the legislation and there is potential for misunderstanding, this may even lead to difference in interpretation of test results. The development of a well maintained and updated information system was endorsed by the working group as a useful resource to inform and prevent such difficulties arising.

The establishment of a Harmful Algal Information System (HAIS) builds on the evolution over the past 15 years of a number of separate data bases and data products on harmful algae developed in partnerships between IOC (Intergovernmental Oceanographic Commission) of UNESCO (United Nations Educational, Scientific and Cultural Organization), the International Council for the Exploration of the Seas (ICES), the North Pacific Marine Science Organization (PICES), and the International Society for the Study of Harmful Algae (ISSHA). This document constitutes a joint basis for the linkage between and further development of these data bases and data products.

There is an agreement with OBIS to be used as a platform for collating data.

The plan is to expand the database to include impacts on human health and animals. The taxonomic reference list to be used will be WORMS and the housing of the database is being explored with EoL. Decadal maps are being compiled in a similar manner to the google map and should be available at the website. The hope is that any maps will be able to be generated based on the data in HAIS and the data will provide originator of the data.
6 Term of Reference C

6.1 With reference to modelling in the ICES region, review the state of knowledge of initiation, maintenance, and senescence of cyanobacteria blooms, including transfer of toxins and effects on the foodweb

6.1.1 Chemotaxonomy of the Baltic Nodularia

Hannah Mazur

It was postulated that apart from morphological features, modern taxonomy of cyanobacteria should include genetic, chemical and physiological characteristics of investigated species, as well. Recently, the analysis of oligopeptides was used as a good tool in chemotaxonomy of cyanobacteria.

Nodularin produced by Nodularia spumigena is the best recognized biotoxin produced by phytoplankton organisms in the Baltic. Apart from the compound and its demethylated analogues, Nodularia produces spumigins, nodulapeptins and suomilid. Some of the peptides show inhibitory activity towards key enzymes (e.g. phosphatases and proteases).

In the presentation the intra and inter-species variability in oligopeptides production within Nodularia have been showed. The nine detected oligopeptides (including three novel once) are characterized by different amino acid composition and modifications in their structure. Neither of the oligopeptides was produced by the two non-toxic Nodularia isolates. Moreover, it was observed that environmental conditions had no effect on the production of specific oligopeptides by Nodularia. In this work, the LC-MS/MS technique was confirmed to be a powerful tool in taxonomic studies of cyanobacteria. The peptide fingerprint of an individual cyanobacteria can be used to distinguish the genetically and morphologically undistinguished clones.


7 Term of reference D

7.1 Discuss and formulate the description and justification for a thematic session on HABs in the Baltic for the 2010 ASC.

The WG discussed a theme session for the ASC in Nantes in 2010. Bengt Karlson and Emil Vahtera will look into recruiting people, collate abstracts and organizing the session. The deadline for submission of abstracts will be 20 April 2010. A wealth of information on Cyanobacterial HABs is already gathered and WGHABD wish to foster further collaborative studies in the Baltic area, the theme session is proposed to report on studies to date and as a focus to promote future potential activities. The theme synopsis is presented in the recommendations (Section 15 below).
8 Term of Reference E

8.1 Identify the requirements for observing specific TPA and HAB species in near real time using automated techniques and produce automated forecasts of harmful Algal Events using observations and models.

At the VIIIth meeting of the International Panel on Harmful Algal Blooms, Intergovernmental Oceanographic Commission in Paris, France, a resolution about 'Implementation of HAB monitoring within the Global Ocean Observing System' was made (resolution IPHAB-VIII.2). This was accepted by the IOC in 2007. The present document constitute the advice from the 'IPHAB Task Team on HAB Observations and Forecasting Systems' to the 'Global Ocean Observing System', in particular to the Panel for Integrated Coastal Observations (PICO), a technical subcommittee of the GOOS Scientific Steering Committee.

Version history

Draft 1 of document
Distributed at the IOC-ICES-WGHABD in Galway, Ireland, 10–13 March, 2008

Draft 2 of document
Distributed at the GEOHAB SSC meeting in Annapolis, Maryland, USA, 10 April 2008

Draft 3 of document
Distributed to the 'IPHAB Task Team on HAB Observations and Forecasting Systems' and the 'IOC/ICES-WGHABD' 9 April 2009

Prepared by Bengt Karlson after advice from participants of the meeting of the ICES/IOC Working Group on Harmful Algal Bloom Dynamics, Punta Umbria, Spain, 30 March – 3 April 2009

Version 1
20 April 2009
Prepared by Bengt Karlson after advice from Task Team members.
Presented at IPHAB IX 23 April 2009

Version 1.1 (this document)
Updated by Bengt Karlson after advice from IPHAB
Accepted by IPHAB IX 24 April 2009
8.1.1 IOC-IPHAB recommended procedures for automated and semi-automated HAB-monitoring and forecasting within the Global Ocean Observing System

Operational requirements

The procedures included are those that may produce results in near real time. A common definition for real time data is data that is accessible within 1 hour after measurement. This applies to many but not all methods included in this document. Data made available within 24 hours of measurement or later may also be useful for operational HAB observations and forecasts within the Global Ocean Observing System.

Acronyms and definitions

- Adaptive sampling - an example of adaptive sampling is when water sampling is automatically triggered by a signal of high night-time chlorophyll fluorescence indicating a high biomass of algae.
- GEOHAB = The Global Ecology and Oceanography of Harmful Algal Blooms, a SCOR/IPHAB programme
- GOOS = The IOC programme Global Ocean Observing System
- HAB = Harmful Algal Bloom
- ICES = International Council for the Exploration of the Seas (North Atlantic)
- IOC HAB Programme = The IOC Harmful Algal Bloom Programme
- PICO = Panel for Integrated Coastal Observations, a technical subcommittee of the GOOS Scientific Steering Committee.
- SCOR = Scientific Committee on Oceanic Research
- WGHABD = ICES/IOC Working Group on Harmful Algal Bloom Dynamics

8.1.2 Harmful Algal Blooms

Most algal blooms are natural phenomena and cause no harm and indeed the growth of phytoplankton is the base of the major part of the marine food web. However, some algae are harmful and Harmful Algal Blooms (HABs) are of concern since they may affect human health, fisheries and aquaculture as well as large parts of marine ecosystems. Harmful algae include species that produce toxins that may accumulate through the food web starting with filter feeders (e.g. mussels). Fish killing species and species causing nuisance blooms (e.g. foam on beaches) are also included in the term harmful algae. Harmful effects of blooms of microalgae such as hypoxia due to eutrophication or upwelling resulting in high algal growth is also included. Some HABs have direct effects (clogging of filters) on industries such as desalination plants. It should be noted that most harmful algae only constitute a small part of the total phytoplankton biomass while they may still cause harm. A few hundred cells per litre of sea water may be enough to cause lethal toxicity in shellfish. The term low biomass blooms are used for these types of HABs in this document. Other harmful algae grow to high densities (e.g. several hundred thousand cells per litre or more) and the term high biomass blooms is used for these HABs. It should be noted that chlorophyll, which is a proxy for total phytoplankton biomass, is not an indicator for the presence of harmful algae.
8.1.3 Automated HAB-observations

Only some HABs can be monitored using automated techniques.

There is value in monitoring for HAB species occurrence as well as for HAB-toxins/metabolites.

High biomass HABs with properties detectable using automated techniques (e.g. optical signatures) are good examples of cell detection. The following are examples of HABs that may be detected using optical signatures:

a) blooms of some filamentous cyanobacteria, e.g. Nodularia spumigena in the Baltic Sea
b) blooms of the fish killing dinoflagellate Karenia mikimotoi (e.g. in UK waters)
c) blooms of the dinoflagellate Karenia brevis, that form toxic blooms in the Gulf of Mexico.

Low biomass HABs can be detected in rare cases with optical techniques (e.g. automated image analyses of morphologically distinct species) but other less distinct forms require molecular techniques for cell detection. Algal toxins can be measured in plankton or water samples using new analytical techniques, some of which are being miniaturised and automated. Instruments for automated in situ cell and toxin detection are still under development and thus are not available commercially, although this will change within a few years.

The observing system should be designed to detect the HAB species that occur within a given region. No single system will work in all areas. The observing system should be designed with sufficient spatial (horizontal and vertical) resolution to capture the time-space evolution of HABs and associated environmental conditions. This can best be accomplished with scientists who know the local oceanographic conditions such as stratification, currents, etc. A combination of automated in situ measurements, remote sensing, automated sampling and adaptive sampling from research vessels is recommended for most circumstances.

Some HAB detecting systems require significant power and bandwidth. These will require cabled configurations and/or special hardware installations. In time these instruments will be miniaturized and easier to deploy but it is essential to deploy such instruments on test platforms at an early stage. Some HABs develop in “hot spots” and in these cases HAB observing systems can be positioned there instead of attempting to achieve full areal coverage.

8.1.4 In situ systems

In situ systems include:

- Sensors on buoys
- Sensors on permanent structures, e.g. piles, wind mill masts, oil platforms and bridges
- Sensors on AUV, autonomous underwater vehicles (gliders and powered vehicles)
- Sensors on drifting profilers, e.g. Argo-type floats
- Towed sensors, e.g. undulating oceanographic recorders
Sensors in flow-through systems on research vessels, voluntary observing ships (VOS), ships of opportunity etc. These systems, often called Ferry-Box-systems, only sample near surface water while many HABs are found deeper down.

Minimum set of parameters:
- Phytoplankton biomass proxy, i.e. night-time chlorophyll fluorescence
- Turbidity
- Salinity
- Temperature

Specific HAB sensor if available (based on e.g. specific optical signature, molecular techniques or in situ flow cytometers with optical image analysis). Sensors should be distributed in depth according to the local occurrence of HAB’s. In areas where HABs occur in sub surface layers sensors should be mounted on depth profiling platforms. Depth resolution for depth profiling platforms should be 25 cm or better, so as to be able to detect HABs aggregated in fine structures (fine layers). Sampling frequency should be adapted to the spatial and temporal HAB-distribution in the area, if the HAB-species often occur in hot spots these should be monitored with greater temporal resolution.

Minimum frequency is once a day, Recommended frequency is every 1–3 hours, In FerryBox systems recommended horizontal frequency is 200 m or better. Arrangements should be made for adaptive sampling triggered from data provided by in situ sensors. Quality assurance and quality control of data collected should be documented. Reference water sampling and analyses of reference samples is an essential part of automated HAB-monitoring.

Here follows some examples:

a) Microscopy for cell counts and HAB species identification (also molecular methods may be included)

b) Phytoplankton pigment analysis using laboratory fluorometry or spectrophotometry, ideally combined with High Performance Liquid Chromatography

c) Some automated instruments can archive samples for quality assurance.

All in situ instruments must include anti bio fouling measures adapted to local conditions and the deployment period. Anti bio fouling measures include

- Copper shutters covering optical windows
- Chlorination
- Special coatings of optical windows
- Automated cleaning/washing equipment in FerryBox and other flow through systems
- Profiling platforms that spend most of their time in deep water with few fouling organisms

Optical techniques for observing HABs in situ include but are not limited to:

- Fluorescence
Total phytoplankton biomass can be estimated using *in situ* instruments for measurement of chlorophyll a fluorescence, however quenching of chlorophyll a fluorescence e.g. by sun light should be taken into account and hence:

a) Use only measurements from night (at least 1 h after sunset and 1 h before sunrise)

b) Minimize quenching effect by allowing a period of darkness before measurement

Biomass of phycocyanin containing cyanobacteria can be estimated using *in situ* instruments for measurement of phycocyanin fluorescence. An example of a HAB-organism is Nodularia spumigena and other cyanobacteria that co-occur during blooms in the Baltic Sea.

Biomass of phycoerythrin containing organisms can be estimated using *in situ* instruments for measurement of phycoerythrin fluorescence HAB-organisms containing phycoerythrin include:

- Dinophysis spp. (Diarrhetic Shellfish Toxins)
- some cyanobacteria
- the photosynthetic ciliate Myrionecta rubra (synonym Mesodinium rubrum) that is an optimum prey for Dinophysis spp. Blooms of Myrionecta rubra itself caused fish kills in the Bay of Fundy, Canada and elsewhere.

Absorption and scattering

Example of a HAB-organism detectable using its absorption characteristics:

- Karenia brevis (Brevebuster)
- Phaeocystis spp. (high chl, absorption over broad spectrum without scattering)

Automated image analysis in flow cytometers (e.g. FLOWCAM and FlowCytoBot) is useful for certain HAB-species with distinctive morphology.

### 8.1.5 Molecular methods for automated *in situ* identification of HAB-species

Molecular methods make it possible to identify and quantify HAB-organisms at the species or even at the strain level. Probes may also be directly targeted at genes controlling toxicity. Molecular methods are being implemented in automated *in situ* laboratories. At least one system will be available commercially within a few years. Both antibody and DNA-based methods must be verified with local populations of HAB-species.

Many different types of molecular based assays are under development, ranging from quantitative PCR to sandwich hybridisation and surface plasmon resonance.

### 8.1.6 *In situ* sensors for detecting algal bloom physiological processes

These sensors do not give specific information about harmful algae but may contribute to the understanding of high biomass bloom dynamics. Bio fouling protection is essential as for all *in situ* sensors.

Oxygen sensors may give and indirect measure of photosynthetic activity minus respiration.
Examples:
   a) Optode based oxygen sensor
   b) Other oxygen sensors

Sensors for some specific fluorescence parameters may give information related to primary productivity.

Examples:
   a) Fast repetition rate fluorometers
   b) Fluorometers aimed at fluorescence induction and relaxation

8.1.7 Remote sensing systems

Remote sensing systems for ocean colour estimate total phytoplankton chlorophyll-a in near surface water. In some cases, e.g. Karenia brevis in the Gulf of Mexico, a good “climatology” exists for HABs and their expression in the chlorophyll field. Many HABs occur deeper down and only a few HAB organisms have optical signatures detectable by remote sensing that can be used to differentiate them from phytoplankton in general. Detection using optical sensors on satellites is often restricted by cloud cover. Despite these limitations, remote sensing detection and monitoring of HABs may be very useful in some circumstances. The advantages are that remote sensing systems can observe over large areas on a regular basis and so can detect rapid increases in chlorophyll-a that can be targeted with in situ sampling. Remote sensing of currents and coastal upwelling/downwelling cycles through ocean colour, SST and altimetry observations can show how an algal bloom is advected, say, inshore or into neighbouring waters; these observations also provide valuable input to assimilate or update physical and / or ecosystem models. Remote sensing systems for HAB-observations include:

- Sensors on satellites
- Airborne systems
- In air observations from ships, buoys and masts

Parameters useful for HAB-observations from remote sensing include:

- Chlorophyll a
- Turbidity
- Some algae-group specific algorithms, e.g. for certain cyanobacteria
- Sea Surface Temperature (SST), e.g. for detection of specific water masses and advection processes
- Remote sensing systems should be combined with in situ systems to ensure that non surface blooms are included in observations
- Quality assurance and quality control of data collected should be documented
- Reference measurements (sea truth) are an essential part of automated HAB-monitoring using remote sensing
- Combination of reference measurements from automated in situ systems and reference sampling from ships is recommended
- Cell counts and identification of HAB-species using microscopy or molecular methods should be part of the quality control and assurance procedure
• Phytoplankton pigment analysis using laboratory fluorometry or spectrophotometry ideally combined with High Performance Liquid Chromatography may also be part of the quality control and assurance procedure

8.1.8 HAB-forecasting systems

Short term HAB forecasting models are most often driven (forced) by the same type of physical meteorological models that produce weather forecasts. The maximum length of these forecasts, often 5-10 days, also limit the range of HAB forecasts. This could be lengthened if observing systems could be placed in the (known) path of the bloom, upstream of the point of impact. To be able to model HAB development a basic requirement is that the HAB species possess properties that can be used to differentiate it from other phytoplankters. These properties must be described in mathematical terms. The existing HAB forecast models can be divided in three main types:

a) transport models, e.g. the use of drift models for prediction of movements of surface HABs
b) biogeochemical models for predicting some high biomass HABs
c) Lagrangian models – particle based models specifically designed for HAB-species

Forecasting systems should be combined with observation systems.

