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10–13 April 2007

Riga, Latvia

International Council for the Exploration of the Sea

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Contents

Executive Summary

Highlights

- Reviewed the 2006 WGHABD Report;
- Reviewed the outcome of the WKEUT workshop on long term data sets and eutrophication;
- Reviewed the progress and analysis REGNS North Sea group have made;
- Carried out a Group Self assessment;
- Discussed new findings that pertain to Harmful Algal Bloom Dynamics;
- Reviewed the online HAEDAT format;
- Discussed the structure and composition of the decadal HAE MAPS;
- Collated and discussed the National HAB Reports.

Discussed and reviewed progress by PGPYME in developing the mission and draft resolutions for a new Expert Group on phytoplankton and microbial ecology.

There were eight presentations made by the group to report new findings in the area of HAB dynamics. These included signs of declining phytoplankton biomass measured by Chlorophyll a in summer/autumn periods along the Norwegian coast associated with a lower abundance of large dinoflagellates such as the Ceratium species. This has been observed over the past five years but whether it is a short term or permanent feature is as yet unclear. The group also received and discussed updates of the work carried out in the Gulf of Maine in the USA including the quantitative role of cysts in *Alexandrium* dynamics in the Gulf, and progress in modelling and forecasting. This novel work has demonstrated the possibility of providing near real time maps of cell distributions of *Alexandrium fundyense* based on cyst distributions measured the previous autumn. This has progressed through making model runs of Gulf current trajectories and associated *A. fundyense* transport, and thereby may provide valuable information to shellfish regulators and industry management.

These ongoing developments in modelling interactions between the physical and biological systems were noted by the group as key essential parameters to further the understanding of the dynamic nature of HABs. It was also noted that while WGHABD has a lot of biological expertise it would benefit from more numerical and physical oceanographic input. It was proposed that contact with WGPBI would be initiated and the possibility for joint working group activities in the near future be investigated.

Analysis of *A. fundyense* in the Bay of Fundy was shown not to be directly associated with the intensity of the following years cell density, and there are years of high and low concentration not related to the previous year. Also the relationship with nutrients was not positively correlated at normal cell densities. Preliminary analysis showed that *A. fundyense* appeared to be more climate related. Other issues in this region include periodic *Eucampia zoodiacus* blooms that can impact on salmon farms. These have only been observed post 1999, indicating a shift towards more amenable conditions for this species after this date.

The publication during 2006 of the first establishment of *Dinophysis acuminata* cultures promises to improve our knowledge of the dinoflagellate in terms of ecophysiology, life history, toxicology, and evolution of the plastids in members of this genus. Cultivation of *D. acuminata* in this study solves a major bottleneck in this research and these findings will allow laboratories around the world to expand research efforts on this cosmopolitan species.

A spatially and temporally extensive bloom of *Karenia mikimotoi* was reported from Scotland in 2006. While the reasons for the development of the 2006 bloom remain unclear it is possible that remnants of the 2005 Irish *K. mikimotoi* bloom reported in the WGHABD 2006 report were able to over winter on the shelf to provide the seed population. The unusually warm summer and resultant elevated sea temperatures and favourable winds may then have provided suitable conditions for bloom development and subsequent advection to the Scottish coast in 2006.

The progress of the IOC-ICES-PICES HAEDAT and HAEMAPS continue to develop. Since the 2006 meeting the HAEDAT system was revised made possible by funding received through the US National Atmospheric and Oceanographic Administration. Continuing testing and revisions will continue intersessionally. The HAEMAPS decadal maps maintained by IFREMER on behalf of WGHABD are also being revised with linkages built to HAEDAT. This will provide more accurate and up to date information based on the current information provided by members to the HAEDAT system.

A summary of the Terms of Reference for the 2007 meeting is given in Section 2 of this report. All TORs were addressed and are summarised in this report. The IOC-ICES WGHABD proposes to meet in 2008 from 10 to 13 March 2008 in the Marine Institute, Oranmore, Co. Galway, Ireland.

1 Welcome and opening of the meeting

The **ICES-IOC Working Group on Harmful Algal Bloom Dynamics** meeting for 2007 was hosted by the Institute of Aquatic Ecology of the University of Latvia from 10 to 13 April 2007. The meeting of the WGHABD was formally opened with a welcome address by Dr Maris Vitins Director of the Latvian Fish Resources Agency. The agenda was agreed and Dr Eileen Bresnan elected as Rapporteur. Nineteen scientists representing eleven countries travelled to Riga to participate at 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. Over the course of the four-day meeting the group made presentations on 21 topics and this report presents a summary of, these and subsequent discussions.

The Chair, Joe Silke (Ireland) gave a summary of the presentation of the WGHABD 2006 report to the Oceanographic committee at the ASC meeting in Maastricht. The report was very well received and feedback indicated the report was well organised, informative and the meeting was well attended. The committee were also positive about the joint session held with the Working Group for the implementation of GEOHAB in the Baltic and the Terms of Reference for the 2007 meeting.

Being a joint ICES-IOC working group, the IOC in most years announces the possibility for its Member Countries outside the ICES area to attend WGHABD and offers travel support. In 2007 however, the IOC were not in a position to offer this support due to other demands on their budget. The IOC continues to support the general aims of WGHABD, and continues valuable interaction regarding data collection and management of HAB data through the development of the HAEDAT database.

Techniques for analysis and prediction of population dynamics of HABs is a developing science and measures of species-specific growth rates and mortality rates are often very difficult. Monitoring is an important aspect of HAB research and one of the strengths of the WGHABD is the interaction between monitoring programme managers, research scientists and data analysts. For example, environmental data is often needed in modelling HAB events and sampling should 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. WGHABD facilitates the interaction between scientists working in these areas and provides a useful forum for interchange of useful terms of reference on diverse approaches to HAB research.

The importance of the WGHABD approach and focus on population dynamics of specific HAB species as distinct to studies of overall phytoplankton ecology in general was emphasised. The demise of the WGPE was noted in the opening session and discussed more fully under a later TOR. The group recognised economic, resource and environmental effects of HABs are included within the remit of WGHABD and the justification for reorientation of the proposed phytoplankton and microbial ecology working group was supported. WGHABD recognised that phytoplankton ecology models are usually based on biomass, nutrient, and carbon cycling and in many cases cannot define, explain or predict HAB dynamics. In the past we have had joint meetings with modellers to try and incorporate physics and HAB dynamics into the models and liaison with other working groups will be furthered in coming years.

The WG felt that the existing ToRs were related and important to dynamics and the Terms of Reference for 2007 were reviewed and adopted.

2 Terms of Reference

At the 93rd Statutory Meeting (2006), in Maastricht, the Netherlands, the Council approved the WGHABD Terms of References for 2007:

The **ICES-IOC Working Group on Harmful Algal Bloom Dynamics [WGHABD]** (Chair J. Silke Ireland) will meet in Riga 10–13 April 2007 to:

a) review outcome of the WKEUT workshop on Long term data sets and eutrophication held 11–15 September, 2006, Tisvildeleje, Denmark;

b) review progress and analyses that REGNS North Sea Group have done and report on the second REGNS workshop held 15–19 May, 2006, Copenhagen, Denmark;

c) 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;

d) review the on-line format of HAEDAT system and developments made towards developing an integrated system and evaluate the amendments made to update historical submissions and links to mapping. Perform user identification and plan the promotion of the system;

e) review the structure and composition of the decadal HAE maps for the ICES region with special reference to clarifying the distinction between harmful algal blooms and the harmful affects that are reported on the maps;

f) collate and assess National reports and update the decadal mapping of harmful algal events for the IOC/ICES harmful algal database, HAE-DAT;

g) take part in the intersessional work led by PGPYME in developing the mission and draft resolutions for a new Expert Group related to phytoplankton and microbial ecology .

3 Term of Reference a)

3.1 Review the outcome of the WKEUT workshop on Long Term data sets and eutrophication held 11–15 September, 2006, Tisvildeleje, Denmark

3.1.1 Objectives of the Workshop:

A workshop on Time-series Data relevant to Eutrophication Ecological Quality Objectives [WKEUT] (Co-Conveners: T. Smayda, USA, and G. Ærtebjerg, Denmark) was held from 11–15 September 2006, Tisvildeleje, Denmark to:

a) examine long-term time-series data sets available for European and relevant North American coastal sites and evaluate specific issues relevant to EcoQOs premises and standards through a comparative analysis of the regional and temporal variations exhibited in long-term time-series observatories;

b) examine the correlations between the patterns in nutrient levels and cycles together with:

- i) changes in the abundance, composition, primary production, and dynamics of phytoplankton,
- ii) changes in blooms of harmful and novel species, and
- iii) changes in oxygen patterns and other water quality parameters. This comparative, regional analysis will seek to establish the properties of nutrient regulated behaviour of plankton dynamics, regionally and temporally, and potential mitigation of undesirable changes where they occur.

3.1.2 Summary of Findings

Professor Ted Smayda, University of Rhode Island, USA who chaired this meeting had intended to attend the WGHBD meeting to present the outcomes of this workshop however lack of funds prevented his travel to Riga. Joe Silke (Ireland) presented the outcomes from this workshop supported by, Jennifer Martin (Canada) and Eileen Bresnan (Scotland) who had attended this workshop. The group discussed the main points from the report of the workshop:

The time-series data presented at the WKEUT were determined to be adequate to address the question if eutrophication or long-term changes in nutrient levels may have affected phytoplankton dynamics and composition at the time-series locations evaluated. Trends in the time-series data, indicative of an elevated nutrient effect on phytoplankton species behaviour and biomass, and in response to long-term changes in nutrient concentrations and nutrient type, were observed to have occurred at many of the time-series locations evaluated. There was evidence that a regional pattern and temporal synchronization in the altered phytoplankton behaviour was taking place in response to changing nutrient concentrations at the time-series collection sites. In systems where the winter nutrient concentrations were less and the systems better mixed (e.g. Bay of Fundy, Canada, Stonehaven, Scotland, and Bantry Bay, Ireland) changes in the phytoplankton community were less obvious.

There was no convincing evidence, except in Belgian coastal waters, that harmful algal blooms and red tides, are generally linked to eutrophication processes, to elevated nutrient concentrations, or to altered nutrient ratios at the time-series locations evaluated. Blooms of *Phaeocystis globosa* in the Belgian coastal waters and in the Wadden Sea were an arguable, and possibly unique exception to this general finding. However, there is evidence that at low or reduced nutrient concentrations harmful algal species may still occur regularly and bloom periodically.

The data sets indicate that action plans to reduce nutrients are having a positive effect. However, no visible effects of nutrient reductions were observed on *Phaeocystis* blooms in the Belgian coastal waters, because the nitrogen load was maintained while the phosphorus load was reduces by 50%.

The data sets at the long-term collection sites considered (n = 15) are inadequate to evaluate long-term climate change effects on phytoplankton behaviour. In a climatic sense, the length of the time-series data sets is too short to capture long-term climate change effects on the phytoplankton.

Good correlations with the NAO Index were found at most of the time-series locations, and suggest that altered habitat conditions and phytoplankton behaviour are occurring in an apparent response to NAO-related changes in short-term weather conditions and patterns. The observed responses of the phytoplankton to the variations in habitat conditions imposed by the NAO should provide useful information for assessing possible effects of long-term climatic changes on phytoplankton processes. It is emphasized that the NAO, *per se*, is not a measure of climate change, but only a relative measure of local weather patterns in winds, temperature and precipitation.

Long-term changes in phytoplankton responses to altered nutrient conditions and NAO patterns are not uniform, both gradual, as well as sudden, changes occur within a given habitat, and differ between habitats.

The variations in the site and system-specific differences in the trends, the patterns and their rates of change evident in the time-series data do not allow identification of threshold levels in the physical, chemical and weather-driven forces useful in serving as borders between ecological classes. There is also no single threshold level or combination of parameter levels evident in the time-series data considered that are generally useful as a uniform indicator, or predictor of the different modes and degree of ecological impact, either within or among systems.

Phytoplankton indicator species and communities having general application are not evident in the time-series data considered. This does not exclude that indicator species or communities specific to some process or habitat conditions may be unique to a given habitat, and remain to be identified. Although *Phaeocystis globosa* is considered by some to be a general indicator of elevated nutrient conditions, this relationship is generally not robust and may be applicable only to the Belgian and Dutch coastal waters and the Wadden Sea, i.e. in areas where huge blooms of large colonies are recorded every year.

3.1.3 Review by WGHABD

The ICES-IOC WGHABD discussed these findings in some detail and concluded that the findings of the WKEUT represented an important step forward in understanding the link between changes in phytoplankton and anthropogenic nutrient enrichment. Considerable discussion centred around the use of statistical tests for the detection of trends in long term phytoplankton datasets and the use of HAB species as indicators of eutrophication.

In its review of the report the WGHABD considered the key findings to be:

1) Some data sets demonstrate that long-term changes in phytoplankton can be linked to anthropogenic nutrient enrichment but the effects are region specific.
2) A correlation between HAB species and blooms was only found in Belgian and Dutch coastal waters
3) Changes in phytoplankton community structure appear to be linked to the North Atlantic Oscillation Index.

The results of the WKEUT clearly demonstrate that some caution is needed in attributing changes in phytoplankton composition to anthropogenic nutrient enrichment because other drivers such as climate can have similar effects. Furthermore, with the exception of time-series from Belgium coastal waters, there is a lack of evidence of a link between anthropogenic nutrient enrichment and HABs.

WGHABD highlighted the need for careful clarification of HABs as there are different types of Harmful Algal Blooms which have different functional roles and effects in the marine ecosystem. These HAB types have already been described as part of the *EUROHAB* project and recognition of these definitions is supported. The term “Harmful Algal Blooms” (HAB), as coined by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, is not a scientific term, but a socio-economic term used to designate any population of microalgae causing a harmful effect, either to the ecosystem (mass mortalities of fish and benthic populations) or to human resources (human health, shellfish exploitation, fish cultivation, fisheries, tourist resorts etc.). Therefore, under the acronym HAB, a wide array of microalgal species, with very different nutritional requirements (photosynthetic, mixotrophic and heterotrophic), from different habitats (neritic and littoral species; planktonic and benthic) and biogeographic distribution (tropical, subtropical, temperate, boreal/cold water-species) are included.

All through the workshop report, the authors use this generic expression when discussing the potential link between eutrophication and harmful algae populations. Obviously, the response to nutrient enrichment from anthropogenic sources is not going to be the same in the case of a high-biomass-forming microalgal species than in that of a toxin-producing HAB organism (that causes its harmful effect even at very low cellular concentrations or a mixotrophic species than cannot be directly related with nitrate and phosphate levels.

There are available in the literature different classifications of Harmful Algae. One example is given in the EUROHAB (Granéli *et al.*, 1999) report. In this document, HABs are classified into:

1) the toxin producers, which even with low biomass can contaminate seafood, causing sickness and death in humans eating the seafood, or sickness and death in the shellfish and fin-fish themselves;
2) the high-biomass toxin producers (cyanobacteria), which can have similar harmful effects; and
3) the high-biomass bloom species (HB-HAB), which can cause either anoxia that indiscriminately kills off marine life, or unpleasant foam or gelatinous masses that are a nuisance for tourists who may develop allergic skin reactions after bathing.

WGHABD recommended that the WKEUT report should provide some kind of classification, and thereby, try to analyze if anthropogenic impacts affect different kinds of HABs in different ways.

The North Atlantic Oscillation (NAO) is an index based on fluctuations in the difference of sea-level pressure between the Icelandic Low and the Azores High; it expresses the strength and direction of westerly winds and storm tracks across the North Atlantic. Changes in NAO are statistically related to primary production and the interannual variability of planktonic biomass. But the establishment of such relations between NAO and different organisms or populations is rarely accompanied by any attempt to investigate the underlying mechanisms that explain these relations. It is difficult to ascertain whether there is a real relation between atmospheric oscillations and living resources or if we are just examining a statistical artefact.

All through the report, and whenever a relation between NAO and certain time-series is mentioned, there should be an attempt to be more precise, to explain how NAO may affect specific mechanisms that control population numbers in a given system in the North Atlantic region.

3.1.4 Recommendations

1) The WGHABD recommends that the use of HABs and toxin producing phytoplankton as indicators of eutrophication and the role of the NAO should be further evaluated.
2) The WGHABD recommends that the advice of the ICES statistician or WGSAEM on the most appropriate statistics for the analysis of phytoplankton time-series data should be employed for future ICES activities.
3) WGHABD noted that WKEUT represents Atlantic Basin datasets only and there may be other regions that may have different conclusions from long-term datasets, e.g. Asia and Black Sea.

3.1.5 References

Granéli, E., Codd, G. A., Dale, B., Lipiatou, E., Maestrini, S. Y., and Rosenthal, H. 1998. Harmful Algal Blooms in European Marine and Brackish Waters. Research in enclosed seas series, 5, European Communities, Belgium, 97pp.

4 Term of Reference b)

4.1 Review progress and analyses performed by the REGNS North Sea Group and report on the second REGNS workshop held 15–19 May 2006, Copenhagen, Denmark.

REGNS has been an interesting and important exercise, which has given valuable insights into the regime shifts in the North Sea ecosystem. The source of plankton data used in this exercise came from the Continuous Plankton Recorder (CPR). This has a very specific sampling method and this section of the report may have benefited from a short assessment of advantages and limitations of this method in plankton monitoring. The reasons for the selection of the phytoplankton species analyzed is only briefly described and thus somewhat unclear. WGHABD have a specific interest in HAB species, examples of which from the North Sea include *Pseudo-nitzschia, Phaeocystis, Dinophysis* and *Alexandrium*. The inclusion of some of these species in the analysis would have yielded interesting results however none of these species were selected for analysis in this study.

Examining the data shows that for phytoplankton, especially diatoms (Figure 1), but partly also for dinoflagellates (Figure 2), there seems to be a more stable period pre-1983 than after (post-1983). The decrease in dinoflagellates and increeas in diatoms (page 48) may be a short-term observation; as there may be a recovery during the following years.

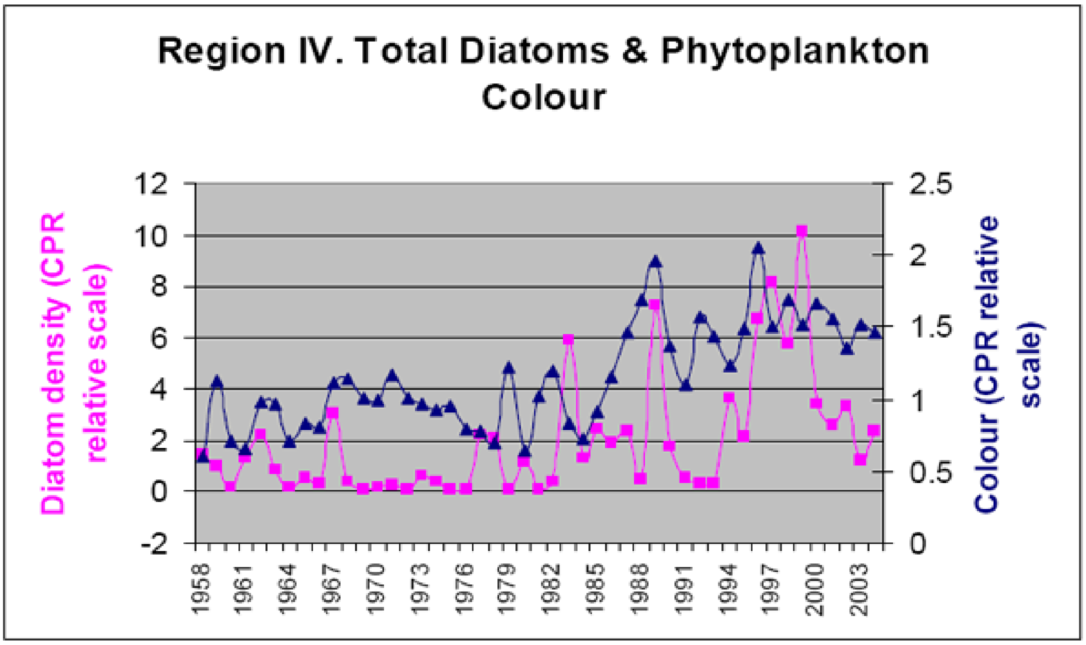

Figure 1. Total relative densities of diatoms and colour from the CPR survey. Data are annual averages for the entire North Sea from 1958 to 2004. (From REGNS Report 2006).