Assimilation of data from observation systems is an integrated part in forecasting systems.

Quality assurance and quality control of forecasts should be documented.

Models:

a) Equations and algorithms should be published scientifically
b) Computer program code should be documented
c) It is recommended that computer program code is made available to the scientific community as open source software.

Validation of model results:

a) Reference measurements from in situ observation systems should be used for validation of forecasts. Skill assessments are essential.

8.1.9 HAB-warnings

Warnings must be based on best available knowledge, derived from a combination of observations, forecasts and expert knowledge.

GOOS Regional alliances identified for the first HAB observation and forecasting systems.

One of the activities of the Task Team is to identify regional locations where the first HAB observation and forecasting systems should be implemented. A large part of the infrastructure needed should already be in place. The following is a list of GOOS regional alliances and the regional locations that the Task Team has identified:
EuroGOOS
BOOS - Baltic Sea Operational Oceanographic System
example:
a) blooms of HAB-cyanobacteria

NOOS - North West Shelf Operational Oceanographic System
examples:
a) Skagerrak-Kattegat blooms of fish killing flagellates, e.g. Pseudochattonella farci-
men.
b) Scottish waters with blooms of the fish killing dinoflagellate Karenia mikimotoi

IBI-ROOS - Iberia-Biscay-Ireland Regional Operational Oceanographic System
examples:
a) Blooms of Dinophysis spp. in Galician Rias, Irish waters and in the Bay of Biscay.
b) Blooms of Karenia mikimotoi in the Bay of Biscay and in Irish waters

Mediterranean GOOS
Northern Adriatic Sea

Black Sea GOOS – no regional location identified

NEAR - North-East Asian Regional-GOOS
Japan – Seto Inland Sea – several HAB species
Korea – blooms of Cochlodinium polykrikoides

PI-GOOS - Pacific Islands Global Ocean Observing System – no regional location
identified

Indian Ocean GOOS – no regional location identified

IOCARIBE-GOOS - Global Ocean Observation system in the Caribbean Region –
Karenia brevis blooms in the Gulf of Mexico.

GOOS-Africa
Benguela area
Example: High biomass blooms of dinoflagellates cause hypoxia resulting in mortal-
ties of fish and shellfish

US GOOS
Gulf of Mexico Coastal Ocean Observing System (GCOOS)
Example: Karenia brevis blooms

North-eastern Regional Association Of Coastal Ocean Observing Systems (NERA-
COOS) example:
a) Alexandrium blooms (PSP) in the Gulf of Maine and in the Bay of Fundy (Canada)
Northwest Association of Networked Ocean Observing Systems (NANOOS)
Example: Blooms of Pseudo-nitzschia (ASP) along the west coast of the North Ameri-
can continent.

SEA-GOOS - Southeast Asian GOOS – no regional location identified

OCEATLAN - Regional Alliance for the Upper Southwest and Tropical Atlantic – no
regional location identified
9 Term of Reference F

9.1 Pursue by interdisciplinary work with WGPBI the development of joint ToRs and a joint WG session in 2009

A one day meeting was held jointly between WGHABD and the Working Group on Physical and Biological Interactions. WGPBI and WGHABD met on 1 April 2009. The agenda for the joint day, as well as abstracts for the presentations in the WGPBI session, are below. The joint day was deemed a success, in particular due to inspired discussion in break-out groups following presentations. It was mutually agreed to propose a joint theme session for ICES ASC 2010, convened by WGPBI member Geneviève Lacroix (Belgium) and WGHABD member Donald Anderson (USA). It was also mutually agreed to propose a joint meeting between the two groups in 2011, which should stretch over more than one day and include more time for discussions. WGPBI has generated a Term of Reference for the 2010 meeting to follow up on this. Discussions are also underway on the feasibility of adding WGOOFE to the 2011 meeting.

9.1.1 Agenda

09:00 - 11:30: WGHABD presentations

09:00 - 09:20: Tim Wyatt HAB Modelling Overview: Phycocosmos

09:20 - 09:40: Bengt Karlson/Lennart Funkquist The Baltic Cyanobacterial modeling,

09:40 - 10:00: Don Anderson: Gulf of Maine Alexandrium,

10:00 - 10:20: Patrick Gentien: Modeling Karenia / Dinophysis in Biscay

10:20 - 10:50: Coffee


11:10 - 11:30: Beatriz Reguera: Spatio temporal variability of division rates: implications for modelling

11:30 - 13:00: Discussion

13:00 - 14:00: Lunch

14:00 - 16:30: WGPBI presentations

14:00 - 14:15: Charles Hannah: Overview of WGPBI

14:15 - 14:55: Andy Visser: Small scale physical/biological interactions

14:55 - 15:25: Tom Osborn: Holographic imaging of plankton

15:25 - 15:45: Manolo Ruiz: Modelling oceanographic conditions on the western Iberian shelf during autumn HABs

15:45 – 16:05: Geneviève Lacroix: Spatial and interannual variability of primary production (Phaeocystis vs. diatoms) in the Southern North Sea

16:05 - 16:30: Coffee

16:30 - 16:50: Elizabeth North: Overview and application of recommended practices for modelling physical/biological interactions during the early life of fish

16:50 - 18:00: Discussion in 3 breakout groups

18:00 - 18:30: Plenary session: Discussion and Conclusion

9.1.2 Summary of discussions

After presentations from both the WGPBI and WGHABD groups on key topics / examples in the area of HABS models, the combined group was split into three groups for discussions, using the three questions:
• what are the key processes needed for modelling HABs?
• what key life stages history should be represented?
• what drives or determines toxicity, e.g. how does toxicity relate to fitness?

The breakout sessions were followed by reports from the breakout sessions and a plenary discussion. Key points from plenary discussion and breakout group reports:

• HABs are defined by nuisance value to humans and they are not necessarily toxic. Some HABs are bloom species and effect is simply caused by biomass (cover beach, clog nets, bad smell, etc.) whereas some exist in relatively low abundance and the effect is caused by toxicity.
• The properties of HABs need to be species and site specific. Nevertheless it should be possible to define HAB functional types which share common features but differ in the details. In other words we ought to be able to define which features of a particular HAB are generic and which are species and site specific.
• Currently, most models address just the biomass of HAB species. However toxicity in terms of seafood safety also depends on the toxicity levels of the HAB cells and the processes that transport the cells (and the toxins) up the food chain. Modelling of cell toxicity is an open field. Also, the vertical transport of the cells by sedimentation, e.g. in marine snow, is understudied.
• There is still a need for improved understanding and modelling of the processes that initiate and terminate the blooms for the bloom species and the onset of toxicity for the toxic species.
• The role of cell-to-cell communication, chemical cues and behaviour needs attention.
• There are physical processes that affect harmful algae in ways that deserve further work: Mixing and stratification, small-scale eddies, transport in the benthic boundary layer and in the near-shore, e.g. the surf zone.
• In terms of life histories of harmful algae, the triggering factors that inducing life stages shifts are unclear for many species, as are major control factors for each life stage. Finally, the phenotypic variability within the population during the various life stages, and its effects, are unclear.
• There is a need for systematic model validation and techniques for the use of available data to improve the simulations (data assimilation and parameter estimation).
• There is need for studies of processes on a large scale by multidisciplinary teams. Such projects should be associated to pre-existing hydrodynamical models and built on a conceptual model for one given species.
• It is essential that lab experiments be validated in situ by identifying all life stages.
• There are always concerns about spatial scale: For example is necessary to model filaments? Does density dependence matter, and if so, at which spatial scale must density be modelled? How do we model inter-particle distance in the cases where that is an important quantity? For model validation, is a point measurement useful? As usual the answer to the last question depends on spatial and temporal decorrelation scales.
• Several of the HAB applications presented were shelf oriented and the primary issue is whether the cells get advected to the coast where they interact with humans. So the key issues are identifying the initial location of the cells and the quality of the advective fields provided by the hydrodynamic model. In these cases useful results can be obtained and practical advice given to managers without sophisticated modelling of the biological processes.
• In small embayments the biological processes may overwhelm the physical ones and spatially explicit physical fields may not be required; a flushing time scale may
suffice to present the effects of horizontal advection. The calculation of the flushing
time scale may be nontrivial.
• Light: if light levels are important to the HAB process then sophisticated light mod-
els are available to calculate light attenuation are available. This calculation may re-
quire models or observations of phytoplankton and CDOM (coloured, dis-solved
organic matter). The relevant atmospheric forcing is often available from numerical
weather prediction models (ECMWF, NECP).
• Climate change: Estimation of impact of climate change on HAB magnitude and
frequency of occurrence is problematic. One needs to be able to link the HAB pro-
cesses closely to the physics and biogeochemistry. This will be easier for in cases
where temperature and stratification are the dominant factors in controlling the HAB.

Actions: The participants felt that the time for the small group discussions (40 mi-
utes) was too short: the discussions were just starting to get interesting. A future joint
meeting should ensure that much more time is devoted to small group discussions
(perhaps 3 hours). Participants enjoyed the discussion enough that a second joint
meeting has been pro-posed for 2011. This will be pursued. A second joint meeting in
2010 was rejected because WGPBI already occupied by WKMOR. A theme session for
the 2010 ASC will be proposed by Don Anderson (WGHABD) and Geneviève Lacroix
(WGPBI). The details are in Annex 8.

9.2 Presentation Abstracts

9.2.1 Phycocosmos

Tim Wyatt, Instituto de Investigaciones Marinas, Vigo, Spain

Phycocosmos is a model of phytoplankton succession cast with time and space as
explicit axes, inspired by Big Bang models of cosmological evolution. The central
path through phycocosmos is analogous to the main sequence of Margalef’s (1978)
mandala, along which turbulence decays and nutrient concentrations decline with
time, and as space expands. New inputs of energy either slow succession, reset it to
some earlier stage, or even reset it back to its initial stage. So time scales of succession
are determined partly by the character of these energy pulses and their decay rates,
but also by biological activity (Wyatt & Ribera 2005). In Sverdrup’s (1953) model, the
nominal reset time is several months, from spring equinox to autumn gales. Succes-
sion can however be interrupted any time during the growth season by mixing
events caused by wind, upwelling events, or spring tides. These higher frequency
influences lead to oscillations in the succession trajectory. To either side of the main
sequence are alternative paths which lead to red tides, anoxic events, and oligotro-
phy.

The phycocosmos expands the range of contrasting traits of MacArthur & Wilson’s
(1970) classical r-K axis which parallels the main sequence. It indicates trends from
relatively open to relatively closed systems, meaning that as succession proceeds,
ecosystem responses to external perturbations are damped more effectively, and that
biological responses to physical forcing give way to or are superseded by physical
responses to biological forcing. The growing structural and dynamical complexity of
the community which phytoplankton creates by succession calls for augmented
amounts of information. Vertical inheritance is not the only means to supply this
need – lateral gene transfer, symbiosis, kleptoplasty, and karyoplasty - all increase
genetic complexity in parallel with the system complexity within which species with
these arcane habits are embedded; these processes are the dark energy of inheritance.
Some flavours of the phycocosmos are suggested in the following tables. The axis from A to Ω, from early to late succession, amplifies the classical r-K continuum and should be read in conjunction with it.

Phycocosmos structure/architecture:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>Ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>system boundary</td>
<td>more open</td>
<td>more closed</td>
</tr>
<tr>
<td>species diversity</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>web architecture</td>
<td>few nodes, high linkage</td>
<td>many nodes, low linkage</td>
</tr>
<tr>
<td>links</td>
<td>mostly trophic</td>
<td>diversified</td>
</tr>
<tr>
<td>trophic architecture</td>
<td>simple trees</td>
<td>complex nested webs</td>
</tr>
<tr>
<td>social architecture</td>
<td>chains, colonies</td>
<td>thin layers</td>
</tr>
</tbody>
</table>

Phycocosmos dynamics:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>Ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>popn dynamics</td>
<td>exponential</td>
<td>logistic</td>
</tr>
<tr>
<td>competition</td>
<td>weak</td>
<td>strong</td>
</tr>
<tr>
<td>trophic control</td>
<td>bottom-up</td>
<td>top-down, “sideways”</td>
</tr>
<tr>
<td>E</td>
<td>Algae autotrophic</td>
<td>Protozoa heterotrophic</td>
</tr>
<tr>
<td></td>
<td>Protozoa autotrophic</td>
<td></td>
</tr>
<tr>
<td>phenology</td>
<td>rigid, geophysical cues</td>
<td>flexible, community-based</td>
</tr>
<tr>
<td>Σ</td>
<td>physical forcing</td>
<td>biological forcing</td>
</tr>
</tbody>
</table>

Phycocosmos information:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>Ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>information flow, heredity</td>
<td>tree-like</td>
<td>web-like, symbiosis, LGT, kleptoplasty</td>
</tr>
<tr>
<td>quorum sensing allelopathy</td>
<td>2ⁿ metabolites rare, cyclomorphosis</td>
<td>2ⁿ metabolites important, community integration</td>
</tr>
<tr>
<td>phenology</td>
<td>rigid, geophysical cues</td>
<td>flexible, community-based</td>
</tr>
<tr>
<td>statistics</td>
<td>Gaussian</td>
<td>Paretian</td>
</tr>
</tbody>
</table>


9.2.2 Toxix Alexandrium blooms in the Gulf of Maine region: development of forecasting or advisory capabilities

Don Anderson, Woods Hole Oceanographic Institution

A coupled physical/biological model of *A. fundyense* population dynamics in the Gulf of Maine has been described in several recent publications (e.g., McGillicuddy *et al.* 2005; Anderson *et al.*, 2005b; He *et al.* 2008). The model is initiated from large-scale maps of cyst distribution, with germination rates parameterized through laboratory
experiments. Likewise, the growth of the resulting vegetative cells is regulated by light, temperature, and salinity, again parameterized using laboratory cultures. The physics of the system are well represented by a Regional Ocean Modeling System (ROMS) model for the Gulf of Maine, nested within two larger models – HYCOM (Hybrid Coordinate Ocean Model, maintained by the NRL and U. Miami) and the ROMS for the Mid Atlantic Bight and the Gulf of Maine, maintained by Rutgers and UCLA. Two types of forecasting capabilities were discussed at this meeting – 1) synoptic forecasts (days to weeks); and 2) Seasonal forecasts.