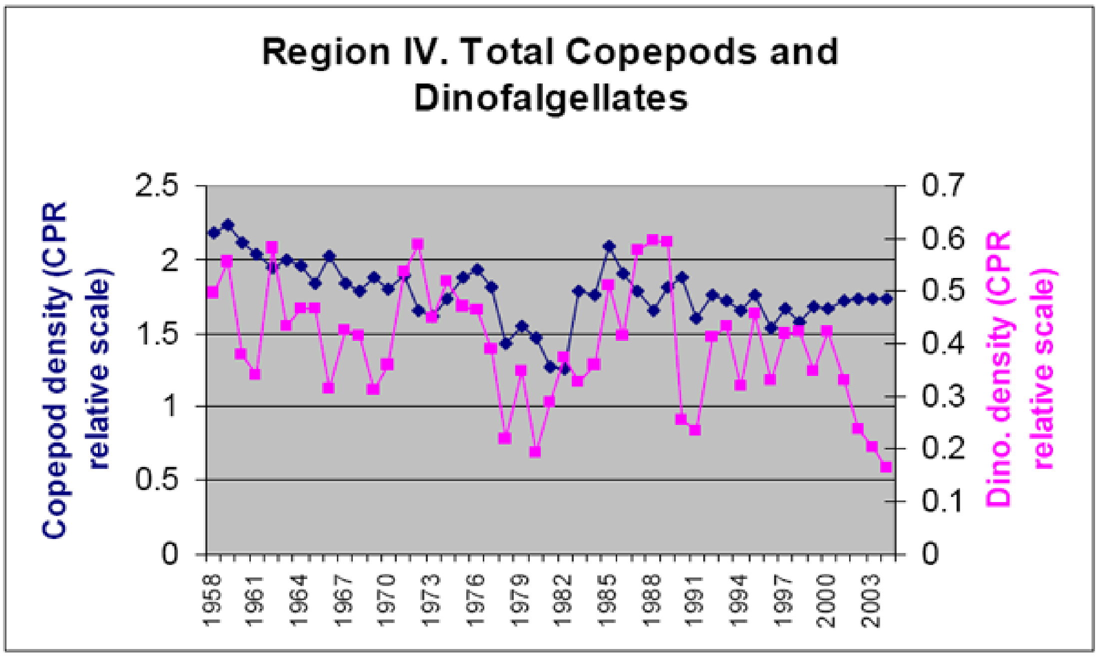

Figure 2. Total relative densities of copepods and dinoflagellates from the CPR survey. Data are annual averages for the entire North Sea from 1958 to 2004. (From REGNS Report 2006).

The future analyses of specific HAB species should be done with assistance from specialists from relevant working groups, such as WGHABD. However, we realize that access to competent people and data may not be straightforward. Data on HAB species are mainly collected at in-shore monitoring stations. These sites may not always be representative of the larger ICES-regions assessed by REGNS, but influenced by local environmental conditions and local driving forces. The data needed for analyses of HAB species are also, in some occasions, not accessible due to protective measures of competent authorities or cost considerations. The REGNS-report addresses the difficulties in obtaining data from different sources. Future initiatives have to learn from this, and ensure that data, controlled with respect to quality, will be made accessible for regional analyses. The integrated approach applied to the North Sea could be useful for other ocean areas where relevant sets of data are available.

In conclusion the group welcomed the REGNS report and suggested that the approach could be strengthened with further attempts towards getting consistent and representative HAB-data from the different regions for an integrated analysis, and further aggregation of data should be considered. It was agreed that too much weight on single measurements of maximum or peak concentrations may misrepresent the occurrence of HABs in a region.

5 Term of Reference c)

5.1 Discuss new findings that pertain to Harmful Algal Bloom Dynamics. Bring new findings in phytoplankton population dynamic models to the attention of the WGHABD for discussion

Nine presentations were made under this ToR.

5.1.1 Signs of declining phytoplankton biomass in summer/autumn along the Norwegian coast

Einar Dahl (Norway)

During the past five years the average phytoplankton biomass along the Norwegian Skagerrak from August - November, measured as chlorophyll a, has been considerably lower than in the years before. The reason seems to be a lower abundance of large dinoflagellates, e.g. *Ceratium* spp. If this is a short-term shift or will become more permanent is still unclear. The causes for the observed shifts are not obvious, but it seems to coincident with a period with unusual high summer and autumn temperatures.

5.1.2 The quantitative role of cysts in *Alexandrium* dynamics in the Gulf of Maine, and progress in modelling and forecasting Don Anderson, WHOI

Don Anderson (USA)

This presentation focused on two major developments in studies of *Alexandrium* dynamics in the Gulf of Maine. One was a review of the development and application of coupled, physical/biological numerical models, and the second was a study that demonstrates the quantitative importance of cysts in regional bloom dynamics.

Modelling progress. 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). 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 Altantic Bight and the Gulf of Maine, maintained by Rutgers and UCLA.

Looking to the working group's interest in HAB forecasts, it is first necessary to define the scales of forecasts and hindcasts that might be attempted, not all of which require numerical models. These include:

1) Long-term (interannual) empirical forecasts. This would be analogous to decadal patterns of tropical cyclones (hurricanes), which tend to follow cyclical trends. That can be predictive.
2) Annual to seasonal forecasts. This would be analogous to forecasting a "heavy winter of snow", or a "cold" or "warm" winter.
3) Synoptic forecasts (days to weeks).
4) Hindcast analyses for hypothesis testing.

Which of these modelling or predictive capabilities is possible or even desirable for HABs? Using the Gulf of Maine *Alexandrium* blooms as an example, all four are now being attempted.

Hindcasts. Physical/biological models (McGillicuddy *et al.*, 2005) have been used in hindcast mode to examine the relative importance of three major factors in the massive 2005 New England red tide (Anderson *et al.*, 2005). By keeping environmental forcings constant, but varying cyst abundance by approximately an order of magnitude (equivalent to differences observed in cyst maps from prior years), dramatic changes in bloom magnitude and extent are observed. These changes are larger than those observed when the cyst map was held constant at 2004 levels, and the winds or freshwater input were varied (R. He, D. McGillicuddy, D.

Anderson, unpub data). The lessons learned from these hindcast analyses are that high cyst abundance appears to have been the most important factor in the 2005 bloom. Wind was very important in bringing cells to shore, but a large, regional bloom with extensive alongshore toxicity would have occurred even with "normal" wind conditions and river discharge.

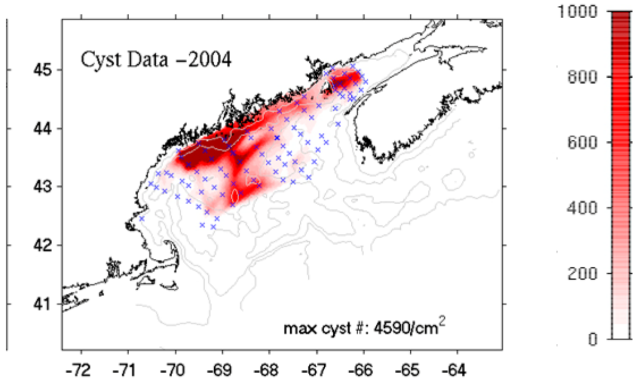

Figure 3: Map of *Alexandrium fundyense* cyst abundance in surface sediments of the Gulf of Maine in 2004. x denotes station locations.

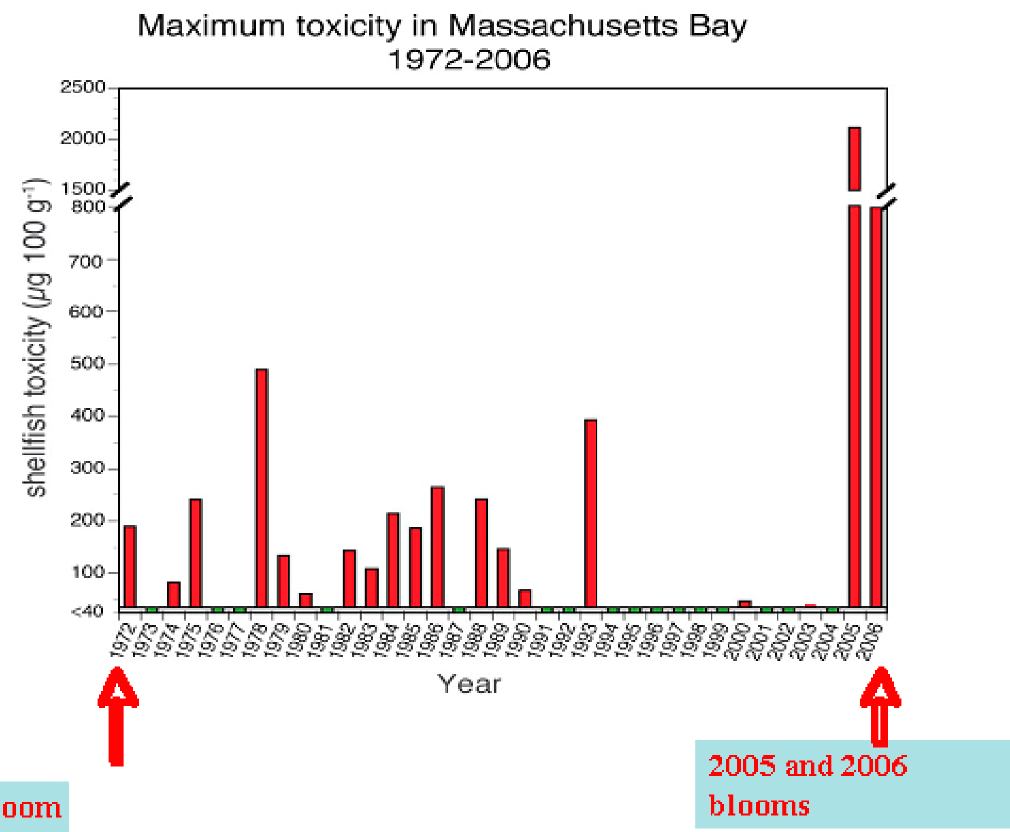

Figure 4. Maximum PSP toxicity within Massachusetts Bay, 1972–2006. Data courtesy of Massachusetts Division of Marine Fisheries.

Long-term and interannual forecasts. Forecasts of this nature are being made on the basis of two factors: 1) annual maps of *A. fundyense* cyst abundance (see Figure 3); and 2) long-term trends in PSP toxicity in shellfish. This is not a modeling exercise, but rather a use of historical patterns on which to base predictions. For example, Figure 4 shows the pattern of toxicity in Massachusetts Bay since 1972. Prior to 1972, there were no records of PSP toxicity ever in Massachusetts Bay (Anderson, 1997). A major bloom occurred that year, followed for the next 20 years by frequent, recurrent episodes of PSP. This pattern was broken in 1994, which marked the beginning of a decade with virtually no toxicity within Massachusetts Bay. Then the massive 2005 bloom hit the region, followed by another major event in 2006. This historical pattern suggests that a major regional bloom conditions the system for subsequent outbreaks, presumably through the deposition of large numbers of cysts that serve as an inoculum for future blooms. On the basis of these historical data, we were able to hypothesize in 2005 that the region was likely to enter a "new era" with high and frequent PSP toxicity in the western Gulf of Maine region, a forecast which has been borne out in 2006. Long-term, decadal forecasts may therefore be possible with sufficient background data and understanding of the HAB system.

Annual forecasts: The analyses described above allow us to use cyst maps obtained in the fall of one year to predict the general size of the regional outbreak the following year. In this way, we correctly predicted that 2006 would be a year with a major regional bloom, based on a 2005 cyst map that showed cell abundances about 50% of those seen in 2004 (Figure 3) but still 5X higher than we had seen in 1997 (Anderson *et al.*, 2005). Looking ahead to 2007, the cyst abundance is now about 70% of that observed in 2006, so we can "forecast" another regional bloom of major size, but perhaps with fewer cells than either 2005 or 2006. We need to acknowledge that wind patterns can greatly influence the extent to which these large regional blooms are carried to shore, but with a large population offshore, "normal" wind patterns will generally bring cells to shore. In years when the cyst inoculum is small, the regional population is correspondingly small and patchy, and thus high concentrations of cells are less likely to be carried to shore. We thus can begin to envision issuing bloom forecasts with probabilities, much as is done for rain or snowfall on a seasonal basis. Such forecasts are inherently uncertain, but are of value to managers and industry if they are relatively reliable.

One significant challenge for the annual forecasts reflect the need to initialize the *A. fundyense* population model with an annual cyst map, which is an expensive undertaking requiring a week or more of dedicated shiptime, as well as considerable personnel time for the counting. In this regard, we are working with the cyst maps we have for 1997, 2004, 2005, 2006 and 2007 (later this year) and are hoping to analyze them statistically to define a minimal sampling program from which the regional cyst distribution can be extrapolated.

Synoptic forecasts: On a short-term level, the numerical models we are using can be augmented with real-time data in a process called data assimilation, leading to HAB forecasts on the time scale of weather predictions. Thus far, however, there are no instruments or monitoring programs that can provide *Alexandrium* cell abundance estimates on a real-time basis for incorporation into these modeling efforts. The Environmental Sample Processor (ESP) developed by C. Scholin at the MBARI (Scholin *et al.*, in press) shows great promise in this regard, but is still in the experimental stage of development.

It has been possible to assimilate current measurements into model runs during Gulf of Maine cruises, and combined with weather forecasts, to predict the trajectory of water masses and patches of *A. fundyense* cells. In a recent test of this technology, drifters were released from a research vessel and tracked by satellite, with those tracks compared to forecasts of their transport by the model, with assimilated velocity data from ADCPs. In the most skilful at-sea simulation, numerical drifters separated from the real drifters at a rate of 3.4 km d^{-1} (McGillicuddy, He, Keafer, and Anderson, unpub. data.). This experiment demonstrates the potential for near real-time forecasts of *A. fundyense* transport using numerical models and data assimilation, but as mentioned above, it will be a challenge to obtain data on cell abundance which can be assimilated into the model.

In summary, modelling efforts and our conceptual understanding of *A. fundyense* dynamics in the Gulf of Maine have progressed to the point where we can make both long- and short-term forecasts 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.

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5.1.3 *Alexandrium* and toxicity trends in the Bay of Fundy, eastern Canada

Martin, J.L., M.M. LeGresley, A. Hanke and F. H. Page (Canada)

The Bay of Fundy has a long history of *Alexandrium fundyense* blooms and annual shellfish harvesting area closures due to unsafe levels of PSP toxins. A monitoring programme was initiated in 1988 in the Bay of Fundy to study phytoplankton populations and various environmental parameters. Samples are analysed for total phytoplankton community and in most cases, the harmful algal species make up a minor component of the community. Analysis of *A. fundyense* abundance from the 18-year period 1987–2005 at an offshore indicator site indicates that cell abundance from one year does not reflect the following year and there have been years of both low and high cell density (Figure 1). Analyses of data indicate that nitrate values and cell densities appear to have a negative relationship when >100,000 cells L^{-1} were observed. Preliminary analyses indicate that *A. fundyense* abundance and intensity appears to be more climate-related than nutrient flux related.

Data on PSP toxin concentrations in shellfish have been collected since the 1940s and provide an important perspective on *A. fundyense* inter-annual and seasonal patterns. Analyses of PSP shellfish toxicity data from *Mya arenaria* since 1944 indicate that there are periods of increased toxicity. For example, there were higher shellfish values recorded in the mid 1940s, early 1960's, late 1970s and 1980 and again in the late 1990s and early 2000s. Highest cell densities since the early 1980s were observed in 2003 (8.8 x 10^5 cells L^{-1}) in the Grand Manan Island area and in 2004 in Bliss Harbour (>3 million cells L^{-1}) and both bloom events resulted in farmed salmon mortalities.

5.1.4 *Eucampia zodiacus* population trends in the Bay of Fundy

Martin, J.L., L.E. Burridge and M.M. LeGresley (Canada)

In 2002, an intense bloom of *Eucampia zodiacus* (177,000 cells•L^{-1}) occurred and was thought to cause problems with the salmon industry. Data from an existing phytoplankton monitoring study in the southwest portion of the Bay of Fundy initiated in 1987 were examined to determine the possible threat of *E. zodiacus* to the industry for future years. This study revealed that *E. zodiacus* was observed at very low cell densities (<2600 cells L^{-1}) at all sampling sites prior to 1999 and was absent in 1987, 1988 and 1996. In the years following 1999, cell densities increased to greater than 2600 cells L^{-1}. The more inshore stations, Brandy Cove and mid-Passamaquoddy Bay, had the highest concentrations (1.78 x 10^5 cells•L^{-1} and 1.44 x 10^5 cells•L^{-1}) in 2002 by an order of magnitude of 5. Analyses from the study period suggest that the Passamaquoddy Bay region was more conducive to the higher cell densities and blooms of *E. zodiacus*. The inshore area has more freshwater influence, shallower water, and enhanced mixing and flushing. Additionally, conditions in 2002 must have been conducive to blooms of *E. zodiacus*. The high cell densities in that year were the highest recorded in the 18 yr of the phytoplankton monitoring programme (Figure 1). These high numbers coincided with problems which were associated with salmon farms in the Passamaquoddy Bay area. These observations suggested that if concentrations reach levels that were detected in 2002, there might be problems with salmon in adjacent net pens. Further exposure of Atlantic salmon to *E. zodiacus* under laboratory conditions would also need to be conducted as preliminary initial laboratory experiments exposing salmon to high concentrations of *E. zodiacus* (2.6 x 10^{-6} chains of cells•L^{-1}) for 24 h did not result in fish mortalities.

5.1.5 New issues on *Dinophysis* nutrition and behaviour

Beatriz Reguera (Spain)

During the last two decades, many biologists were curious to find out what was the nutritional source of phototropic species of *Dinophysis*, and tried to grow them with different enriched media, with or without additions of small prey. In the luckiest cases, picked cells, incubated in cell culture plates, go through 2 or at most 5 divisions (generations); when transferred to fresh medium, small cells start to appear, and the culture does not progress in a conventional way (Nishitani *et al.*, 2003). Field data usually show a lack of correlation between *Dinophysis* spp and levels of inorganic nutrients, and results from incubation experiments suggested carbon uptake in the dark (reviewed in Maestrini 1998). A key observation by Hansen (1991) was that the heterotrophic *Dinophysis* (*Phalacroma*) *rotundata* can feed on the ciliate *Tiarina fusus* after piercing its lorica with a feeding peduncle and sucking its contents, a feeding mechanism known as “myzocytosis” (Schnepf and Deichgräber1984). It seemed logical to imagine that other species of *Dinophysis* could feed on other ciliates in a similar way, and years later, remains of ciliates were found in the digestive vacuoles of *D. acuminata*, *D. norvegica* (Jacobson and Andersen 1994) and *D. fortii* (Koike *et al.*, 2000). But nobody had seen in nature what the potential prey of *Dinophysis* might be.

Advances in molecular biology were applied to *Dinophysis* issues, and Takishita *et al.* (2002) and Janson (2004) found that portions of the ribosomal DNA that code the plastids of *D. acuminata* are identical to those with the same function for the plastids of the cryptophyte *Teleaulax amphioxeia.* The hypothesis of kleptoplastidy came into conflict with the idea that *Dinophysis*’ cryptophyte-like plastids are constitutive (Hackett *et al.*, 2003), i.e., the result of an evolutionary association between a “domesticated” cryptophyte prey and a eukaryotic cell. Attention was diverted to the potential cryptophyte prey, but nobody managed to grow *Dinophysis* on them. Takishita *et al.* (2005) confirmed the cryptophyte-like sequence of the plastids of several DSP toxin-producing *Dinophysis* spp., and even developed molecular probes that, as a very innovative early warning system, could be bound to the cryptophytes with a plastid sequence like that of *Dinophysis* spp. plastids, and detect the prey before the build-up of *Dinophysis* populations.

The findings of Park *et al.* (2006), presented at the XII HAB Conference (Copenhagen, 4–8 September 2006) constitute a breakthrough that opens new possibilities for research on *Dinophysis* spp., but also leads to many new questions. *D. acuminata* feeds on the ciliate *Myrionecta rubra*, which is eaten through a feeding peduncle in a similar manner as *D.*

rotundata eats *T. fusus*. *M. rubra*, that contains a cryptophyte endosymbiont, needs addition of *Teleaulax* sp. to grow successfully in f/2 medium (Yih *et al.*, 2004).

Key questions that need to be addressed are:

- Is *Myrionecta* the main (or the only) prey in natural populations of *Dinophysis* spp?
- Can *Dinophysis* survive on other nutritional sources when *Myrionecta* is not available?
- Do *Dinophysis* perform photosynthesis with stolen plastids from *Myrionecta*, or does the ciliate act only as an exogenous nutritional source? What are *Dinophysis* nutritional sources?

Addition of high molecular weight (> 1 kD) dissolved organic matter (DOM), concentrated by ultra-filtration, leads to improved division rates in incubated *Dinophysis* compared with those, isolated from the same population, grown in filtered seawater (Reguera *et al.*, 2005; Reguera *et al.*, unpubl. data). Maximum values of μ obtained in these experiments -below 0.3 d^{-1}- are three times lower than those obtained in cultures of *D. acuminata* fed with *Myrionecta* (0.95 d^{-1}) under continuous illumination. Nevertheless, the positive response of *Dinophysis* to additions of DOM suggests that, even if *Dinophysis* cells, after predation on *Myrionecta*, can store enough kleptoplastids/organic matter to fuel several divisions, DOM or other alternative nutritional sources may act as a supplement to maintain the population in times of scarcity of *Myrionecta*. At least in the case of the heterotroph *Dinophysis mitra*, Koike *et al.* (2005) found kleptoplastids of haptophyte origin.