**Seasonal (annual) forecasts**

Our numerical model of *A. fundyense* dynamics (e.g., McGillicuddy et al., 2005) is initiated from maps of cyst abundance in the prior year. At this time, we are testing the hypothesis that cyst abundance is a first-order predictor of regional bloom magnitude in the Gulf of Maine. Our studies have generally demonstrated a correlation between the abundance of *A. fundyense* cysts in a mid-coast Maine “seedbed” and the overall magnitude of the bloom in the western Gulf of Maine and waters further to the south and west. Note that this does not mean that the cyst abundance correlates with levels or extent of PSP toxicity (though that is sometimes the case), as it is possible to have a lot of cells in offshore waters that are not delivered to shore (and the toxin monitoring stations) by ocean currents (influenced by wind and other factors). For this reason, we speak of issuing “advisories” rather than forecasts.

Figure 1 shows a map of the *A. fundyense* cysts that were in surface sediments of the Gulf of Maine in late 2008. That map is attached here, along with maps for 1997, 2004, 2005, 2006 and 2007. Considerable interannual variability in cyst abundance is evident. Note several features of the cyst data. First, cyst abundance in surface sediments decreased by about 50% after a massive 2005 bloom, leading to a 2006 bloom that was quite large, but not as extensive as the one in 2005. Cyst abundance fell again in 2006, but increase again to historic levels in 2007. Based on the high 2007 cyst abundance, we issued an advisory last year saying that we expected a major regional *Alexandrium* bloom in 2008, which in fact occurred (Figure 2).

What does this suggest about the 2009 bloom season? Given the working hypothesis that the size of the mid-Maine cyst population is a predictor of regional bloom magnitude, the cyst abundance would argue that the 2009 bloom could be moderate year for toxicity. To be more quantitative, we have run our *Alexandrium* population dynamics model using the 2008 cyst map as input, but with the weather and oceanographic conditions of the years from 2004 to 2008. In all cases, we get simulations that suggest a moderate year of toxicity – similar perhaps to 2006, when much of the Maine, NH, and Massachusetts coasts were closed to harvesting of shellfish. We are not able to predict short-term weather patterns (such as the frequency and strength of northeast storms that cause downwelling and shoreward transport of water and cells), so we are not willing to issue a firm forecast. Instead we are issuing an advisory to the management community and other scientists that there is a significant possibility of a large regional bloom in 2009. This forecast is also consistent with an apparent upward trend in overall PSP toxicity in the western Gulf of Maine region that began in late 2003 and 2004, following a decade or more of low toxicity years (unpublished data).
Synoptic forecasts

On a short-term level, the *Alexandrium* population dynamics model is being used to provide weekly forecasts of bloom distribution and cell abundance. These runs are posted on a web site and notices of the latest results are posted to the NortheastPSP listserv that has several hundred subscribers, including state and federal managers and others interested in news and information about PSP outbreaks in the region. In past years, these results have proven to be very valuable to managers, as otherwise, their information is predominantly limited to nearshore shellfish toxicity measurements. The model runs provide perspective on what might be occurring offshore, and upstream. See http://omglnx3.meas.ncsu.edu/yli/09for ecast/ for an example of the announcement, and model run for this time period in 2009.

In summary, modeling efforts and our conceptual understanding of *A. fundyense* dynamics in the Gulf of Maine have progressed to the point where we can issue both long- and short-term advisories of bloom magnitude. It is also possible to provide near real-time maps of potential cell distributions along the coast, working from an annual cyst map from the preceding fall. Through data assimilation techniques, these latter forecasts could be made even more accurate once remote, automated cell detection of *A. fundyense* becomes a reality.

References


9.2.3 Variability in growth rate and vertical distribution: implications for modelling

Beatriz Reguera. IEO-Vigo, Spain.

Most nuisance blooms in the ICES domain are caused by low density blooms \((10^2 - 10^4 \text{ cell} \cdot \text{l}^{-1})\) of dinoflagellates and by denser blooms \((10^5 - 10^6 \text{ cell} \cdot \text{l}^{-1})\) of diatoms from the genus *Pseudo-nitzschia*, all of them constituted by toxin producing microalgae (TPA). They contaminate shellfish with toxin concentrations above regulatory levels established by EU and/or FDA directives and lead to prolonged shellfish harvesting closures. TPA populations often show a very patchy distribution and may form thin layers at specific depths of the water column. Since the ICES Working Group on *Toxic Phytoplankton and Management of their Effects* was established in 1986, hose- samplers were recommended that collected integrated-water-column samples and did not miss populations aggregated in narrow layers.

A key question is to determine if high numbers of a TPA species are reached either by high division rates or by physical accumulation, or by a combination of these two. *In situ* species-specific division rates estimated with the mitotic index approach, both from integrated-column water samples —\(\mu_{\text{int}}\)— and from specific depths —\(\mu_z\)— can be used to run simple growth models and determine if growth is due either to gains (advection) or to intrinsic growth. Vertical distribution of the populations during different times of the year and the presence or absence of vertical diurnal migration are other important factor to consider if a coupled hydrodynamic-biological models is to be developed for the species of interest.

Taking into account all different parameters —germination, division, advection, diffusion, grazing, encystment, death — in a population growth equation may look like an unattainable task. Nevertheless, there are scenarios where a large simplification can be made. Such is the case during downwelling events at the end of the upwelling season in Northwester Iberia, when division rate can be irrelevant, cell aggregate in the top 5m layer and cells increase is due mainly to advection. In that situation the use of a physical transport model combined with a the mesoscale distribution of the target species can provide a good prediction of the forthcoming bloom.

References


10 Term of Reference G

10.1 Discuss and report new findings that pertain to harmful algal bloom dynamics. Bring new findings in phytoplankton population dynamics models to the attention of WGHABD for discussion

10.1.1 *Azadinium spinosum* gen. et sp. nov. (Dinophyceae) identified as a primary producer of azaspiracid toxins

Urban Tillmann *; Malte Elbrächter *; Bernd Krock *; Uwe John *; Allan Cembella *

* Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
* Deutsches Zentrum für Marine Biodiversitätsforschung, Forschungsinstitut Senckenberg, Germany

Published in European Journal of Phycology, Volume 44, Issue 1 February 2009, pages 63–79.

Azaspiracids (AZAs) are a group of lipophilic marine biotoxins associated with human incidents of shellfish poisoning. During a research cruise to the North Sea, we analysed size-fractionated plankton for AZA by mass spectrometry and successfully isolated an AZA-producing dinoflagellate from the east coast of Scotland. As shown previously, an axenic culture of this dinoflagellate produces AZA 1, AZA 2 and an isomer of AZA 2. Here we give a taxonomic description of this new taxon *Azadinium spinosum* gen. et sp. nov., as a de novo producer of AZAs. *Azadinium spinosum* is a small (12-16 µm length and 7–11 µm width) peridinin-containing photosynthetic dinoflagellate with a superficial resemblance under light microscopy to gymnodinoids, but with a thin theca. The large nucleus is spherical and located posteriorly, whereas the single chloroplast is parietal, lobed, and typically extends into both the epi- and hyposome. The Kofoidian thecal tabulation is APC, 4', 3a, 6", 6C, 5?S, 6"", 2"". This plate pattern has an epithecal affinity to the Peridiniales and a hypothecal affinity to the Gonyaulacales, but is distinctly different from described dinoflagellate genera. The assignment of *A. spinosum* to the dinoflagellates is supported by molecular phylogenetic analysis of four genes, SSU rDNA, LSU rDNA (D1/D2 region), ITS and cytochrome oxidase (sub-unit 1) (COI). In agreement with the morphological description, phylogenetic analysis did not show any particularly close affiliation to the Peridiniales or Gonyaulacales, nor to any other dinoflagellate order represented in molecular databases. Consequently, we erected a new genus, *Azadinium*, for this taxon. However the ordinal affiliation of the genus is uncertain. This study represents the first description and confirmation of a new dinoflagellate species capable of producing AZA and is thus an important advance in surveillance programmes for toxigenic microalgae and toxins of human health significance.

10.1.2 *Dinophysis* and Arcachon basin.

Patrick Gentien

IFREMER France

Some ongoing work on *Dinophysis* related to the Arcachon basin (France): Arcachon basin has been a sensitive area in terms of *Dinophysis* intoxications. It has recently been demonstrated that *Dinophysis* populations are advected into the Basin from offshore under well-defined tidal and meteorological conditions.
These populations susceptible to enter the basin and contaminate oysters originate from coastal waters about 150 km. A 10–15-days forecast based on initial conditions and lagrangian modelling is within reach.

The quality of the forecast will highly depend on the 3D-hydrodynamical model. Since the continental shelf is very narrow in this area, a good prediction of trajectories requires proper boundary conditions.

10.1.3 Climate impact on HAB

Maija Balode, Latvia

One of the most significant factors related to the climate change is an increase in water temperature. A temperature increase of 1º C in European waters and 2º C in Danish coastal waters in the last 100 year has been documented. Global sea surface temperature has warmed by a mean of 0.6º C resulting in a redistribution and loss of marine organisms, hypoxia, higher frequency of anomalous and harmful algal bloom (HAB) events. Increase in air temperature by 0.5–1º C during the last century is documented also in the Eastern part of the Baltic Sea (in Latvia), reaching the highest values in the 1990s.

Oceanographic studies show that the mean annual sea surface temperature could increase by 2 to 4º C by the end of the 21st century in the Baltic Sea Basin.

The aim of our study was to detect the links between the temperature increment and possible shifts in HABs in the Eastern Baltic Sea. Experimental studies on the possible impact of climate change on development of Baltic HAB species show that an upward trend in temperature may result in significant changes in phytoplankton community structure causing an increase in total phytoplankton biomass; provoking changes of phytoplankton species composition; diminishing species diversity and promoting development of HAB species. The rise in temperature has facilitated growth of moderate boreal HAB species in spring (at the same time preventing the growth of arctic species) and stimulated the development of warm water HAB species in the summer. Our studies show that phytoplankton could be more influenced by the increment of temperature in summer due to the increase of HAB cyanobacteria. Taking in account that toxic blooms may become more frequent and intensive due to global warming, possible shifts related to the climate change could promote serious changes of the structure and function of the whole ecosystem of the Baltic Sea and significantly influence their sustainable development.


Don Anderson

Woods Hole Oceanographic Institute, USA

This report is of a major HAB in the Arabian Sea, Arabian Gulf, and Gulf of Oman. Although this is not in the ICES region, the findings are presented here because some of the impacts of the bloom are unique, and thus deserve to be more widely known among HAB workers.

In September 2008, blooms of the dinoflagellate Cochlodinium polykrikoides first occurred along the coast of Oman, spreading thereafter to the eastern coast of the United Arab emirates, and then to Iran near the Strait of Hormuz within the Arabian Gulf, from which it spread further to Qatar, and also to the United Arab Emirates’
(UAE) coast within the Gulf. The visible “red tide” bloom has been occurring for at least 8 months at this writing. This organism had been observed in 2002 in Kuwait waters, so it was not new to the region, but no major blooms had been observed until the 2008/2009 event. This outbreak is described here because it introduced some new impacts associated with a species that has been spreading throughout the world in recent years.

The Cochlodinium blooms in the UAE and Oman region caused extensive damage to wild fish stocks, drove the fledgling offshore fish farming industry in both countries out of business, and devastated coral reef systems. Some of the impacts are associated with low oxygen conditions resulting from deposition of the dense blooms, but other impacts are linked to the living cells, and the apparent production of huge quantities of mucous that killed fish and corals.

The ongoing red tide represents a serious threat to public health, given that earlier analyses by scientists at the Kuwait Institute for Scientific Research identified multiple HAB species in the bloom, including Gymnodinium catenatum, Pyrodinium bahamense, and Karenia mikimotoi. As described in the pre-proposal, the first two of these produce potent neurotoxins that accumulate in shellfish, and can cause illness and death in human consumers through Paralytic Shellfish Poisoning (PSP).

One unique impact of the outbreak was the threat to desalination plants that are critical to the region’s water supply. Worldwide, we know of no other instances in which HABs have affected desalination plants. This means that there is no data or experience to guide officials in the UAE and in Oman who are struggling with decisions to keep plants open or to shut them down during HABs because of the clogging of intake filters or reverse osmosis membranes by Cochlodinium cells, and concerns about the presence of potent biotoxins in the finished water. Desalination plants are desperately in need of guidance on these issues.

10.1.5 Characteristic profiles of Ciguatera toxins in different strains of Gambierdiscus toxicus

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Ciguatera fish poisoning characterizes the intoxication caused by consumption of fish from tropical and subtropical areas, which have accumulated ciguatoxins (CTXs). The observed profile of CTXs in fish highly depends on the marine region and the causative organisms. It is evident that differences exist between ciguatoxins produced by certain strains of the dinoflagellate Gambierdiscus toxicus and other Gambierdiscus species. Different strains of Gambierdiscus ssp. from Vietnam have been grown in culture at Biologische Anstalt Helgoland, Alfred Wegener Institute for Polar and Marine Research (AWI), Germany, since 2007. These strains as well as Gambierdiscus ssp. purchased from the Bigelow Laboratory for Ocean Sciences (CCMP) and lyophilized samples of several Gambierdiscus ssp. from the National Oceanic and Atmospheric Administration (NOAA), USA were analyzed for the presence of CTXs.
The LC-MS/MS analyses revealed the presence of CTXs and allowed the classification of all strains of *Gambierdiscus* ssp. as producer of the pacific ciguatera toxins (P-CTXs). The CTX profiles of the Vietnamese samples were compared with cultures of *Gambierdiscus* ssp. from CCMP and the NOAA resulting in an overview of CTXs in cultures from different regions (Guam, Mataiva, Moorea, Martinique, Belize, Cayman Island and Hawaii).

It was obvious that the strain from Vietnam forms a characteristic CTX profile which is not directly comparable to CTX pattern observed in other tropical marine regions. In addition, differences were observed between the toxin ratios of the CTX analogues in the strains from Vietnam depending on the salinity.

The biogeographical distribution of *Gambierdiscus* species was until recently restricted to tropical and subtropical areas, specifically in discrete regions of the Pacific and West Indian Oceans and the Caribbean Sea. Recent findings of *Gambierdiscus* ssp. in the Canary Islands, Spain and Crete, Greece may indicate spreading of this genus into new areas. In this context it is of great interest to analyse the strains from Canary Island and Crete concerning the CTX profile to obtain deeper insight into the correlation between the Canarian and the Greek *Gambierdiscus* species. Furthermore, morphological, genetic sequences and toxicological analyses of cultured strains are necessary to provide answers to questions with regard to spread of new species as consequence of climate change.