Other important findings presented were that i) *Dinophysis* planozygotes can divide directly without the need to mature into hypnozygotes (Escalera and Reguera, submitted); ii) the toxin profile of *D. acuta* showed significant changes in the proportion between okadaiates (OA, DTX2, OA diol esters) and pectenotoxins (PTX2) during an *in situ* cell cycle study (Pizarro *et al.*, accepted); iii) *D. acuminata* formed thin layers (TLs) in an upwelling system, but these layers were very near the surface and not at the depth of maximum density gradient, where TLs of *Pseudo-nitzschia* and *Chaetoceros socialis* predominated (Reguera *et al.*, 2006). This work showed that it is important to consider the phase of population growth to predict the locations of the cell maxima in the water column.

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5.1.6 Niche separation on the vertical

Patrick Gentian (France)

Competitive exclusion theory suggests that phytoplankton species number in an assemblage at equilibrium will be limited to the number of simultaneously limiting resources, generally three or fewer. However, natural phytoplankton assemblages usually exhibit high species diversity, hence the concept of Hutchinson's paradox of the plankton (Hutchinson, 1961). Up to twelve different explanations (Bastow Wilson, 1990) have been proposed to explain how the species of a community coexist without competitive exclusion occurring; the main being that in the ocean, a mixed water column is not that mixed.

The recent findings by Lunven (2005) illustrate the separation of niches in the top of the pycnocline layer. Two different species, a diatom *Chaetoceros socialis* and a toxic dinoflagellate *Dinophysis acuminata* were found to constitute two superimposed layers at a vertical distance of 60 cm. The diatom had been present sufficiently long to locally exhaust dissolved silica to the point that supply for the population was provided by vertical diffusion: this layer had been relatively stable.

These considerations in the vertical distribution of phytoplankton species mean that sampling of toxic dinoflagellates may be really challenging in this case.

New results (Gentien, unpublished) point to a further difficulty. Monospecific populations of *Gymnodinium chlorophorum* (a non-toxic dinoflagellate) have been detected in the 3 meters above the bottom in huge densities saturating the fluorometer, i.e. above 30 µg Chlorophyll equivalent.l^{-1} and corresponding to cell densities of the order of 5.10^6 l^{-1}. In some profiles, two layers of the same species were detected at a separation distance of 60 cm but the top layer was senescent and the bottom was actively growing as judged by the concentrations of dissolved organic Carbon and Nitrogen in these layers.

These examples point out the difficulty in performing an exhaustive and relevant sampling and an appropriate sampling strategy designed for each special case.

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5.1.7 *Karenia mikimotoi* in Scottish Waters during 2006

K. Davidson, S. Swan, E. Bresnan. And K. Kennington (Scotland)

Karenia mikimotoi is often identified as a member of the phytoplankton community in various parts of North West Europe. Recently, in 2005, a major *K. mikimotoi* event occurred in the west of Ireland, with pelagic and benthic mortalities being reported. In Scottish waters *Karenia mikimotoi* has regularly been identified, but with few major environmental consequences. However, a red tide in a number of sea lochs of the Firth of Clyde in 1980 was associated with fish deaths in Loch Fyne. Subsequently *K. mikimotoi* assumed reduced significance in Scottish waters for nearly two decades, with the next recorded bloom of red tide proportions being in 1999 in Orkney and in 2003 in the Orkney and Shetland Islands.

However, in 2006 a spatially and temporally extensive *K. mikimotoi* bloom was evident in Scottish waters resulting in significant mortalities of benthic organisms. Fortunately the 2006 *K. mikimotoi* bloom was not associated with the same level of farmed fish mortalities as in 2003, where extensive fish mortalities (53,000 farmed fish) were reported from four sites in the Shetland Islands.

The bloom first became evident on the Scottish west coast in mid July. These observations coincided with satellite observations of elevated chlorophyll concentrations that had previously been evident offshore, reaching the coast. These satellite data strongly suggest that the *K. mikimotoi* bloom developed offshore and was advected towards the coast.

While the advective transport of phytoplankton in Scottish waters is relatively poorly understood, the progression of the bloom is consistent with cells being transported on the northwards flowing Scottish coastal Current. However, the rate of increase of cell numbers and the peak cell density at particular sampling sites (generally within sea lochs) was most likely related to the particular hydrological and chemical status of the site and hence were quite variable between locations.

Presently the reasons for the development of the 2006 bloom remain unclear. However, it is possible that remnants of the 2005 Irish *K. mikimotoi* bloom were able to over winter on the shelf to provide the seed population. The unusually warm summer and resultant elevated sea temperatures and favourable winds may then have provided suitable conditions for bloom development and subsequent advection to the Scottish coast. Studies are currently ongoing to improve satellite remote sensing of *K. mikimotoi*, to model the transport of the bloom and to determine the relationship between bloom magnitude and environmental drivers.

5.1.8 B-NEAT – a new web resource for images and information about phyto- and zoo plankton as well as benthic microalgae.

Bengt Karlson (Sweden)

A prototype of the new web site *Baltic and North East Atlantic Taxa* (B-NEAT) was presented. This site contains images, videos and information about phytoplankton from the Norwegian Sea, the North Sea, the Skagerrak, the Kattegat and the Baltic. Images and information about zooplankton and benthic micro algae is being amended. The aim is to provide information about species that is relevant for monitoring and research including harmful algal bloom research. Another aim is to provide species lists that are updated yearly. These should be possible to refer to as publications. The present content of the web site is based on the "Checklist of phytoplankton in the Skagerrak and the Kattegat" by Mats Kuylenstierna and Bengt Karlson. It is being amended with information from Norway, Denmark and Finland. Contribution of images and information to the site is done using a web interface. Most image formats are supported and it is really easy to contribute. The idea is that small groups of experts will take responsibility for different groups of organisms. Funding for developing the system comes from the EU-project Forum Skagerrak II. The B-NEAT initiative was made because the different species lists available, e.g. ITIS (Integrated Taxonomic Information System), ERMS (European Register of Marine Species), the IOC list of toxic algae, AlgaeBase and Plankton*net does not fulfil the need for information about species properties, e.g. size, harmfulness or toxicity, taxonomic position, images and videos and links to other information, e.g. genes sequences at EMBL/Genbank.

5.1.9 New findings concerning toxins in phytoplankton of the Baltic Sea

Bernd Lukas (Germany)

Good cooperation exists between institutions in Finland (Finnish Environment Institute (SYKE)) and Germany (Alfred Wegener Institute for Polar and Marine Research, Dept. Chemistry of Natural Compounds, Helgoland, and Friedrich Schiller University, Jena) in the field of toxin research focusing on the harmful substances occurring during harmful algal blooms in the Baltic Sea.

The most important blooms in the Baltic Sea are formed by the cyanobacteria *Nodularia spumigena* as a producer of the hepatotoxic pentapeptide nodularin. It could be proven that all blooms of *Nodularia spumigena* in the Baltic Sea were connected with the formation of higher concentrations of nodularin followed by transfer into zooplankton and in fish, e.g. flounder. Using LC/MS based methods for determination of nodularin in bulk samples of phytoplankton, desmethylated structure variants of nodularin in addition to nodularin were detected with the percentage of these desmethylated nodularins in the range of 10–30 % of the sum of nodularins present. At this time, no data concerning the toxicity of the desmethylated nodularins exists and so in Germany, research in this field is ongoing. In addition, the monitoring of blooms of *Nodularia spumigena* in the Baltic Sea in connection with measurements of the different nodularins will be continued in order to generate data with regard to assessing the threat to human health caused by blooms of *Nodularia spumigena.*

New LC/MS based methods for determination of DSP toxins were applied in bulk samples of plankton from the Baltic Sea. Here, especially the toxins of the okadaic acid group (OA, DTX 1) were often detectable. However, during the last few years many samples were observed to contain the pectenotoxin PTX 2 and his seco acid PTX 2sa. This typical metabolite of PTX 2 was detectable in higher amounts in zooplankton and mussels. Since the toxicity of PTX 2sa is very low it is of importance to monitor the accumulation of both DSP groups, i.e. the OA group and the PTXs in the food web of the Baltic Sea with focus on the degradation of PTX 2 to PTX 2sa.

Another field of research is the monitoring of blooms concerning the presence of spirolides formed by *Alexandrium ostenfeldii*. Therefore, different strains of *Alexandrium ostenfeldii* isolated from Gulf of Finland were compared with the spirolide producing strain KO 297 from Denmark (Collection of marine algae of the University of Copenhagen). However, no strains of *Alexandrium ostenfeldii* isolated from NE regions of the Baltic Sea were observed to produce spirolides. These strains were proved to be strong producers of GTX 3, GTX 2 and STX and, consequently, it will be essential in the future to also monitor the phytoplankton of the Baltic Sea for PSP toxins. In this context, blooms in the western Baltic Sea which may often consist of both *Alexandrium minutum* and *Alexandrium ostenfeldii* must be monitored to determine if *Alexandrium minutum* will result in PSP contamination of mussels in the western regions of the Baltic Sea, e.g. *Mytilus edulis* harvested 2006 near Norsminde, Denmark.

6 Term of reference d)

6.1 Review the on-line format of HAEDAT system and developments made towards developing an integrated system and evaluate the amendments made to update historical submissions and links to mapping. Perform user identification and plan the promotion of the system

IOC-ICES-PICES Harmful Algal Event Data Base, HAEDAT

Monical Lion, IOC-IEO SCCHA, Vigo, Spain

A review of the on-line format of HAEDAT system and developments made toward developing an integrating system on Harmful Events and maps was presented by Monica Lion of the IOC-IEO SCCHA, Vigo, Spain.

Since the WGHABD meeting in 2006, the HAEDAT on-line form was revised to account for minor adjustments that were made to the database and also to allow a direct coupling of records and maps using UMN Mapserver. The expertise needed to prepare the coupling with the GIS type system required resources that were not available at the IOC Secretariat, but thanks to the extra-budgetary support from the US National Oceanic and Atmospheric Administration through its Center for Sponsored Coastal Ocean Research, it was possible to contract an external expert (form Coldrose Consulting) to implement the new system.

WGHABD has been invited to participate in a testing period to check the last amendments, which allow:

- online input of new reports by National Editors;
- browse and/or search of events;
- display of frequency maps based on searches; and
- download of data and maps directly from the web site by end-users.