10.1.6 Diversity and toxicity of *Alexandrium* in Scottish waters

Eileen Bresnan

Marine Scotland

*Alexandrium* species paralytic shellfish poisoning (PSP) toxins are observed in Scottish coastal waters and Scottish shellfish on an annual basis. Historic investigations into the diversity of *Alexandrium* have been limited in their regional coverage. To examine the diversity and toxicity of *Alexandrium* in Scottish coastal waters, *Alexandrium* cultures were established from sediment and water samples collected from around the Scottish coast. Four species of *Alexandrium* (*A. tamarense* (Group I and Group III strains), *A. ostenfeldii*, *A. minutum* and *A. tamutum*) were established in laboratory culture and identified using morphological criteria. Molecular sequencing of LSU rDNA from isolates of *A. ostenfeldii*, *A. minutum* and *A. tamutum* confirmed their identification and showed them to be similar to other European strains. *A. tamarense* was observed to have a widespread distribution around the Scottish coast with both Group I and Group III producing strains isolated. Saxitoxin and Neo Saxitoxin dominated the toxin profile of *A. tamarense* (Group I) cultures isolated. *A. ostenfeldii* was isolated from the Scottish east coast and Shetland Islands and was observed to produce both spirolide and PSP toxins. *A. tamutum* was identified from cultures isolated from Shetland and Orkney; the most northerly observation of this species to date. Isolates of *A. minutum* from the Scottish east coast and Orkneys and *A. tamutum* did not produce PSP toxins under the culture conditions investigated. This study has highlighted the diversity of *Alexandrium* in Scottish waters and reveals the requirement regional studies on a species level in order to understand the variation in cell densities and PSP toxicity that is observed on an annual and decadal scale.
10.1.7 Thematic network on toxic phytoplankton and biotoxins: REDIBAL

Margarita Fernandez, Esther Garces; Santiago Fraga

http://www.redibal.org/index.php

The proposal to create a thematic network on toxic phytoplankton and biotoxins was suggested during the 2007 Iberian Meeting of Toxic Phytoplankton and Biotoxins and it was launched in November 2008 with the support of the Spanish Government. REDIBAL has been conceived as a professional thematic network dealing with harmful algae, and was born out of the spirit of promoting interaction among scientists, technicians, managers and other groups of interest in the Iberian Peninsula. The dispersion of coastal monitoring efforts and the continuous scientific advances made in the methods of detection and mitigation of harmful algae make it advisable to establish a system for the exchange of knowledge between scientists and environmental management agencies so that the effort dedicated to this matter can function more efficiently.

Furthermore, the intention of REDIBAL is to open an information exchange channel between science and society regarding harmful algae by promoting leadership in the areas of education and transmission of information related to this topic. The contents are written in Spanish and although some of the contents are under construction the web page gives information about the research on toxic phytoplankton and biotoxins in Spain and Portugal and allows the exchange and discussion.

To participate actively in the network it is necessary to register, there are already 73 users registered from 48 different institutions. The distribution of 16 toxic species along the Iberian coastline is shown using Google maps. During the next 2009 Iberian Meeting on Toxic Phytoplankton and Biotoxins this thematic network will be evaluated.

10.1.8 Summary of Phytoplankton QC Scheme

Joe Silke

Marine Institute, Ireland

Biological effects measurements are increasingly being incorporated into national and international environmental monitoring programmes to supplement chemical measurements. The Biological Effects Quality Assurance in Monitoring Programmes (BEQUALM) project, funded by the European Union through the Standards, Measurements and Testing programme of the European Commission, was initiated in 1998. This was in direct response to the requirements of OSPAR to establish a European infrastructure for biological effects QA/QC, in order that laboratories contributing to national and international marine monitoring programmes can attain defined quality standards. The UK based National Marine Biological Analytical Quality Control Scheme (NMBAQC) is a quality assurance scheme originally developed to provide benthic invertebrate taxonomy QC among UK monitoring labs. It has in more recent years expanded to cover QC schemes in other marine group sincluding Phytoplankton. Its principal aim is to provide assessment of marine biological data contributing to European monitoring programmes. The NMBAQC scheme provides a source of external Quality Assurance (QA) for laboratories engaged in the production of marine biological data.

The Marine Institute, Galway, Ireland, has conducted a Phytoplankton Enumeration and Identification ring trial, under the auspices of NMBAQC and BEQUALM annu-
ally since 2005. The purpose of this exercise is to compare the performance of laboratories engaged in national official/non-official phytoplankton monitoring programmes and other labs working in the area of phytoplankton in the European North Atlantic area (see bequalm website). Most of the labs taking part in this scheme at present come from the UK and Ireland. In 2008 national monitoring programme in Spain, took part for the first time and labs from Holland and Germany joined in 2009. The Marine Institute is accredited to ISO 17025 for Toxic Marine phytoplankton identification and enumeration since 2004, and recognises that regular Quality Control assessments are crucial to ensure a high quality output of Phytoplankton data.

In January of each year an invitation to register for the phytoplankton assemblage component of the community analysis scheme is issued to laboratories involved in phytoplankton analysis via the BEQUALM website (www.bequalm.org). This included a timetable showing the dates samples would be sent to analysts and expected result dates.

At the beginning of February, samples, Taxonomic quiz, instructions and results sheets are sent to all analysts who had registered through the website. Analysts are generally given until the end of February to return enumeration and identification results to the Marine Institute (MI) Phytoplankton laboratory. Up to 30 analysts involved in monitoring programmes have taken part in this exercise, which culminates in a workshop for participants to discuss results and to participate in training exercises/lectures.

11 Term of Reference H

11.1 Collate and assess National reports (country reps) and collate data of HAEDAT

11.1.1 National report - Canada

Jennifer Martin
Fisheries and Oceans Canada

British Columbia (west coast)

During 2008, fish kills occurred at a number of salmon aquaculture operations. *Chrysochromulina* bloomed at high cell densities in the Sechelt Inlet on Apr 7, affecting farmed fish. *Pseudoophotonella cf. verruculosa* (2.8 x 10⁷ cells·L⁻¹) was responsible for mortalities on Sept 13 at Quasino Sound although it co-occurred with high cell concentrations of *Heterosigma akashiwo* (1.1 x 10⁶ cells·L⁻¹) which may also have contributed to toxicity; wild salmon were also affected. Another *Pseudoophotonella* event (1.2 x 10⁶ cells·L⁻¹) occurred at Esperenza Inlet on 16 September. *Heterosigma akashiwo* (2.7 x 10⁶ cells·L⁻¹) was also responsible for salmon mortalities in Sechelt Inlet on 29 August and Finlayson Channel (1.2 x 10⁷ cells·L⁻¹) on 25 August.

PSP occurred at a number of locations through the coast of BC with highest concentrations detected (3800 µg STX equiv. 100g) in sea mussels at Chamiss Bay.

East Coast

PSP was detected in shellfish in the St. Lawrence Estuary with highest concentrations detected in mussels at levels of 10, 603 µg STX equiv. 100g and water discolouration observed as a result of *Alexandrium tamarense*. Not only did the bloom affect shellfish in the region, 10 beluga whales (endangered species), seals, 1000 birds, wild fish
(sturgeon, sand lance) also died. In the same region, ASP toxin levels of 289 µg DA g\(^{-1}\) were measured in sea scallops in addition to elevated concentrations of \textit{Pseudo-nitzschia} spp.

In the southern Gulf of Lawrence (Miramichi Bay to the western Northumberland Strait) PSP levels of 99 µg STX equiv. 100g were detected in blue mussels, closing the shellfish harvesting area as a result of \textit{A. tamarense}. Highest cell concentrations observed were 300 cells\(\cdot\)L\(^{-1}\).

The southwest New Brunswick portion of the Bay of Fundy also experienced closures of shellfish harvesting areas due to elevated \((4.6 \times 10^5 \text{ cells}\cdot\text{L}^{-1})\) concentrations of \textit{A. fundyense}. Highest concentrations of toxins detected were 14,932 µg STX equiv. 100g in blue mussels. Four people became ill from eating contaminated soft-shell clams. In August, there was also a precautionary closure of shellfish harvesting areas as a result of elevated levels of DA (7.1 µ DA g\(^{-1}\)) in soft-shell clams as a result of high concentrations of \textit{P. pseudodelicatissima} \((1.6 \times 10^6 \text{ cells}\cdot\text{L}^{-1})\).

11.1.2 National Report – Germany

\textbf{Allan Cembella (AWI)}

During the annual review period, the Baltic Sea coast of Germany was exposed to the usual summer blooms of the potentially toxic cyanobacterium \textit{Nodularia spumigena}. The intensity of the cyanobacterial blooms changes dramatically from year to year, with high regional variability. In this respect, 2008 was a rather typical year with a rather persistent \textit{Nodularia} bloom evident from the Mecklenburg-Western Pomerania coast from August to October 2008. The only known toxic effects associated with these blooms was the mortality of a dog caused by drinking water from the Greifswald-Wieck in October 2008. Analysis of water samples containing high concentration of \textit{Nodularia} revealed the presence of nodularin and about 10% desmethyl-nodularin in the cyanobacteria – the putative cause of the dog death. From autumn 2007 to spring of 2008, an unusual long-lasting occurrence of the potentially toxic prymnesiophyte \textit{Chrysochromulina polylepis} occurred, with high abundance in the German Baltic region. This event was, however, not related with toxic symptoms. The the dictyochophyte \textit{Pseudochattenella farcimen} was observed, occasionally in high abundance in inshore waters, but this organism was not associated with harmful events.

The HAB situation along the German Wadden Sea and North Sea coast was uneventful as regards toxic incidents in 2008. Potentially toxic species, including \textit{Alexandrium minutum}, \textit{A. ostenfeldii} and \textit{A. tamarense} associated with PSP or spirolide toxins, and \textit{Dinophysis acuminata}, \textit{D. acuta} and \textit{D. norvegica} linked to DSP toxins were sporadically observed observed on the Wadden Sea coast at Sylt but only in low cell numbers and without determination of toxicity. Results of toxin analysis by LC-MS from an oceanographic cruise in early summer 2008 along the Wadden Sea coast from Bremerhaven to Skagen, Denmark revealed multiple lipophilic toxins in plankton with a general increasing trend northward along the Danish coast. In the German Bight and Wadden Sea coast of Germany the dominant toxins in the plankton size-fractions >20-200µm were domoic acid, 20-des-methyl spirolide G and dinophysistoxin DTX2, with traces of okadaic acid, and pectenotoxins PTX2 and PTX2-seco acid. Azaspiracids (AZA) were generally below detection limit. No comparative taxonomic information on associated species distribution is yet available.
11.1.3 National Report- Poland

Hannah Mazur

In February 2007, a bluebox equipment was installed on a ferry that sails between Gdynia, Poland (GK1) and Karlskrona, Sweden (GK6). It opened a possibility to extend the Baltic ecosystem observations and the HAB studies more to the central and southern part of the Baltic Sea. In 2008, the first Polish regular monitoring program of harmful algal blooms started. The 3-year project is coordinated by the Institute of Meteorology and Water Management in Gdynia (IMWM), Poland. Data are collected by three different ways: remote sensing satellite techniques, in situ measurements (STD, Chla) and analysis of discreet water samples (Chla, nutrients, toxins, toxicity). In 2008, samples were collected from 7 July till 6 September. The highest biomass of the toxic cyanobacterium Nodularia spumigena were recorded in the first two weeks of July, reaching the maximum value of 1.3 mm$^3$/L. In the same time, the mean nodularin (NOD) concentration in water samples collected during the ferry crossing reached ca. 3 µg/L. In blue mussels collected in 2008 in the Gulf of Gdańsk the measured NOD concentration ranged from 24–87 ng/g d.w. Due to mild toxic bloom intensity, no beach closures nor fish kills were recorded in summer 2007 and 2008.

11.1.4 National report- Sweden

Bengt Karlson

The Skagerrak and the Kattegat

No major harmful algal blooms occurred in the area in 2008. In April cf. Alexandrium tamarense occurred at several locations along the Swedish Skagerrak coast and the northern part of the Swedish Kattegat coast. Abundances up to 4700 cells per litre were recorded. Simultaneously Paralytic Shellfish toxins above regulatory levels were recorded in blue mussels (Mytilus edulis) by the Swedish National Food Administration. Alexandrium were also recorded in May and September in the same area but in low abundances. Dinophysis spp., a dinoflagellate genus with representatives producing Diarrhetic Shellfish Toxins (DST) was observed during most of the year but in abundances lower than usual. In 2008 DST were not recorded at levels above the regulatory limit of 160 mg per 100 g of mussel meat in blue mussels. Pseudo-nitzschia spp. occurred in abundances up to 800 000 cells l$^{-1}$. No Amnesic Shellfish Toxins were observed in shellfish. The diatom Chaetoceros concavicornis, known to affect the gills of fish negatively, was observed during the year. Other potentially harmful algae observed include Pseudochattonella farcimen, Akashiwo sanguinea, Karenia mikimotoi, Procentrum minimum and Karlodinium veneficium. No harmful effects were reported other than the PSP event in April.

The Baltic proper

The potentially harmful flagellate Chrysocromulina cf. polylepis was observed in bloom abundances (max ca 4 000 000 cells per litre) in the whole Baltic proper during winter and spring. No harmful effects were reported. Surface accumulations of cyanobacteria were observed in a large part of the Baltic proper in July. At the end of the month beaches were affected in the Kalmar Sound area. The toxin producing species Nodularia spumigena was found in the water together with non toxic Aphanizomenon sp. and Anabaena sp. No toxin analyses were carried out.
The Bothnian bay

Surface accumulations of cyanobacteria were observed from satellite in the Bothnian Sea in July and August. These offshore blooms did not reach the Swedish coasts. In October local blooms of cyanobacteria occurred along the coast of the Bothnian Sea. In one site the composition of the bloom was confirmed to consist of *Nodularia spumigena*, *Aphanizomenon* sp. and *Anabaena* sp. In a few places the public noticed what they thought was turquoise paint spilled on stony beaches. This is a common phenomenon and actually consists of dry cyanobacteria.

Zooplankton

The ctenophore, *Mnemiopsis leidyi*, was observed in the Skagerrak, the Kattegat and in the southern Baltic Proper. In the northern Baltic proper and in the Bothnian Sea the ctenophore *Mertensia ovum* was observed. These two gelatinous zooplankton species are supposedly introduced species and there is concern about effects on the ecosystem, especially in the Baltic where ctenophores have not been part of the ecosystem earlier. There have also been speculations about a connection between low abundances of *Dinophysis* spp. and the occurrence of the new ctenophores in the Skagerrak the last few years. *Mertensia ovum* was previously misidentified as *Mnemiopsis leidyi*.

11.1.5 National Report- United States

Don Anderson (WHOI)

2008 was basically a “normal” HAB year for most regions of the U.S., with several noteworthy events.