The new Harmful Algal Event Information System was warmly welcomed by WG Members, especially the new option to create maps. After the testing period, some WGHABD members submitted their comments to HAEDAT managers to improve the quality of the database and to make the Harmful Event Information System web site more user-friendly.

Some of the comments submitted were:

- prepare a quick and easier first web site for the general public;
- add legends on the maps;
- adjust the map minimum zoom to include the whole country;

- allow the production of Regional maps, creating a new field for regions;
- add two new kind of syndromes: Cyanobacteria toxins and Aerosol toxins.

HAEDAT managers noted these comments and will perform them in the intersessional period.

In the near future, HAEDAT will continue its development into a general and global information system on Harmful Algae, integrating new data related to the events, as the information compiled in MON-DAT (IOC-Database on monitoring programmes) or HAB-MAPs (ISSHA).

7 Term of Reference e)

7.1 Review the structure and composition of the decadal HAE maps for the ICES region with special reference to clarifying the distinction between harmful algal blooms and the harmful effects that are reported on the maps

Decadal maps have been generated for many years by IFREMER for WGHABD. These maps are hosted on the IFREMER website and linked to the IOC website. They have not been updated for a few years, as it was difficult to receive updates from all countries at the same time. The format of the data submitted (paper files) was not very efficient, making this update cumbersome.

With the development of HAEDAT, it is possible to generate all the maps automatically. However it has not yet been planned to have global pre-prepared maps, of a similar period of time as the historic decadal maps for a fixed set of countries in this database. Pre-prepared decadal maps could be appealing data products and an interesting supplement to the on-line individual search option. These maps should be limited to a few categories, e.g. toxins. They would be relevant for people searching for a global view on harmful algal events.

In this context, IFREMER has already begun to re-design the decadal maps, by linking it with a very simple MySql database. Moreover, maps are becoming dynamic, as it is now possible to select the toxin criteria. The only requirement needed to update these maps the ability to download HAEDAT, in order to extract the relevant information: country code, area code, toxin. The geographical position of the areas for each country should be first registered in the MySql database as internal coordinates (the real coordinates of the events will not be taken account in these global maps). Then, the number of occurrences for each toxin will be counted, and the maps will be built and updated on an annual basis.

The WGHABD group has decided to retain the decadal maps as a supplementary output from HAEDAT : Initially they will apply to only the main groups of toxins (lipophilic toxins, PSP, ASP, maybe cyanotoxins and aerosol toxins), and fish kill events. The current cyanobacteria map will be removed, as it concerns species more than toxins. Subsequent decadal maps could be planned for selected groups of harmful species. Quantifying the occurrences of HAE will be determined as the number of years by effected by toxic events, and not as the actual number of events, since the definition of an event may be different from one country to another.

These decadal maps will be produced as soon as data will have been updated in HAEDAT (probably not before the second semester of 2007). The first thing that could be made is the update of the position of area codes for each country from maps which will be provided by Monica Leon of the IOC centre, Vigo.

8 Term of Reference f)

8.1 National reports

8.1.1 Ireland

The Marine Institute has undertaken a monitoring programme since the late 1980s on Irish shellfish to detect the presence of various natural toxins that originate from the micro-plankton. This work is carried out in conjunction with the Department of Communications, Marine and Natural Resources and the Food Safety Authority of Ireland. Filter feeding shellfish such as mussels, oysters, clams etc filter planktonic food particles from the water, and at certain times of the year these can cause the shellfish to become unsafe for consumption. This programme monitors seawater samples from around the coast for harmful plankton, and also checks the shellfish for the presence of toxins before harvesting is permitted. Toxicity in shellfish is grouped according to the various toxins present, in Ireland the principal ones that impact shellfisheries are ASP (Amnesic Shellfish Poisoning), DSP (Diarrhetic Shellfish Poisoning), PSP (Paralytic Shellfish Poisoning) and AZA (Azaspiracid Shellfish Poisoning).

There is considerable variation from year to year in toxicity of Irish shellfish depending on the presence, intensity and distribution of toxic plankton. In contrast to the previous year there was a very significant reduction in toxic species observed in 2006. In 2006 *Alexandrium,* which causes PSP, peaked at 18% of the 2005 high count. Similarly, *Dinophysis acuminata* and *Dinophysis acuta*, both responsible for DSP, showed only 2.4% and 10.4% respectively of 2005 levels. *Pseudo nitzschia* spp., which can result in ASP was also notable by its reduction to 14.7% of the previous year's intensity.

The result of this was a notable reduction nationally in the resultant toxicity of shellfish on the previous year. For 2006, ASP concentrations were significantly lower than observed in previous years, with only 1 mussel sample over the regulatory limit observed in June in the Southwest. Only 4 samples of scallop gonad tissues were observed to be over the regulatory limit for 2006 in the Southwest. For 2006, 2 samples showed quantifiable levels of PSP toxins where one of these was above the regulatory limit. This was in a sample of mussels from the South in June at a level just above the regulatory threshold. DSP concentrations in shellfish were observed also to be lower than observed in previous years, with a relatively small percentage of samples above the regulatory limit mainly confined to the Southwest. The majority of the DSP in this area has dissipated by September but unfortunately was replaced by AZA which typically tends to occur later in the year. This persisted in some areas of the South west until the end of the year, however most areas did clear up and harvesting was resumed by early January 2007.

A summary of these events was presented by Marine Institute staff at the 7th Annual Shellfish Safety Workshop held in Galway on 30 November. In general the intensity of toxicity observed nationally in 2006 was generally much lower than 2005, but these successive low level events resulted in protracted closures mainly in the South West where the majority of mussel aquaculture occurs from early summer to the year end. The phytoplankton monitoring programme explained that lower concentrations of toxic species observed in Irish waters throughout 2006 were responsible for the reduced toxicity of the shellfish.

8.1.2 United Kingdom

8.1.2.1 *Northern Ireland*

In 2006, thirty five sites were sampled routinely on a fortnightly basis from N. Ireland sea loughs.

Alexandrium spp. were recorded in 2% of samples reaching a maximum of 60 cells l^{-1} in a sample from Belfast Lough and one from Carlingford Lough. No PSP toxins were detected.

Dinophysis spp. were present in water samples from May to November reaching a maximum abundance of 280 cells l^{-1} in Belfast Lough late June. The most abundant species was *D. acuminata* with only small numbers of *D. acuta*, *D. rotundata* and *D. fortii* counted. Diarrhetic shellfish toxins were detected on three occasions during 2006 but were not linked with the presence of any known microalgal species in water samples.

Pseudo-nitzschia spp. were present in 58% of samples reaching a maximum concentration of 50,080 cells l^{-1}. Toxicity, however, was confined to samples of scallops (*Pecten maximus*). Domoic acid levels reached a peak of 18.57 µg g^{-1} whole flesh.

No major phytoplankton blooms of harmful or other microalgal species were recorded during the year.

8.1.2.2 *England and Wales*

From the 1 June 2005, the Food Standards Agency (FSA) funded a comprehensive phytoplankton monitoring programme for England and Wales for the first time. All commercial shellfish harvesting areas in England and Wales were included in the phytoplankton monitoring programme for the next 3 years. The programme was gradually introduced during the second half of 2005 and by 1 January 2006 regular water samples were being collected and analysed from 48 active harvesting areas.

Alexandrium spp. (PSP)

This species were very widespread this year, being recorded from 30 of the 48 sampled areas. They occurred in 150 of the 899 samples collected. Highest concentrations were found in the Salcombe Estuary (Devon) at concentrations of 1.7 million cells l^{-1} in late June. *Alexandrium spp*. were once again found regularly in samples collected from four sites in the Fal Estuary from June to October, and even occurred at low levels in one sample collected in December 2006. Samples from Weymouth inner harbour also regularly contained *Alexandrium spp* with concentrations reaching 0.5 million cells l^{-1} for one week in July. PSP toxins were found on eight occasions in 2006, all in mussel flesh. The occurrence of *Alexandrium spp* coincided with PSP toxins being found in shellfish flesh at two of the Fal sites (Malpas (2) and Turnaware Pontoon (3)), with a peak of 95 ug g^{-1} in a sample collected at the end of June. PSP toxins were also found in two samples of mussels collected from Holy Island (Northumberland) and once in a sample from the Fowey.

Dinophysis spp. (DSP)

These were found in 15 sampling areas, but often at low concentrations. Highest concentrations (1,000 cells l^{-1}) were found in the Camel Estuary in early September. Low concentrations were found regularly in samples from the Fal from June to October. Unusually, *Dinophysis spp.* only occurred infrequently and at low concentrations in samples collected offshore at Blyth, Northumberland. *Prorocentrum lima* (DSP) were found on nine occasions, in the Burry Inlet, two sites in the Fal Estuary and on five occasions at Weymouth (Fleet Oyster farm). Peak concentrations of 240 cells l^{-1} were found in a water sample collected from the Fleet at the end of July. DSP toxins were recorded on four occasions in samples of mussels from the Camel Estuary and once from a sample of oysters collected from the Fal (Penryn), all in September.

Pseudonitzchia spp. (ASP)

These were found in most of the sampled areas in 2006 and were much more widespread and persistent than in previous years. In addition, they also occurred regularly at much higher concentrations than had been seen in the past. They breached the 'investigative' level (50,000 cells l^{-1}) on 4 occasions and the action level (150,000 cells/litre) 30 times during the summer of 2006. This was totally unprecedented (in the previous five years, action levels had only been breached on three occasions) and led to some areas being monitored on a weekly basis for several months. ASP toxins were usually most frequently found in samples of scallops from offshore fishing grounds, particularly in the Western Channel. However, in 2006, samples of cockles from South Wales (Burry Inlet, Milford Haven and Three Rivers) also contained low levels of ASP toxins with the highest concentration (12.0 µg/g) being found in a sample of cockles taken from Three Rivers at the end of June.

8.1.2.3 *Scotland*

In previous years (2004 and 2005), a reduced number of shellfish harvesting areas were closed due to concentrations of PSP and DSP toxicity exceeding EU closure limits. However, 2006 once more saw high numbers of *Alexandrium* and *Dinophysis* occurring in Scottish waters. *Alexandrium* cell densities >2,000 cells per litre were observed along the east coast and Orkney in as well as selected sites on the west coast and Western Isles (> 1,000 cells *per* litre) . High cell densities, exceeding 6,000 cells *per* litre, were observed in Shetland in August and September and were coincident with closures of shellfish harvesting areas due to high levels of PSP.