PSP. Similar to previous years, Maine, New Hampshire, Massachusetts, Washington, Oregon, and California all recorded PSP toxicity in 2008. A significant regional-scale *Alexandrium fundyense* bloom occurred within the Gulf of Maine in 2008. It is noteworthy that this bloom was predicted several months in advance based on the abundance of *A. fundyense* cysts in Gulf of Maine sediments. Toxicity was particularly high in eastern Maine but also extended south to Massachusetts Bay and parts of Cape Cod. An offshore bloom of the species was also detected on Georges Bank. In Maine, three humans were treated for PSP due to harvesting mussels from a closed area. They were hospitalized due to life-threatening exposures. California experienced an unusual a seasonal event in Santa Barbara in January and San Diego in March. Historically it is rare to have detectable PSP toxicity below Pt. Conception (Santa Barbara through San Diego); this pattern has changed in recent years with PSP occurring in this region each of the past several years. Washington State experienced persistent PSP on the outer coast for many months which was unusual in its timing (winter months). In 2008 much of the Oregon coast was closed due to high PSP levels. Closures began in June on the south coast and were subsequently extended to include the central and part of the north coast the following month. The entire coast was reopened in the first week of September. However, levels rose again in the next sampling series in September necessitating further closures. By October, the entire coast was closed once more to recreational mussel harvest and remained closed for the remainder of the year and into mid January of 2009. As in 2006 and 2007, there were no PSP events in Alaska in 2008.

Another noteworthy event related to PSP was the detection of high levels of saxitoxins in the tomalley of lobsters. After a risk assessment, the state of Maine felt it prudent to issue an advisory warning against consumption of the tomalley. This, as well as advisories issued by the US FDA caused significant disruption of the industry, as
foreign buyers ceased their purchases of live product. PSP scores in tomalley were highest in eastern Maine, with scores generally in the 50–300 µg per 100 g tomalley range. Some lobsters collected from far eastern Maine had higher scores, with one area testing at 3500 µg per 100 g tomalley.

ASP. California, with the exception of one sample above the alert level, experienced persistent low levels of domoic acid at various locations along the southern California coast. They experienced a rare bloom of *Pseudo-nitzschia* at monitoring sites in Marin and Sonoma counties with low levels of domoic acid detected in sentinel mussels (1–5 ppm). This was the first year since 2000 that they did not experience significant domoic acid concentrations above the alert level. Washington State had very low levels of domoic acid with no closures reported. Oregon State did not have any closures due to domoic acid.

NSP. *Karenia brevis* blooms occurred in two areas of Florida: the southwest and east coast. Two manatee mortalities were associated with the southwest bloom.

DSP. For the first time, shellfish beds in Texas, from Galveston Bay to Corpus Christi Bay, were closed to harvesting due to DSP toxins. *Dinophysis ovum* cells were initially detected by the Imaging FlowCytoBot deployed at Aransas Pass.

Brown tide. The south shore of Long Island, NY experienced a significant brown tide bloom, which began in early April in Great South Bay, spreading west to east, and in between Moriches Bay and Shinnecock Bay, spreading east into Shinnecock and west into Moriches. Suffolk County reported 1.8 million cells per ml in June and a fall resurgence to nearly 1 million cells per ml again in October. With the exception of a dip in cell densities in late summer, the bloom lasted for nearly 8 months in some locales in 2008 (April through November).

*Karlodinium*. As in 2007, Chesapeake Bay experienced a *Karlodinium veneficum* bloom in 2008.

11.1.6 National report- Denmark

Per Andersen
Orbicon, Denmark

Toxins in shellfish – DK 2008

ASP – no observations above the regulatory limit - but some closures/restrictions due to high concentrations of *Pseudo-nitzschia* - above the regulatory limit.

PSP – above regulatory limit (MBA) in one production area in the Limfjord during a short period (12-20th of May) – max. conc. of *Alexandrium tamarense* = 400 cells/l. A revision of the current regulatory limit (500 cells/l) might be needed. A method for measurement of single cell toxicity test, similar to the one used routinely for *Dinophysis* is currently under development.

The species *Alexandrium pseudogonyaulax* was responsible for closures in the Limfjord during the period 2nd June-22nd September due to high concentrations (max= 8.000 cells/l). No reaction in the MBA and no toxicity measured with chemical method!

A revision of the regulatory limit for this species is needed.

DSP – no observations above the regulatory limit in 2008, but a lot of closures/restrictions due to high concentrations of *Dinophysis acuminata* - above the regulatory limit.
Using the “SINGLE CELL TOXICITY” many closures were turned into re-opening of production areas in the case of low toxicity of *Dinophysis acuminata*. In conclusion, the “SINGLE CELL TOXICITY” approach worked out well. The *Dinophysis acuminata* populations investigated were very low in toxicity. No traces of DSP toxins showed up in shellfish.

Fish and invertebrate kills

No fish invertebrate kills were observed in 2008, related to algal blooms. Blooms of the fish killing flagellate Chattonella/Pseudochattonella resulted in a delay in the release of fish into the marine fish farms.

Recreational HABs

No HABs caused problems for recreational use of Danish marine waters in 2008.

11.1.7 National Report- Ireland

Joe Silke

Marine Institute Ireland

There was considerable shellfish toxicity detected in Ireland in 2008 resulting in widespread closures of shellfish production areas. These were mainly due to the presence once more of Azaspiracid and Okadaic acid/DTX2 in the shellfish.

Azaspiracid

During 2008 AZA toxicity persisted in samples of *M. edulis* for a small period throughout January, and resulted in closures in a number of sites within Bantry & Dunmanus above the regulatory level of 0.16µg/g-1 Total Tissue, as a carryover of the AZA event which began in Oct 2007. AZA concentrations were observed to decrease further to levels below the regulatory level during January resulting in Open status being assigned. From the end of May 2007, AZA levels were observed to increase in samples of *M. edulis* from sites within Bantry and Dunmanus, and from June in sites within Kenmare to concentrations above the regulatory limit. The highest AZA concentrations above the Upper Limit of Quantification (>ULQ = > 1 µg/g-1 Total Tissue) were observed in these sites during July – September. ZA concentrations were also observed above the regulatory level in samples of *M. edulis* from Galway Bay, Killary Harbour, Drumcliff and Ballysadare during July and August, and also in Bruckless in August and September. From October onwards, AZA concentrations were observed to decrease nationally, resulting in previously affected sites in the West and NorthWest being assigned Open status. In the affected sites in the SouthWest, concentrations were observed to decrease to levels < ULQ, however remained above the regulatory level. Further decreases were observed in November to below the regulatory limit, where the majority of sites within Kenmare were assigned Open status, and during December the remaining affected sites within Bantry and Dunmanus were assigned Open status.
Levels of Azaspiracid detected nationally in Ireland during 2008

**DSP Toxins**

From Mid July, DSP concentrations were observed to increase above the regulatory level in samples of *M. edulis* from Bantry and Dunmanus. These concentrations increased during August in these, where the highest concentration of 0.92 µg/g-1 Total Tissue was observed. DSP concentrations decreased during September, though concentrations did not significantly increase or decrease during October and November. Further decreases in concentrations were observed in December enabling the previously affected sites to be assigned Open status. The predominant quantifiable DSP toxin in samples from July to August was Okadaic Acid (OA), and from late August onwards the predominant DSP toxin present was *Dinophysys* Toxin 2 (DTX-2).
Levels of DSP toxin detected nationally in Ireland during 2008

**Amnesic Shellfish Poisoning**

During 2008, 506 analyses for ASP were conducted on Scallop tissues (*P. maximus*), typically Gonad and adductor muscle tissues, where the levels observed on Adductor Muscle tissues (240 analyses) were all below the regulatory limit (highest level observed 7.7 μg/g⁻¹). 1 of 238 Gonad tissues analysed were observed to be above the regulatory limit > 20 μg/g⁻¹, where the highest level observed was 29.6μg/g⁻¹.

**Paralytic Shellfish Poisoning (PSP)**

During 2008, 139 samples of *M.edulis, C.gigas, O.edulis, E.siliqua* & *T.philippinarium*, were submitted for PSP analysis. All samples were <LOQ via AOAC PSP Bioassay.

**National Report- United Kingdom**

**Eileen Bresnan**

**Northern Ireland**

In 2008, forty sites were sampled routinely on a fortnightly basis from N. Ireland sea loughs.

*Alexandrium* spp. were recorded in 1.6 % of samples. The maximum cell abundance (80 cells l⁻¹) was recorded in a sample from Belfast Lough on the 14th April. No PSP toxins were detected in shellfish in 2008.

*Dinophysis* spp. were present in water samples throughout the year (January – December). The maximum abundance (600 cells l⁻¹) was recorded in a sample collected from Dundrum Bay in mid August. The most abundant species was *D. acuminata*. Cells of *Prorocentrum lima* were present in 2.3% of samples with a maximum abundance of 80 cells l⁻¹ recorded in a sample from Lough Foyle in August. No DSP toxins were detected in shellfish sampled during the year.
Pseudo-nitzschia spp. were present in 72.1% of samples and reached a maximum concentration of 464,800 cells l$^{-1}$ in a sample from Dundrum Bay in mid August. Toxicity due to domoic acid was confined to samples of scallops (Pecten maximus) from Strangford Lough.

One incident of phytoplankton causing water discolouration was reported during 2008. This was in Belfast Lough in mid October. A sample collected on the 14th October contained 165,840 cells l$^{-1}$ of the ciliate Myrionecta rubra.

**England and Wales**

In 2008 a total of 1072 samples were collected from 53 production areas. Alexandrium spp. occurred less frequently than in 2007, being recorded from 25 of the 53 sampled areas. Highest concentrations were once again found in the River Yealm (Devon) at concentrations of 1.7 million cells/litre in August, where it persisted from May to September. Alexandrium spp. was found in samples from the Salcombe Estuary, Devon, from April - September with a maximum concentration of 500,000 cells/litre occurring in July. As in 2007, PSP toxins were found on only three occasions in 2008, all at Holy Island, Northumberland at the end of May – early June, in mussel flesh. Alexandrium spp. did not coincide with PSP toxins being found on any occasion this year.

Dinophysis spp. were found in low concentrations on 23 occasions, but only breached action levels once at each of four sites in Devon and Cornwall. Prorocentrum lima (DSP) were found on ten occasions with only four breaches of action levels, once in the Fleet Lagoon, Weymouth, Dorset and three times at separate sites in the Thames Estuary. DSP toxins were recorded on four occasions in samples of cockles from Three Rivers (twice) and Burry Inlet, South Wales and once in a sample of Pacific Oysters from the Fleet Lagoon.

Pseudo-nitzschia spp. were found in most of the sampled areas in 2008 and were more widespread and persistent than in 2007. They breached the 'investigative' level (50,000 cells/litre) on only 3 occasions but breached the action level (150,000 cells/litre) 14 times during May - June 2008. ASP toxins were not found in any shellfish flesh samples in 2008.

Scotland

Alexandrium spp. was observed less frequently compared with previous years. The largest blooms recorded during 2008 were all observed at the same location in southwest Shetland over a period of approximately four months, with peaks in May, June and August, the maximum being 1,440 cells l$^{-1}$ in mid June. Low levels of PSP toxicity were frequently reported throughout the period from March through to October at numerous sites, although Alexandrium cell counts were below detection levels in the water samples. A low density bloom of 160 cells l$^{-1}$ occurring in the Dornoch Firth in May 2008 was associated with elevated levels of PSP toxicity in shellfish (detected by bioassay).

Dinophysis spp. was observed from May - September. The largest bloom occurred in Loch Roag (Western Isles) in early June, with a density of 2,220 cells l$^{-1}$. Other blooms were recorded from the north west: 1,080 cells l$^{-1}$ in Loch Laxford in late July; 840 cells l$^{-1}$ in Loch Ewe in mid August; and from Argyll: 600 cells l$^{-1}$ in Loch Striven in early July. Both the Loch Laxford and Loch Striven blooms had associated DSP toxicity. However, DSP positive results in shellfish did not always coincide with an elevated Dinophysis cell count.
Pseudo-nitzschia spp. were first recorded on the Scottish west coast (Isle of Skye and Sutherland) and around Shetland in early April. Similar to 2007, dense Pseudo-nitzschia concentrations were mostly absent in southwest Scotland and southern Argyll during 2008, although relatively less dense blooms appearing in Loch Striven in August and West Loch Tarbert in October did have some associated toxicity. The largest recorded Pseudo-nitzschia bloom was observed in NE Shetland in early June, with a cell density of > 2.8 million cells/\text{l}. An unusual bloom of \textit{P. subpacifica} was observed in Shetland in August. Pseudo-nitzschia concentrations of approx. 70,000 cells/l recorded in the Western Isles in early September resulted in ASP toxicity above permitted levels in shellfish.

\textit{Prorocentrum minimum} was frequently observed at Scottish monitoring sites during 2008, with blooms above background level first noted in Shetland, Orkney and the Isle of Skye in April. The largest recorded bloom occurred in Loch Roag in early June, with a density of >4 million cells/l. Maximum cell density of \textit{Prorocentrum lima} reached 340 cells/l in Colonsay in mid June. Large blooms of \textit{Karenia mikimotoi} were not observed during 2008. Cell densities were at their greatest in late August, with a maximum concentration of 140,140 cells/l recorded in Loch Stockinish (east coast - Harris). This bloom was first noted around St. Kilda in early August. \textit{Karenia} cell counts were at their maximum around Shetland in late September.

11.1.8 National Report - Finland

\textbf{Riitta Autio (with contribution from Seija Hällfors, Seppo Kaitala, Vivi Flemming-Lehtinen and Maija Huttunen)}

\textbf{Finnish Environment Institute Marine Centre}

The most important HAB –species in Finnish territorial waters in 2008 were the diazotrophic filamentous cyanobacteria \textit{Aphanizomenon} sp. (currently considered non-toxic in the Baltic Sea), \textit{Nodularia spumigena} (hepatotoxic), and \textit{Anabaena} spp. (neurotoxic). Besides these species, haptophyceans of the genus \textit{Chrysochromulina} (ichthyotoxic) were abundant and toxin producing dinoflagellates (\textit{Dinophysis acuminata}, \textit{D. norvegica}, \textit{D. rotundata}, \textit{Protoceratium reticulatum}, \textit{Alexandrium ostenfeldii}, \textit{Protoperidinium reticulatum}, \textit{Gonyaulax spinifera}) were observed throughout the growth season generally in small numbers.

In summer 2008, the most abundant blooms were predicted to occur in the central and western sections of the Gulf of Finland, the southern parts of the Archipelago Sea, and the southeastern and southern sections of the Baltic Sea. The prognosis is based on runs with the dimensional coupled physical-biological models. The amount of available phosphate and weather condition largely govern the development of the blooms. In 2008 phosphate concentrations were at normally high levels. However, cool and windy weather conditions prevailed during summer. These conditions are generally unfavourable for the development of surface scums and exceptionally large biomasses.

As a consequence of the prevailing weather conditions the cyanobacteria largely remained mixed into the water column and larger surface accumulations were mainly observed in late July 2008. Nevertheless, if the whole growth season is considered, the amount of cyanobacteria was substantial. During windy summers it is common for the dinoflagellate \textit{Heterocapsa triquetra} to be abundant. This was also the case this year in the archipelago of the western Gulf of Finland. Although the magnitude of cyanobacterial blooms varies considerably between years in different sea areas, there have
not been any significant changes in the intensity of the blooms over the last 12 years on a Baltic Sea-wide scale.

No toxic events were reported in 2008 of either humans or animals.

11.1.9 National Report - Spain

DSP and Yessotoxins

Catalonia

One month closure in the Ebro Delta bays in July-August associated with *D. caudata* (max. 1800 cell · L⁻¹) and further closures by the end of October caused by the former plus *D. sacculus*. Two closures were enforced in open waters after detection of positive results by mousse bioassay: one in July-August with the occurrence of *D. acuta*, *D. caudata*, *D. rotundata*, *D. sacculus* and *Protoceratium reticulatum*; the second closure in open waters, in November, was not associated to detection of toxigenic species.

Andalucía

DSP closures in Western Andalucía followed similar patterns than in previous years: Closures associated with *Dinophysis cf acuminata* (5840 cell · L⁻¹) in February and record numbers of *D. acuta* (> 12000) in July. Analyses of okadaates by LC-MS were implemented. Maximum levels of 4000 mcg OA equiv · kg⁻¹ were found in *Donax trunculus*.

Galicia

In the Northern rías (Rías Altas), intermittent closures were associated with *D. sacculus* + *D. acuminata* in spring-summer. There was a persistent bloom of *Lingulodinium polyedra* with no apparent harmful effects. It was a very mild year for the Rías Baixas concerning DSP toxins. There was a late initiation of *D. acuminata* by the end of May, and maximum concentrations (2900 cell · L⁻¹) were detected in early September during upwelling relaxation.

REDIBAL

A thematic network on harmful algae, REDIBAL, has been established to promote interaction among scientists, technicians, managers and other groups of interest in the Iberian Peninsula (www.redibal.es)

PSP

Catalonia:

Cell densities of *A. minutum* and *A. catenella* remained below trigger levels where a maximum of 39 µg eq-STX · 100 g⁻¹ were found in clams in April. *A. minutum* did not exceed 2 · 10³ cell · L⁻¹ in the bays of Ebro Delta, but dense blooms were observed in several harbours and beaches in the north, where *A. catenella* levels were lower than usual. Toxins remained below regulatory levels in shellfish areas.

Andalucía

*Gymnodinium catenatum* moderate blooms in the Mediterranean coast associated with local upwelling events. Maximum levels of 4800 cell l⁻¹ in January, and toxin levels of 12440 µg eq STX kg⁻¹ in cultivated mussels. Toxin levels in *Acanthocardia tuberculata*, a species with a high affinity for PSP toxins, were lower than usual. Moderate levels (1000 cell l⁻¹) of this species were found on the Western Atlantic coast of Andalucía after 5 years of absence.
Galicia

Very localized spring proliferation of *Alexandrium minutum* in the brackish Baiona Bay within the Ría de Vigo, with maximum levels of 11000 cell · l⁻¹. There were no PSP events caused by *Gymnodinium catenatum*

ASP

Catalonia

*Pseudo-nitzschia* spp. attained a maximum of 11.7 · 10⁶ cells l⁻¹ in October in Alfacs Bay where a bloom began in August and lasted until October. *Pseudo-nitzschia* spp. attained a maximum of 1.2 · 10⁶ cells l⁻¹ in Fangar Bay. Domoic acid was detected for the first time in shellfish meat from the growing areas of Catalonia. In smooth clams exceeded regulatory limits in February in open waters; the closure was not enforced because the shellfish area was in the 'biological rest' season.

Andalucía

High densities of *Pseudo-nitzschia cf delicatissima* (up to 6 · 10⁵ cell l⁻¹) in March-April in the Mediterranean coast, but levels of DA were above regulatory limits in only one sample. In the Atlantic coast, maximum levels of *P. australis* were 35760 cell l⁻¹ in May and levels of DA were below R.L. Some *Pecten maximus* beds, permanently closed because of their low exploitation and almost permanent levels of DA above R.L. exhibited lower concentrations than usual (13-61 mg DA kg⁻¹).

Galicia

Closures of mussel harvesting caused by *Pseudo-nitzschia* spp of one week in the Rías Altas by the end of March (3.5 · 10⁶ cell l⁻¹) and of two weeks in Ria de Vigo by the end of October (2.2 · 10⁶ cell l⁻¹)

Ichthyotoxins

*Karlodinium* spp. was present in the Ebro Delta (max 8000 cell/l) in low densities that did not cause any harmful effect.

Toxic aerosols

*Ostreopsis* spp. reached high levels (10⁴ cell · l⁻¹) in several beaches of the Costa Brava between July and September, but there were no reports of noxious effects in sunbathers.

Basque Country

Monitoring of ASP, DSP, and PSP toxins in wild mussels was carried out in the harvesting season between October and December. No reports of toxins levels above R.L. were given. Quarterly cruises are organized to study the distribution of potentially harmful species and other parameters to be measured according to the Water Directive.

Report presented by Beatriz Reguera (IEO, Spain) with information provided by regional monitoring programmes from the following institutions:

1) Andalucía. LCCRRPP. Fisheries and Agriculture Department from the Junta de Andalucía.

2) Basque Country. AZTI-SIO and University of the Basque Country, funded by the Basque Government.
3) Catalonia. Data provided by IRTA (Tarragona) and by ICMSIC (Barcelona) supported by the Agriculture and the Environmental Department, respectively, from the Generalitat de Cataluña.

4) Galicia. INTECMAR from the Fisheries and Maritime Affairs Department of the Xunta de Galicia.

11.1.10 National report- Norway

Einar Dahl

In 2008 the number of weekly monitoring stations for algal toxins in shellfish funded by the Norwegian Food Safety Authority was 45, covering the entire Norwegian coast.

ASP

There were no recordings of ASP-toxin (domoic acid) above regulatory levels in mussels along the Norwegian coast in 2008.

DSP

DSP-toxins were, as usual, detected above regulatory levels in mussels at some monitoring stations in southern Norway, while not at others. In total the problems due to DSP-toxins in southern Norway in 2008 turned out to be less than normal. One station, however, in the inner part of the Hardangerfjord at the west-coast, was closed for about 30 weeks due to presence of DSP-toxins in the mussels, and up to 2 000 microgram per kg mussel meat were recorded. In northern Norway, on the other hand, recordings of DSP-toxins in 2008 were more extensive, especially in the northernmost part. Up to about 350 microgram of DSP-toxins were recorded per kg mussel meat during October-November. The causative species was Dinophysys acuta, up to 160 cells per litre were found in the area.

PSP

Also occurrences of PSP-toxins in mussels are recurrent problems in Norway. In 2008 these problems were bigger in the southern Norway than the recent years. Most of the coastal stretch from the Swedish border to the Nord-Trøndelag county was hit, and up to 2 300 microgram per kg mussel meat was recorded. The problem was most extensive in April and May. In northern Norway problems due to PSP-toxins were less with respect to levels of toxins accumulated in the mussels, up to about 1 000 microgram per kg mussel meat was recorded, but at some stations the problem lasted from late April to mid August.

AZA (Azaspiracides)

At four monitoring station, along the west coast of Norway, Azaspiracides was detected at concentrations up to about 180 microgram per kg mussel meat in October, which is slightly above the regulatory level.

YTX (Yessotoxins)

Accumulation of yessotoxins in mussels, up to about 3 000 microgram per kg mussel meat, were detected at one monitoring stations at the west coast in the period July – November.
Ichthyotoxic events

Events of enhanced fish mortality in fish farms in northern Norway were reported at some few locations in mid-May, when the species Chrysochromulina leadbeateri was common. The mortalities were not very extensive.

12 Term of Reference I

12.1 Review the UK’s DEFRA funded literature and data analysis on HABs and nutrient enrichment. Identify follow up activities.

R. Gowen
AFBI, Northern Ireland

A summary of a UK funded project on the relationship between anthropogenic nutrient enrichment and HABs was presented to the group for discussion.

Anthropogenic nutrient enrichment of coastal waters is often invoked as a reason for the occurrence of harmful blooms of micro-algae and evidence of a link between harmful blooms and enrichment in some coastal waters is taken as evidence that a link exists in a wide range of coastal regions. This has led to the view that the occurrence of harmful algal blooms, diagnoses the undesirable consequence of enrichment and thus the occurrence of eutrophication as defined by the EC and OSPAR. A number of assumptions are involved in this view, and there is a clear need to examine the associated scientific arguments and evidence if HABs and the occurrence of harmful algae are to be used as indicators of eutrophic conditions and counter-indicators of ecosystem health. This study examined some of the evidence and scientific arguments. The objectives of the project were to (i) review the scientific literature on the putative link between the occurrence and magnitude of HABs and anthropogenic nutrient enrichment of coastal waters and (ii) investigate the relationship between nutrients and HABs and HAB species abundance by statistical analysis of data sets.

Based on a review of the scientific literature, the study concluded that the available data do not support the hypothesis that changes in the global occurrence of HABs is due to anthropogenic nutrient enrichment alone. There is evidence to support the HAB - nutrient enrichment hypothesis in some water bodies at the spatial scales of small regions of restricted exchange (e.g. Tolo Harbour Hong Kong) and regional seas (e.g. the Seto Inland Sea of Japan) but not in other water bodies with similar spatial scales. For many coastal regions attempts to relate trends in the occurrence of HABs to nutrient enrichment are confounded by increased monitoring effort and reporting of HABs during periods covered by time-series, the effects of climate change (e.g. the North Atlantic Oscillation Index and the El Niño Southern Oscillation) and the introduction and transfer of HAB species.

To further examine the HAB - nutrient enrichment hypothesis, data sets from UK and Irish coastal waters were compiled and used to test the hypothesis that the occurrence of HABs and HAB species abundance increases with anthropogenic nutrient enrichment (proxy: riverine loading and mean winter concentrations of nutrients). Preliminary results indicate that the distribution and abundance of HAB species in UK and Irish coastal waters is largely determined by the intersection between ecohydrodynamic conditions (those features of the physical, chemical and biological environment to which phytoplankters are adapted and which can differ between water bodies) and the ecophysiology of individual HAB species.
13 Term of Reference J

13.1 Review the publications in Journal of Sea Research from the ICES Workshop on Time-series data relevant to Eutrophication Ecological Quality Objectives (WKEUT)

Tim Wyatt
Instituto de Investigaciones Marinas, 36208 Vigo - Spain

The group, lead by Dr. Tim Wyatt, reviewed the manuscripts in the special issue of the Journal of Sea research as written by HAB researchers. Eutrophication or climate do not appear to have changed the structure for HABs. Most of the papers indicated that either there has not been a change or changes are so subtle that they are not obvious. Most of the authors have presumed that the European waters were pristine prior to the 1950. However, factors such as fishing, and marine mammals have impacted the environment nad therefore may have impacted the phytoplankton. It was noted that the CPR data was not included, but that data is not coastal.

This issue contains 14 papers which examine time series of inshore phytoplankton or chlorophyll in relation to environmental data, with particular attention to issues of anthropogenic eutrophication and climate variability. The collection is based on an ICES sponsored meeting held in Tisvildeleje, Denmark, 11–14 September 2006. The lengths of the time series range from about one to four to decades; some are based on sampling at a single station, others on more extensive collections (details in table). Uniquely here, a contribution by Dale provides a deeply thoughtful analysis by examining the same problems using sedimentary records, which can open windows scaled in centuries or millenia.

It seems to have been implicit initially that these data sets do contain significant signals, and that they can be identified and described. The general overall conclusion is much less clear, but several of the authors refer to the variability and the complexity of these data sets, features which muddy the recognition of unambiguous signals. For example, Martin points out that cell concentrations vary between stations and years by up to nearly six orders of magnitude (e.g., 5.7 for Myrionecta in the Bay of Fundy), and that 20-year data sets are not adequate to the questions posed. Henriksen makes the same point: “Quantitative data on phytoplankton composition in Danish waters date back to only 1979 and thus do not represent reference conditions”. Martin also writes, “Each species is ... unique, and parameters important to growth and sustainability of one organism do not apply to another”. This rather obvious point answers the query raised by Loebl in this collection, about “whether or not fixed parameters such as half-saturation constants for nutrients and light can be used over an annual period ... “. Obviously not!

Collectively, the broad range of well-known factors which potentially regulate phytoplankton dynamics are discussed in these papers, including temperature, wind speed, water column stability, turbulence, nutrients, grazing, flushing rate, runoff, competition, the North Atlantic Oscillation, and regime shifts. It is widely recognized here that changes in light availability can alter chlorophyll levels while stock remains unchanged, that high winter temperatures might lead to earlier grazing pressure in spring, hence lower stocks, and so on - there is no shortage of ad hoc hypotheses.

Other factors which might have impacted the phytoplankton communities studied here on decadal time scales, such as introduced species and fishing, are for the most part not considered. The only possibly introduced species recorded here are an ich-
thyotoxic *Chattonella* sp (now *Verrucophora farcimen*) which first appeared in 1998, and has been abundant seasonally since, and *Gymnodinium chlorophorum* which formed a dense bloom in 1999, both these in Danish waters (Henriksen). There has also been a decreasing trend in phytoplankton biomass in Danish waters (Henriksen). Significant declines are recorded in the abundance of *Chaetoceros*, particularly *C. socialis*, in the short Stonehaven series after 2002 (Bresnan), and in *Skeletonema* spp at the Narragansett Bay station (Borkman).