Increased numbers of *Dinophysis* cells were observed during 2006 with a maximum cell density of 10,000 cells *per* litre observed in Shetland. A number of closures due to positive DSP MBAs were enforced during the year. The dominant species observed was *D. acuminata.*

High cell densities of *Pseudo-nitzschia* spp. cells were again observed during the year in most areas, however, surprisingly, this genus was absent from the south west corner of Scotland. Changes in EU legislation (853/2004) meant that King Scallops *(Pecten maximus*) were no longer tested as part of the shellfish hygiene monitoring programme, and so this dataset has ceased. No incidences of ASP toxicity exceeding the closure limit of 20µg DA *per* 100g were observed in other species of shellfish. The highest number of *Pseudo-nitzschia* species recorded since routine monitoring began in Scotland was observed during daily sampling in response to a *Karenia mikimotoi* bloom. Cell densities of 7.5 and 8 million cells *per* litre were observed in the West Coast and Orkney Islands in late August. Electron microscopy analysis of this bloom showed it to be dominated by cells of the *Pseudo-nitzschia pseudodelicatissima* complex.

An extensive *Karenia mikimotoi* bloom occurred along the west coast of Scotland and the Orkney and Shetland Islands during August 2006, with maximum cell densities of between 3 - 4 million cells *per* litre. This bloom event resulted in a number of benthic mortalities in these areas. A more detailed report on this bloom can be found in the new findings section of this report (Section 7.16: *Karenia mikimotoi* in Scottish waters during 2006).

8.1.3 Sweden

The Skagerrak and the Kattegat

In 2006 the flagellate *Verrucophora* sp., formerly known as *Chattonella* cf. *verruculosa* was observed in February, March and April. No harmful effects were noticed. The dinoflagellate genus *Alexandrium* was observed later in spring. Some species in this genus produce Paralytic Shellfish Toxins (PST) but no PST was found in blue mussels. Another dinoflagellate genus, *Dinophysis*, occur in the area. The species *D. acuta* and *D. acuminata* are known producers of Diarrhetic Shellfish Toxins (DST) and they do occur in the are in abundances above the warning levels of 300 cells L^{-1} and 900 cells L^{-1} respectively. Analyses commissioned by the Swedish National Food Administration show DST above the maximum residue limit of 160 µg kg^{-1} mussel meat mainly in January–March and October to December but also some high values in August and September. However, low levels of DST are found in some areas most of the year making harvesting feasible. No Amnesic Shellfish Toxin (AST) was observed in the area in 2006 although the diatom genus *Pseudo-nitzschia* that may produce the AST (domoic acid) is common. In late summer cyanobacteria from the bloom in the Baltic was observed in the Kattegat and the Skagerrak. As a note not related to harmful algal blooms it was reported the gelatinous zooplankton *Mnemiopsis* was observed in the Swedish part of the Skagerrak in the autumn of 2006.

The Baltic

In early July the first surface accumulation of the cyanobacteria bloom was observed in the Baltic proper. Observations using satellites showed that the maximum area was covered in mid July. Ship sampling and microscopy prove that the bloom consists of *Nodularia spumigena*, *Aphanizomenon* sp. and *Anabaena* spp. Analyses for the toxin Nodularin demonstrated that it was present in the plankton samples. The bloom was a nuisance mainly in the South western part of the Baltic proper where beaches were affected. The toxic species *Nodularia spumigena* dominated in this area. The bloom is connected with high phosphate concentrations in the water. These large cyanobacteria have nitrogen fixation ability, which makes it possible for them to out compete other phytoplankton in brackish water when there is phosphate available but no or little dissolved inorganic nitrogen. Calm weather and relatively high temperatures are also required. In August a cyanobacteria bloom in the Bothnian bay was observed from satellite. Samples from the coast near the town Sundsvall contained 100% *Nodularia spumigena*. The bloom was transported southward to the northern part of the archipelago of Stockholm. An unusual observation was bioluminescence in early August near the island of Harö in the archipelago of Stockholm. The organism producing the bioluminescence was not identified.

8.1.4 Norway

In 2006 the number of weekly monitoring stations for algal toxins in shellfish, funded by the Norwegian Food Safety Authority, increased from about 30 to more than 50, 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 2006. One monitoring station was, however, closed due to high concentrations of *Pseudo-nitzschia* spp. recorded (13 million cells l^{-1}), but two weeks later ASP-toxins were not detected in mussels from the area.

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 2006 were observed to be normal. In northern Norway, on the other hand, the occurrence of DSP-toxins in 2006, as in 2004 and 2005, was observed to be extensive. Up to about 3 300 microgram of DSP-toxins were recorded per kg mussel meat at one monitoring station in the Troms county (northern Norway) in the beginning of October. The causative algae was *Dinophysis acuta,* up to 1,000 cells l^{-1} were found in the area during the weeks before.

PSP

The occurrence of PSP-toxins in mussels is a recurrent problem in Norway. In 2006 these problems again were relative small in the southern Norway, while rather large in the north. The highest concentration of PSP-toxins recorded in mussels from the northern Norway in 2006 was about 14 000 microgram per kg mussel meat, detected in the Troms county in the end of July. The event was associated with the presence of 2 000–5 000 cells $l^{-1}$of *Alexandrium tamarense* in the area.

AZA (Azaspiracids)

At one monitoring station, along the west coast of Norway, Azaspiracid was detected at a concentration of 195 microgram per kg mussel meat in the end of October, which is slightly above the regulatory level.

Ichtyotoxic events

Two events of enhanced fish mortality in salmon and cod farms in northern Norway were reported when the algal genus *Chrysochromulina* and *Alexandrium* were common. They could have contributed to the observed mortalities, but the cases were not well documented.

8.1.5 Germany

During 2006–early 2007 no harmful algal events were reported from the North Sea or Wadden Sea coast of Germany, including waters adjacent to Helgoland, Bremen State, Lower Saxony and Schleswig-Holstein. The toxigenic gonyaulacoid species *Alexandrium tamarense*, *A. minutum* and *A. ostenfeldii* were recorded several times but never in "bloom" concentrations, i.e. always <1 X 10^3 cells l^{-1}. At the end of May 2006, a low magnitude bloom of *Phaeocystis* was recorded at the Wattenmeer Station (Sylt) as part of the long time-series on plankton; a second higher magnitude bloom of this species at the end of June was associated with a second annual peak in chlorophyll biomass (~15 µg L^{-1}) and a nutrient (nitrate) minimum. Only low concentrations of the DSP-toxin producers, *Dinophysis acuminata*, *D. acuta* and *D. norvegica* were observed in routine monitoring of the coastal North Sea waters. In particular, *D. acuminata* was observed from early May to the beginning of July and from late August to the end of September from the Wadden Sea coast. The related (probably non-toxic) species *D. rotundata* was found from the end of May until early July from the same station.The taxon originally attributed to the raphidophyte '*Chattonella verruculosa*', but now recognized as a member of the Dictyophyceae, was noted episodically at non-bloom conditions in the coastal waters of Schleswig-Holstein. No major harmful events were associated with the typical appearance of cyanobacterial blooms on the German Baltic coast including, transitional waters. Transient beach-fouling, an inconvenience to bathers, did occur along the margins of Mecklenburg-Western Pomerania in 2006.

8.1.6 The Netherlands

The data used to compile this country report is extracted from two monitoring programs which operate in The Netherlands. First, the Biomonitoring program (National Institute for Coastal and Marine Management/RIKZ), and second the Sanitary Shellfish Monitoring Program (Institute of Food Safety and Wageningen IMARES). From the Biomonitoring program only data for the first semester of 2006 was available during the writing of the report.

Alexandrium spp.

Two species of *Alexandrium* have been recorded, *Alexandrium ostenfeldii* and *Alexandrium tamarense. A. ostenfeldii* was detected at off-shore (100–235 km from the coast) locations in March and May, with cell counts ranging from 78–212 cells per liter. *A. tamarense* was detected in off-shore areas (100–235 km) in May with cell counts of 77–130 cells per liter; *A. tamarense* was also found in the Oosterschelde (Zijpe) in January with cell counts of around 130 cells per liter. No toxin analyses were performed for the off-shore locations. In shellfish (mussels and Ensis) from the Voordelta, North Sea, Oosterschelde and Wadden Sea no PSP toxins could be found using LC-MS analyses.

Chattonella spp. (C. antiqua and C. marina)

In the Delta area (south-western part of The Netherlands) and along the coast line, as well as at off-shore locations, relatively low concentrations of *Chattonella* were detected (January–June, 71–20,314 cells l^{-1}). In the Wadden Sea and above the Wadden Islands (North Sea) a bloom occurred in April with maximum cell numbers of 11 and 24 million cells l^{-1}. No attempt was made in order to analyse for potential toxins.

Dinophysis acuminata

Dinophysis acuminata was detected in the near shore area, the Wadden sea in May and during a short period in September. The cell counts ranged from 42 (May) to 30–220 cells l^{-1}. LC-MS analyses of a selection of samples showed the absence of lipophilic toxins.

Phaeocystis spp.

At off-shore regions (100-235 km) unusual high peaks (up to 8 and 12 million cells l^{-1} in March-April) of *Phaeocystis* were detected in comparison to earlier years. However, an average bloom occurred at the near shore locations along the Dutch coast and above the Wadden Sea Islands. In the Wadden Sea a normal spring bloom occurred in the Wadden Sea with maxima of 5,5–21 million cells per liter. In contrast, in the estuary Westerschelde and in the marine tidal basin Oosterschelde no spring bloom occurred.

Pseudo-nitzschia spp.

Pseudo-nitzschia spp. were recorded at near-shore locations from the end of July through September at cell levels ranging from 62.000 till 950.000 cells l^{-1}. In the Dutch Wadden Sea *Pseudo-nitzschia spp.* were present in background levels throughout the period June-October. However, elevated levels were recorded during mid August, when cell levels reached a maximum of 170.000 cells l^{-1}. No toxin was detected in shellfish using LC-MS analyses. The results of this year and the prior years have resulted in an advise to increase the action levels for *Pseudo-nitzschia spp.* from 100.000 (literature based) to 500.000 (experience based) cells l^{-1}.

8.1.7 Spain

Aerosol-Born Irritatory Syndromes

These syndromes affected sun bathers in the Mediterranean coast in summer (July–August).

In Llavaneres beach (Catalonia), 33 sun-bathers suffered nose and eye irritation during 2 days in August. The suspected cause was the benthic dinoflagellate *Ostreopsis* cf *siamensis*. Concentrations were up to 2,000 cell/l during the toxic events, but 18,000 cell/l 10 d before the irritation.