There is perhaps a consensus here that coastal waters were on the whole ‘pristine’ as recently as the 1950s, despite the enormous reductions of biomass from virgin levels known already to have taken place by that time in other components of the food web of the food web (elasmobranchs, fish, birds, mammals) in some ICES areas. Given that, and the widespread view that since then anthropogenic eutrophication has had a strong, even dominant, impact on phytoplankton ecology, several of these papers contain surprising statements, such as the following:

- “the dominant species a century ago were still among the dominant species during 1979-2006.” – Henriksen, Danish waters
- “dominant spring bloom species … concur with historic reports from this area” (back to 1969) – Bresnan, East Scottish waters
- “HABs are not related to eutrophication of the Mediterranean zone” – Collos, Thau & Leucate lagoons in southern France
- “in the *Phaeocystis*-dominated ecosystem of the BCZ [Belgian Coastal Zone], the sustained pressure of anthropogenic nutrients has not modified substantially the structure and function of the ecosystem” – Lancelot, refers to period since 1950s
- “One station … did not produce patterns in taxonomic group similarities that were consistent with known nutrient loadings and biomass trends.” – Dixon, Tampa Bay and Charlotte Harbour, Florida
- “Even with sophisticated statistical analysis no clear relation between abundance and environmental variables such as nutrients, temperature, etc, could be found.” and
  “… the spatial distribution of *Phaeocystis* in the North Sea has remained essentially unchanged over the past 50 years. *Phaeocystis* shows almost the same phenology in both periods.” – Baretta-Bekker, Dutch coastal waters

Some conclusions of the original WKEUT Report on this meeting (ICES CM 2006/ACE: 07), were:

1. that the time series data presented were adequate to detect the effects of eutrophication on phytoplankton dynamics at these fifteen localities;
2. that neither the intensity nor species of harmful or high biomass blooms are linked to eutrophication or to altered nutrient ratios at these locations, with the exception of Belgian coastal waters;
3. that these data sets are too short to evaluate the effects of climate change on phytoplankton dynamics, but that the NAO has a significant impact on short time scales;

This reviewer concludes:

If point i) is accepted, that the data are adequate to test the hypothesis, then the long-standing *agricultural hypothesis* which basically maintains that increased nutrient
puts result in higher phytoplankton stocks should be abandoned; whatever role eutrophication may play in phytoplankton dynamics, it cannot be considered the dominant one, at least not on the basis of these analyses. Point ii) reinforces this view, and indicates that quite different kinds of models need to be explored to account for exceptional phytoplankton blooms. It is a frequently repeated assertion that nutrient enrichment and changing nutrient ratios lead to an increase in HABs; it is important to emphasize that this view finds little support from this collection of papers.

Thus, despite major changes in the waters of several coastal areas in the ICES region caused by human activities, and on the basis of conventional sampling and monitoring protocols, no clear cut signals are detectable in the phytoplankton composition and dynamics of these areas, nor any which are distinguishable from changes in other areas relatively unaffected by such impacts. Similarly, there do not appear to be any obvious signals in these time series which can be clearly attributed to climate variability. These conclusions reinforce the value Dale’s approach to the same questions based on sediment cores, in which, although only the preservable components of the phytoplankton community are accessible for analysis, clear-cut signals attributable to anthropogenic impacts and to climate variations are detectable. The integration by sedimentary processes of the variability and complexity mentioned earlier is clearly advantageous when searching for patterns in very noisy ecological processes.

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References:
14  Term of Reference K

14.1 Steering Group on Climate Change

The objectives of the Steering Group on Climate Change in ICES is to look at the re-
search, services and operational issues, related to Climate Change supported by ICES
in their expert groups, to assess the quality and adequacy of the assessment process,
and to manage the start up transit of ICES toward the establishment of a programme
in Climate Change.

A medium term (end of 2010) objective of SGCC is to prepare a white paper (or ICES
Position Paper) detailing current knowledge about the effects of climate change on
the physical oceanographic properties of the ICES ocean areas and lower and higher
level trophic responses to change, and directions that research and education should
proceed in order to better understand and anticipate climate change effects on the
marine environment.

A Steering Group meeting was held in ICES HQ on 3 June 2009 to continue progress
towards the preparation of this position paper. WGHABD will contribute to this pa-
er in the area of Climate Change and HABs. The working group has a draft already
in preparation and will be worked on intersessionally.

15  Recommendations

15.1 WGHABD and WGPBI wish to jointly propose a Special Theme Session on
Harmful Algal Blooms and Modelling for the 2010 or 2011 Annual Science
Conference.

Physics and biology in modelling harmful algal blooms (HABs): validation and ap-
plication for forecasting and climate change

Rationale

Harmful Algal Blooms (HABs) are of great concern because of their toxicity and/or
the damage they cause to ecosystems and coastal resources. Toxic HAB events in
aquaculture can have adverse effects on economy (fish or shellfish mortality) and
public health (human disease, mortality) and high-biomass, non-toxic blooms can
affect water quality and tourism. Aquaculture and tourism are mainly located in
coastal zones that can be affected by eutrophication, sometimes cited as a cause of
HABs. Amongst the challenges related to HABs we can cite the need to: (i) under-
stand the physiological/biological/environmental factors that regulate HABs and in
particular the underlying physical/biological interactions that are the most important,
(ii) forecast HAB events and (iii) assess the impact of climate change on HABs (occur-
rence/frequency/magnitude). Models, providing that they are carefully validated and
adapted to the situation (region/species), are necessary tools for forecasting, assessing
the impact of future scenarios and for process studies. The development of HAB
models requires interdisciplinary (biological, chemical, and physical) research. Strong
interaction between modellers and experimentalists is crucial and data availability
essential. Recognizing the rapid progress in HAB modelling in recent years, we invite
contributions of modelling studies, laboratory and experimental research, field stud-
ies and remote sensing investigations that advance our ability to understand underly-
ing physical/biological interactions that control HABs, to improve HAB model
validation, to forecast HAB events, or to assess effect of climate change.
Conveners:
Donald M. Anderson, Woods Hole Oceanographic Institution, USA, e-mail: dander-son@whoi.edu
Geneviève Lacroix, Management Unit of the North Sea Mathematical Models, Royal Belgian Institute of Natural Sciences, BE, e-mail: G.Lacroix@mumm.ac.be

15.2 WGHABD wish to jointly propose a Special Theme Session on Harmful Algal Blooms in the Baltic Sea for the 2010 Annual Science Conference.

Rationale
Harmful Algal Blooms (HABs) have effects on the whole ecosystem in the Baltic Sea. Observations of known and entirely new types of HABs in the Baltic have inspired studies on the ecology and oceanography of the blooms and their effects on other trophic levels. The introduction(s) of new gelatinous zooplankton species (ctenophores Mnemiopsis leidyi and Mertensia ovum) are likely to have effects on the structure of the plankton community including HAB species.

In the Baltic Sea blooms of nitrogen fixing cyanobacteria that form surface accumulations have been a recurrent phenomenon for a long time. The blooms are connected to increased phosphate concentrations which in turn may be related to the release of phosphate from sediment in hypoxic deep basins. These blooms, which include toxic species, are of great concern to the public and affect the regions tourism in summer. A new phenomenon in the Baltic in the recent years is small scale blooms of the dinoflagellate Alexandrium ostenfeldii which has been shown to produce paralytic shellfish toxins (PST) in the area. The toxins may accumulate in the food chain and can be a danger to humans. Other toxin producing dinoflagellates in the Baltic include the genus Dinophysis. Members of this mixotrophic genus produce diarrhetic shellfish toxins (DST). Recently a breakthrough in the investigations of the ecology of Dinophysis has been made since it is now possible to maintain it in laboratory culture. Blooms formed by dinoflagellates are elusive; they often occur in thin layers and have a strong physical regulatory component in addition to the complex biology of the organisms.

The fish killing species Pseudochattonella farcimen (Dictyochophyceae) has formed blooms in the southern Baltic Proper during the last few years. This organism was first observed in the eastern North Sea-Skagerrak-Kattegat in 1998 where it subsequently has become an established species. It has affected fish farms in the Danish part of the Kattegat in a few occasions. In 2008 and 2009 persistent winter blooms of the harmful species Chrysochromulina polylepis (Haptophyta) were observed in the Baltic Proper. No harmful effects were reported. This species formed a devastating bloom in the Skagerrak-Kattegat area in 1988 but no blooms have been observed in the Baltic up until the last few years.

Climate change may influence the future frequency and types of Harmful Algal Blooms affecting the Baltic. Changed temperature, salinity and input of nutrients, humic substances etc. as well as changes in turbulence conditions will influence the plankton community structure. Also possible changes in the carbonate system (pCO₂, alkalinity and pH) may have effects. Scientists in the Baltic Sea area have been forerunners in the use of ships of opportunity and satellites to observe HABs. Recent developments include new sensors and the inclusion of new types of sensor platforms.

Focus of session
- Ecology and oceanography of HABs in the Baltic Sea area
- Introduced species – effects on pelagic ecosystem structure including HABs
- Bioactive compounds produced by harmful algae - their biotransformation (including food chain transport and biodegradation) and effect on other trophic levels
- Climate change effects of HABs
- Eutrophication effects on HABs
- Automated HAB observing systems – results and new technology
- HAB forecasting

**Conveners:**
Bengt Karlson  
bengt.karlson@smhi.se  
Swedish Meteorological and Hydrological Institute  
Research & Development, Oceanography  
Sweden

Emil Vahtera  
evahtera@whoi.edu  
Woods Hole Oceanographic Institution  
Department of Biology  
USA

### 15.3 Cooperative research report on HABs in the ICES Area

Improvements in monitoring capacity as well as technological advances has meant there is a requirement for a more up to date cooperative research report on the HABs and phytoplankton toxins in the ICES area. The WG was in agreement that this would be a useful document that would be of value to scientists and agencies responsible for the implementation of monitoring programmes. Most of the report would be produced intersessionally and chapter leads were identified. The nominated people will bring chapters and data with them to the next WGHABD meeting where the report will be assembled and edited. Chapter headings and responsible persons are listed below:

**Proposed Chapters of Cooperative research report:**

1. Introduction and definitions (Richard Gowen, UK)
2. Harmful species (Beatriz Reguera, Spain)
3. Monitoring: country by country basis (Per Anderson, Denmark)
4. Management strategies: country by country basis (Don Anderson, USA)
5. Predicting occurrence (Patrick Gentian, France)
6. Detection and quantification of algal toxins (Allan Cembella, Germany)
7. Extended country report over the last ten years (Richard Gowen, UK)

### 16 Closing of the meeting

The Chair thanked the local host and his team for their hospitality and generosity. He also thanked the participants for their input especially the rapporteurs and the editing rapporteur and closed the meeting on Thursday, 19:00 hours.
### Annex 1: List of participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Phone/Fax</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amselmo, Tonia</td>
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<tr>
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</tr>
<tr>
<td>Country</td>
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<td>8150-052 S. Bras de Alportel</td>
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<td>Portugal</td>
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<td>Instituto Investiçaciones Marinas,</td>
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<td>36208 Vigo, Spain</td>
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Annex 2: Agenda

30 March
Opening of Meeting
Adoption of the Terms of Reference
Housekeeping Matters
Terms of Reference A-D
- Review and update of JAMP eutrophication and monitoring guidelines
- Review Updated on HAEDAT and MONDAT Data Base
- State of maintenance and senescence of cyanobacteria blooms, including transfer of toxins and effects on the foodweb
- Discuss and formulate the description and justification for a thematic session on HABs in the Baltic Sea for the 2010 ASC

31 March
Terms of reference E-H
- Discussions around the identification of requirements for observing specific Toxin Producing Algae and HAB species in near real time using automated
- Discussions prior to joint interdisciplinary day with WGPBI
- New findings that pertain to harmful algal bloom dynamics
- National reports (Country Reps)
Tour of local HABs monitoring Laboratory “Laboratorio de Control de Calidad de los Recursos Pesqueros” in Punta Umbria

1 April
Joint Meeting with WGPBI.

2 April
Terms of Reference I – K
- Review the UK’s DEFRA funded literature and data analysis on HABS and nutrient enrichment
- Review the publications in Journal of Sea Research from the ICES Workshop on time-series Data Relevant to Eutrophication Ecological Quality Objectives (WKEUT)
- Prepare draft/outline Climate Change report for consideration of SGCC at spring meeting 2009
Drafting Report
Discussion regarding ToRs for 2010
Closing of Meeting
Annex 3: Draft resolution for the 2010 meeting

The ICES - IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD), chaired by Joe Silke, Ireland, will meet in Bermuda on 6–10 April 2010 to:

a) Assess national reports submitted to HAEDAT and review
b) Collate and submit on-line National reports no later than 1 February 2010 national reports 2002–2009 for HAEDAT, review at working group
c) Review and assess the information compiled in the updated ICES-IOC database on HAB monitoring systems, MONDAT
d) Discuss and formulate the description and justification for a thematic session on HABs and Modelling for the 2010 ASC.
e) Review the draft chapters for the cooperative research report
f) Present any relevant information from compilation of data for cooperative research report
g) Review the strategies being used to identify, enumerate, and otherwise investigate the life history stages of HAB species, and the information obtained from such efforts
h) Discuss new findings that pertain to harmful algal bloom dynamics. Bring new findings in phytoplankton population dynamics models to the attention of WGHABD for discussion.
i) Climate Change... review submissions to SGCC

WGHABD will report by 11 May 2010 for the attention of the SCICOM.

Supporting information

<table>
<thead>
<tr>
<th>Priority</th>
<th>Scientific justification and relation to action plan</th>
</tr>
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<tr>
<td></td>
<td>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.</td>
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<thead>
<tr>
<th>Term of Reference a)</th>
<th>National Presentations and review occurrences of HABs in the ICES area, making use of the HADAT system.</th>
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<td>Term of Reference b)</td>
<td>The HAEDAT system is due to be populated to catch up on lost years while it was undergoing database re-design. The working group will assess Status for upload of all records 2002-2009; Status of quality assurance of HAEDAT records prior to 2002; New decadal maps based on HAEDAT data</td>
</tr>
<tr>
<td>Term of Reference c)</td>
<td>The IOC MONDAT database contains valuable information on national HAB monitoring practices. The database will be reviewed and the paper based questionnaire which is used to gather the data examined for potential improvements.</td>
</tr>
<tr>
<td>Term of Reference d)</td>
<td>A thematic session on HABs and Modelling for the 2010 ASC has been proposed jointly with WGPBI. Details of the session will be discussed and information regarding participants/abstracts presented. Potential for future collaborations in this area stemming from this theme session will be explored.</td>
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Term of Reference e)
Assigned lead editors for the proposed cooperative research report on HABs in the ICES area chapters will present the outlines/drafts of their work in progress for discussion at the Working group. Editorial and drafting session will be convened during the course of the working group meeting.

Term of Reference f)
Members of the working group are asked to collaborate and engage in the process of crafting the Cooperative Research Report on HABs in the ICES area. Where data is identified as being important and available, the working group will jointly assess the data and how to best prepare and summarise this in the report. Members with access to relevant data are encouraged to present data holdings.

Term of Reference g)
It is well established that life history stages are critically important in the population dynamics of many HAB species, particularly those that form cysts or other resting stages. Unfortunately, our ability to identify these stages or to enumerate them or study their specific dynamics or physiology are quite limited. New techniques are being developed to accomplish these objectives, and there is thus great value in reviewing the methods being used or developed, and to explore the extent to which these methods can be transferred to other workers, or applied to other HAB species. A realistic model of a phytoplankton population should take into account all the life stages encountered by this same population as well as transitions. As an example, rate of production of gametes and the duration of this stage are essential to estimate a realistic encounter rate. Likely, duration of the free-swimming phase for planozygotes will determine the dispersal of cysts (analogous to the “seed-shadow” for terrestrial plants). In order to produce realistic biological models, it is essential to validate in situ results from laboratory experiments. Methods to identify and quantify different stages of the life cycle of a given species are urgently needed in order to allow a proper validation of assumptions made in the elaboration of population dynamics models.

Term of Reference i)
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 ongoing term of reference.

Term of Reference i)
The Steering Group on Climate Change (SGCC) are in the process of drafting a white paper on Climate Change. WGHABD will work intersessionally to prepare a submission on Climate Change and HABs. This will be discussed at the working group and any last changes to the draft will be made and submitted to the SGCC.

<table>
<thead>
<tr>
<th>Resource Requirements</th>
<th>The research programmes 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.</th>
</tr>
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<tbody>
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<td>Participants</td>
<td>The Group is normally attended by some 20-25 members and guests</td>
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<tr>
<td>Secretariat Facilities</td>
<td>None</td>
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<tr>
<td>Financial</td>
<td>No financial implications</td>
</tr>
<tr>
<td>Linkages to Advisory Committees</td>
<td>There are no obvious direct linkages with the advisory committees</td>
</tr>
<tr>
<td>Linkages to other committees or groups</td>
<td>WGHABD interacts with WGZE, WGPE, WGPBI.</td>
</tr>
<tr>
<td>Linkages to other groups</td>
<td>The work of this group is undertaken in close collaboration with the IOC HAB</td>
</tr>
</tbody>
</table>
organisations 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.

<table>
<thead>
<tr>
<th>Secretariat marginal</th>
<th>ICES Costs</th>
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Annex 4: Theme session proposal for ASC 2010

The ICES - IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) propose a Theme Session for the 2010 Annual Science Conference:

**Title:** Harmful Algal Blooms in the Baltic Sea

**Conveners:** Bengt Karlson (Sweden), Emil Vahtera (USA)

**Description:** Harmful Algal Blooms (HABs) have effects on the whole ecosystem in the Baltic Sea. Observations of known and entirely new types of HABs in the Baltic have inspired studies on the ecology and oceanography of the blooms and their effects on other trophic levels. The introduction(s) of new gelatinous zooplankton species (ctenophores *Mnemiopsis leidyi* and *Mertensia ovum*) are likely to have effects on the structure of the plankton community including HAB species.

In the Baltic Sea blooms of nitrogen fixing cyanobacteria that form surface accumulations have been a recurrent phenomenon for a long time. The blooms are connected to increased phosphate concentrations which in turn may be related to the release of phosphate from sediment in hypoxic deep basins. These blooms, which include toxic species, are of great concern to the public and affect the regions tourism in summer. A new phenomenon in the Baltic in the recent years is small scale blooms of the dinoflagellate *Alexandrium ostenfeldii* which has been shown to produce paralytic shellfish toxins (PST) in the area. The toxins may accumulate in the food chain and can be a danger to humans. Other toxin producing dinoflagellates in the Baltic include the genus *Dinophysis*. Members of this mixotrophic genus produce diarrhetic shellfish toxins (DST). Recently a breakthrough in the investigations of the ecology of *Dinophysis* has been made since it is now possible to maintain it in laboratory culture. Blooms formed by dinoflagellates are elusive; they often occur in thin layers and have a strong physical regulatory component in addition to the complex biology of the organisms.

The fish killing species *Pseudochattonella farcimen* (Dictyochophyceae) has formed blooms in the southern Baltic Proper during the last few years. This organism was first observed in the eastern North Sea-Skagerrak-Kattegat in 1998 where it subsequently has become an established species. It has affected fish farms in the Danish part of the Kattegat in a few occasions. In 2008 and 2009 persistent winter blooms of the harmful species *Chrysochromulina polylepis* (Haptophyta) were observed in the Baltic Proper. No harmful effects were reported. This species formed a devastating bloom in the Skagerrak-Kattegat area in 1988 but no blooms have been observed in the Baltic up until the last few years.

Climate change may influence the future frequency and types of Harmful Algal Blooms affecting the Baltic. Changed temperature, salinity and input of nutrients, humic substances etc. as well as changes in turbulence conditions will influence the plankton community structure. Also possible changes in the carbonate system (pCO₂, alkalinity and pH) may have effects. Scientists in the Baltic Sea area have been forerunners in the use of ships of opportunity and satellites to observe HABs. Recent developments include new sensors and the inclusion of new types of sensor platforms.

**Focus of session**

- Ecology and oceanography of HABs in the Baltic Sea area
- Introduced species – effects on pelagic ecosystem structure including HABs
• Bioactive compounds produced by harmful algae - their biotransformation (including food chain transport and biodegradation) and effect on other trophic levels
• Climate change effects of HABs
• Eutrophication effects on HABs
• Automated HAB observing systems – results and new technology
• HAB forecasting
Annex 5: Draft Resolution for an ICES Internal Publication

Cooperative research report on HABs in the ICES Area

Improvements in monitoring capacity as well as technological advances has meant there is a requirement for a more up to date cooperative research report on HABs and phytoplankton toxins in the ICES area. The previous Cooperative Research Report (No 181 Effects of Harmful Algal Blooms on Mariculture and Marine Fisheries) was published in 1992, and the Working Group on Harmful Algal Bloom Dynamics have identified a requirement to produce an updated document to report on our current status and knowledge on HABs and their impacts, and associated monitoring and management strategies.

The Working Group on Harmful Algal Bloom Dynamics will work on production of this report and agree to submit the final draft of the proposed publication by Dec 31 2010

Supporting information

<table>
<thead>
<tr>
<th>Priority:</th>
<th>This has a high priority for various reasons. Each of the ICES member state has recorded harmful impacts due to the presence of various harmful algae. These range from fish kills in open water and human illness from toxin producing algae to water discolouration and fish net clogging from high biomass blooms. The Working Group on Harmful Algal Bloom Dynamics was in agreement that a Cooperative Research Report would be of value to scientists and agencies responsible for the implementation of monitoring programmes as a summary of the current status of impact, monitoring and management strategies across the ICES area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific justification:</td>
<td>The proposed ICES Cooperative Research Report represents a synthesis of the most recent scientific work, monitoring and management strategies and detection and quantification techniques of the various toxin producing and other harmful algae. Since the previous cooperative research report on this topic (No 181 Effects of Harmful Algal Blooms on Mariculture and Marine Fisheries. 1992) there have been several changes observed including an extension in occurrence and types of HAB events. Therefore, increased attention must be paid to expanding and improving initiatives to monitor, detect and share information on harmful algal occurrence in order to reduce the public health risks associated with these events.</td>
</tr>
<tr>
<td>Resource requirements:</td>
<td>Most of this report would be produced intersessionally and chapter lead authors have been identified. The nominated people will bring chapters and data with them to the 2010 WGHABD meeting where the report will be assembled and edited. The estimated number of pages is 100. The material in the report is fairly straightforward, and therefore no specific additional costs are necessary.</td>
</tr>
<tr>
<td>Participants:</td>
<td>Approximately one month's work is required by the editor to finalise this draft.</td>
</tr>
<tr>
<td>Secretariat facilities:</td>
<td>About one month of the services of Secretariat Professional and General Staff will be required.</td>
</tr>
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<td>Financial:</td>
<td>Cost of production and publication of a 100 page CRR/TIMES.</td>
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<tr>
<td>Linkages to advisory committees:</td>
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<td>Linkages to other committees or groups:</td>
<td>None.</td>
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<td>Linkages to other organizations:</td>
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Annex 6: Technical minutes of the JAMP Review Group related to the WGHABD 2009 report

Review group: Jarle Klungsøyr (Chair), Lars Edler, Jose Fumega, Carlos Vale, Ian Davies, Francis O’Beirn

Expert groups involved: WGMS, MCWG, WGHABD, BEWG, SGIMC


Given that the JAMP Monitoring Eutrophication Monitoring Guidelines for nutrients, oxygen, benthos, phytoplankton and chlorophyll are now over 10 years old, there is a need to review, and where required update, the guidelines to reflect technical developments, best practice and to ensure that the guidance remains fit-for-purpose. The purpose is to support the monitoring of these parameters for the assessment of eutrophication under the Comprehensive Procedure and, more generally, for WFD and MSFD monitoring. The request to ICES has two aims:

a) add more specifications in the current guidelines which includes not only listing different possibilities on analysis but also expressing the most commonly used method if it comes to a choice between different methods and prioritise recommended methods and illustrating best practice so it should be more clear which option to go for as a priority.

b) add standards and protocols to be used for developing techniques that have not been used as a standard parameter but have recognised added value to support assessments from a more general validation perspective to complement ship-borne measurements.

For each parameter further clarification in the guidelines is needed on the aspects set out below:

Inorganic/organic nitrogen:

a) advice on the period and frequency of sampling to have an accurate idea on winter nutrient concentrations

b) a more detailed explanation of contamination risks during sampling and analysis and appropriate temperatures and duration of preservation

c) standards and protocols for moored instrumentation

d) standards and protocols for satellite assessments to complement ship-based measurements

Biomass of phytoplankton: chlorophyll a

a) advice on the kind of analysis to be performed on chlorophyll a (advantages and disadvantages of acidification procedure)

b) advice on the type of chlorophyll a most suitable to report on (total, active, Phaeophytin)

c) required frequency of sampling for accurate estimate of mean and 90th percentiles during growing season (study of Sweden)
Oxygen:

a) a more detailed explanation of contamination risks during sampling and analysis and appropriate temperatures and duration of preservation needs to be included

b) advantages of developing sampling methodology and analysis needs to be included

c) recommendations on accurate analysis of trends (decreased concentration, increased frequency of low O2 concentration, increased consumption rate)

Benthic community structure:

a) advice on monitoring of sufficient surface should be included (advantages of sampling with different devices: Van Veen grab, Reineck boxcore, others)

b) advice on fixation should be added: different fixation mechanisms are in place, like fixation before and after sieving the samples, including advice on staining

c) monitoring of zoobenthos should be done in accordance to ISO 16665 at accredited laboratories or laboratories that can show to perform on this basis

d) advice on calculating biomass of benthos.

Inorganic/organic nitrogen:

a) advice on the period and frequency of sampling to have an accurate idea on winter nutrient concentrations

b) a more detailed explanation of contamination risks during sampling and analysis and appropriate temperatures and duration of preservation

c) standards and protocols for moored instrumentation

d) standards and protocols for satellite assessments to complement ship-based measurements

Comments by RG:

The MCWG 2009, Annex 13 is an updated “Revised guideline for monitoring nutrients/JAMP Eutrophication Monitoring Guidelines: Nutrients”. It covers in a general way the advice on the period and frequency of sampling to have an accurate idea on winter nutrient concentrations. This may be as far as one can go when not having detailed station positions and the detailed hydrographic knowledge. Sampling frequency is not specified and this is probably because it has to do with the region surveyed. Moreover, there may be changes from one year to another, e.g. winter blooms of phytoplankton may occur at a time when it is normally a phytoplankton minimum. However, it should in principle be possible to define reasonable well sampling periods and frequencies for different parts of the Convention area for the measurement of winter nutrient concentrations. No discussion has been made by MCWG of how “accurate idea of winter nutrient concentrations” could be interpreted, and what reliability might be placed on the results.

The new guideline text giving explanation of contamination risks during sampling and analysis and appropriate temperatures and duration of preservation has been expanded and developed from the previous text.
The text on standards and protocols for moored instrumentation needs to be developed further but the revised guideline does not answer this question. There is nothing about standards and little that could be described as a protocol. The text frequently refers to ferrybox technology, but the question refers to moored instruments. There is no text about standards and protocols for satellite assessments to complement ship-based measurements satellites.

WGHABD 2009 provides some new text on analysis of biomass of phytoplankton and analysis of chlorophyll a and/or other phytoplankton pigments. The report states that “OSPAR needs to decide the overall purpose of monitoring chlorophyll.” The requested advice on what kind of analysis to be performed on chlorophyll a (advantages and disadvantages of acidification procedure have not been provided. Further on they have not given clear advice on what form of chlorophyll should be reported.

WGHABD 2009 has suggested changes of the guidelines for Chlorophyll monitoring. All suggestions are appropriate and useful. However, there is a need for a clear statement on what kind of Chlorophyll that should be measured and reported. It is advisable that all contracting parties use the same. This may on the other hand pose a problem for the evaluation of existing long time series.

The new guideline informs about the fluorescence method only and nothing about spectrophotometric methods, which a number of laboratories still use. It is suggested that filters together with extraction solvent can be stored deep frozen. Obviously filters – before extraction – should not be stored deep frozen. This statement is unclear and needs an explanation.

It is stated that the sampling frequency is difficult to give detailed advice on. Considering the short generation time of phytoplankton a very high sampling frequency is needed to cover the succession and development of the phytoplankton communities. Knowing the area you work in will help optimize the sampling frequency.

The section dealing with additional microscopical quantitative and qualitative analysis of phytoplankton is very important and should be more highlighted. The methods used by HELCOM with biovolume estimation can be consulted.

The statistical 90 percentile method is probably a good suggestion, but it should be more elaborated.

A more detailed explanation of contamination risks during sampling and analysis for oxygen and appropriate temperatures and duration of preservation have been provided and the text is adequate.

The question on advantages of developing sampling methodology and analysis is not very clear, but it may be covered by the comments regarding oxygen probes. This needs clarification.

OSPAR asked for recommendations on accurate analysis of trends (decreased concentration, increased frequency of low O2 concentration, increased consumption rate). This question has only partly been addressed. It is a mixed question on data structures and statistical analysis methods for detection of trends. The text makes no reference to sampling schemes to detect changes in the frequency of low dissolved oxygen events. It makes limited reference to oxygen consumption rates, but RG is not sure that the question refers to dissolved oxygen consumption measurements in the field, or to BOD measurements. RG concludes that the text is improved, and should be offered to OSPAR, but that it should be accompanied by questions seeking clarifi-
cation on whether the WG has correctly interpreted and adequately answered points b) and c).

BEWG 2008 and 2009 has reviewed and amended new JAMP monitoring guidelines on benthos.

Technical Annex 1 (hard bottom zoo and phytobenthos etc.) gives comprehensive descriptions of sampling strategies and methods given along with many relevant references. In Technical Annex 2 on soft bottom macrozoobenthos comprehensive details on sampler use is not given. However, there are many references to published work dealing with the advantages of using specific samplers.

Good advice is presented on phytobenthic fixation and preservation. Again, references only for fixing zoobenthos but these papers contain all adequate information on this topic.

ISO 16665 is mentioned in the Guideline introduction. Further detail on general QA is given in Item 8. The text does not stipulate that monitoring of zoobenthos should be done in accordance to ISO 16665 at accredited laboratories or laboratories that can show to perform on this basis, as indicated in the task from OSPAR.

References to calculating soft bottom benthic biomass are very brief and not informative. They amount to “Procedures for the sorting and biomass determination of soft-bottom macrozoobenthos samples are at sections 3.4 and 3.5 of Rumohr (2009).” in the Analytical procedures section of Technical Annex 2. In view of the direct question from OSPAR, it would have been better to be more explanatory.

Overall, the revised Guidelines answer the questions asked by OSPAR, with the possible exception of the soft bottom biomass calculation methods. However, the whole document depends very heavily on the readers having access to quite a wide range of literature. If it is intended that the document should stand alone and be complete in itself, it fails this requirement.