In several beaches in Almeria (Andalucia), 40-50 people (8-9 July) affected with breathing difficulties received medical attention. Water analyses revealed the presence of *Karenia* spp (18,800 cell/l) and *Chattonella* spp. (2,080 cell/l). *Ostreopsis* spp were detected in August.

DSP and Yessotoxin Events

Catalonia: Chronic_closures associated with *D. sacculus* (max 800 cell/l) and *D. caudata* (max. 2600 cell/l) led to six periods of harvesting closures of mussels and oysters in April, July, September, November and December. Yessotoxins were detected for the first associated with *Protoceratium reticulatum* (max. 1,600 cell/l).

Andalucia: Closures between April and July associated with *Dinophysis* cf *acuminata* (5,000 cell/l) in the coasts of Huelva.

Galicia: In the Northern Rías, mussel harvesting closures in late April caused by *D. acuminata* (1760 cell/l) and bottom shellfish between Jul and Nov.

In the Southern Rías Baixas, very long closures due to proliferations of *D. acuminata* followed by *D. acuta* were observed. Remains of a severe outbreak of *D. acuta* in the autumn 2005 kept some raft-mussel areas closed until the end of February 2006. New closures in 2006 were associated with *D. acuminata* (4,000 cell/l) between July and September, and with *D. acuta* (5,160 cell/l) between September and November. There were a few isolated cases of closures of bottom shellfish harvesting.

PSP Events

Catalonia: Cell densities of *A. minutum* exceeded alarm levels in the Delta del Ebro region, but toxins in shellfish kept below regulatory levels.

In areas with no shellfish industry, discolorations of *A. catenella* (214,000 cell/l) from June to August with *Gymnodinium impudicum* (23 ·X 10^7 cell/l), as well as *Lingulodinium polyedrum* (7 X· 10^4 cell/l) were detected in Tarragona. Dense blooms (red tides) of *A. minutum* (Feb to May) were observed in several Catalan harbours

Andalucia: Chronic occurrence of *Gymnodinium catenatum* in the Mediterranean coast, between August and December (max. 15,520 cell/l). PSP toxins above regulatory levels were found in *Chamelea gallina* (466 µg/100 g), *Callista chione* (92 µg/100 g), *Mytilus galloprovincialis* (1,226 µg/100 g), *Pecten maximus* (236 µg/100 g) and *Acanthocardia tuberculata* (407µg/100 g).

Galicia: Due to a very severe outbreak of *Gymnodinium catenatum* in the autumn of 2005, harvesting in some raft-mussel areas in Ria de Vigo was forbidden until April 2006. During autumn 2006, low concentrations of *Gymnodinium catenatum* were detected, and PSP-toxis in shellfish remained below regulatory levels.

Very localized summer-autumn moderate blooms of *Alexandrium minutum* affected bottom shellfish in the Baiona embayment (Ria de Vigo) (up to 483 µg STXeq/100g) and the Rias Altas during short periods of time. Cell concentrations were below 20000 cell/l

ASP Events

Catalonia: Domoic acid (DA) was not detected on *M. galloprovincialis* in the Delta del Ebro region.

Andalucia: In the Mediterranean coasts, DA associated with *Pseudo-nitzschia australis* was detected in *Callista chione* (19 µg/g), *Venerupis romboides* (24 µg/g) and *Pecten maximus* (246 µg/g).

Galicia: Closures of mussel harvesting caused by *Pseudo-nitzschia* spp for one week in May (max 236115 cell/l) in the Rías Altas, and at the end of April (66825 cell/l) in Ria de Vigo. In September, closures due to DA above regulatory levels (up to 87 µg DA · g^{-1}, and 653400 cell/l) affected all the Rías Baixas (Muros, Pontevedra, Vigo) except Arousa.

Scallops (*Pecten maximus*) contained DA above regulatory levels all year round. Restricted harvesting, with evisceration (according to Directive 2002/226/EC) proceeded only during the first term of the year.

Closures of bottom shellfish caused by *Pseudo-nitzschia* spp occurred from April to May in Ría de Vigo (86.9 µg · g^{-1}), and the Rías Altas (278.5 µg · g^{-1}), and in all the Rías Baixas, except Arousa, in September (41.2 µg · g^{-1}).

Foams and Mucilages

Central coast of Catalonia. Foams and mucilage caused by blooms (15 · 10^6 cell/l) of *Phaeocystis* spp. were recorded in the central coasts of Catalonia in August, and by blooms of *Gonyaulax fragilis* (2.3 · 10^6 cell/l) with *Pseudo-nitzschia calliantha* (23 · 10^6 cell/l) in July–August.

The Basque Country started a monitoring programme in 2002. There are no commercial shellfish exploitations in the area, but wild shellfish are collected for home consumption in some estuaries. Fish aquaculture farms are included in this project. Two yearly cruises are carried out in summer and autumn. Potential DSP (*D. acuta*, *D. caudata*, *D. tripos*, *D. rotundata*), PSP (*A. minutum*, *G. catenatum*) and ASP (*Pseudo-nitzschia* spp) producers have been found in low concentrations. So far, no PSP, DSP or ASP toxins have been detected above regulatory levels in shellfish collected at three different estuaries.

8.1.8 France

During recent years the French Phytoplankton and Phycotoxin Monitoring Network (REPHY) has become the main support for the implementation of the European Water Framework Directive for the phytoplankton element (chlorophyll and phytoplankton blooms). Since the beginning of 2005 a systematic toxin research in shellfish has been performed at selected areas during risk periods. These risk areas and periods are calculated from data and toxic events of the last six years. For PSP and ASP toxins, the strategy is still based on the detection of toxic phytoplankton species in water, which activates toxin research in shellfish.

Lipophilic toxins

In 2005–2006, many regions were affected by the presence of these toxins. The first observation of DSP toxins in scallops was made in 2005 in Seine bay (Normandy). The results of LC-MS analysis made on these scallops during this episode, found concentrations up to more than 3,000 $\mu g.kg^{-1}$ (OA+DTXs). In 2006, scallops of Brest and Quiberon bays (West and South Brittany) were also affected by DSP toxins.

In South Brittany, numerous DSP episodes (particularly in 2006) were also observed on several other species of shellfish, as mussels, oysters, donax, clams, cockles, etc.

In Arcachon Bay (South West of France), unexplained toxic events have been observed since spring of 2005. In 2005, positive mouse-tests were observed in mussels and oysters from April to August, with, in some cases, very short survival times. LC-MS results showed presence of spirolides (first observation in France) with a maximum of 60 $\mu g.kg^{-1}$. The group of toxins OA+DTXs was observed with fluctuating results in mussels, often above the sanitary threshold (160 $\mu g.kg^{-1}$), but with low values in oysters, often below 30 $\mu g.kg^{-1}$. Toxins YTXs, AZAs and GYMs were not detected. In 2006, positive mouse-tests were again observed in mussels and oysters from May to September. LC-MS results showed the presence of AO, DTXs, PTXs and SPXs, but with low values in mussels and very low values in oysters. YTXs, AZAs and GYMs were not detected. A similar configuration seems to begin again since the beginning of March 2007. A research study, piloted by Afssa (French Food Sanitary Security Agency), was inititiated, with other scientific partners including Ifremer, to elucidate this problem and try to find the responsible substance.

In Salses Leucate lagoon, at the West Mediterranean coast, some unexplained toxic events were also observed. In 2005 and 2006, mouse-tests have been positive for 9 months out of 12 for mussels, and primarily in November and December for oysters. LC-MS results showed a quite good correlation with mouse-tests results for mussels, but not for oysters, especially at the end of 2006. No YTXs, no AZAs and no GYMS were detected.

PSP toxins

There was no observation of PSP toxins in France in 2005, nor in 2006.

ASP toxins

Scallops were the most affected shellfish by ASP toxins during these two years. In 2005 toxic episodes were observed in Seine bay (Normandy) with a maximum of 42 $\mu g.g^{-1}$ DA, and in West and South Brittany (Brest and Quiberon bays) with a maximum of 43 $\mu g.g^{-1}$ DA for the first one, and 88 µg for the second one.

In 2006, other shellfish were affected by ASP toxins, as *Donax,* in South Brittany with a maximum of 52 $\mu g.g^{-1}$ DA, and along the Mediterranean coast. In South Brittany, mussels and clams (*Venerupis rhomboides*) were also affected, with a maximum of 88 $\mu g.g^{-1}$ DA in clams.

8.1.9 Latvia

HAB Monitoring in Latvian territorial waters is performed in the Gulf of Riga and on the Latvian coast of the open Baltic Sea. It is managed by Latvian Agency of Environment, Geology and Meteorology and realised by Monitoring Department of the Latvian Institute of Aquatic Ecology. Phytoplankton samples are collected year round, mostly once per month. Analyses of phytoplankton community structure are performed using Uthermöhl techniques. Studies of cells bound cyanobacterial hepatotoxins (nodularin and microcystins) and their accumulation in biota (benthic fish and molluscs) have commenced, but these studies are not included in the National Monitoring Programme. Toxicological studies are performed by Department of Experimental Hydrobiology of the Latvian Institute of Aquatic Ecology in co-operation with Finish Institute of Marine Research. . Hepatotoxins in flounders and molluscs are analysed by ELISA and HPLC.

No HAB blooms were observed in Latvian territorial waters in 2006. Totally 18 HAB species were detected, representing 4 taxonomical groups: 13 – cyanobacteria (5 *Anabaena spp*., 3 *Aphanizomenon spp*., 2 *Microcystis spp*., *Nodularia spumigena*, *Planktothrix agardhii, Pseudanabaena limnetica*), 3 - dinoflagellates (*Dinophysis spp., Prorocentrum minimium*), 1 – diatoms (*Chaetoceros danicus*) 1 –prymnesiophytes (*Chrysochromulina sp.*).

The maximal abundance of harmful cyanobacteria was observed in summer (in July–August in the Gulf of Riga; in August–September in the open part of the Baltic Sea).

Cyanobacterial blooms coexisted with harmful dinoflagellates and prymnesiophytes reaching the maximum in summer (in July - in the Gulf of Riga; in August–September in the Open Baltic). Harmful diatoms reached their maximum in autumn (September–October).

The prevailing genera comprised ofsmall cells species -*Aphanizomenon spp., Microcystis spp*. and *Chrysochromulina. sp.,* but according the biovolume the maximum values were presented by *Aphanizomenon flos-aquae* (169 mg/m^3 in the Open Baltic) and *Chaetoceros danicus* (146 mg/m^3 in the Gulf of Riga).

The total HAB biomass didn't exceed 250 mg/m^3 which was in the same range compared to 2005 (200 mg/m^3). Analysis of a long term data set (1997–2006) shows a decrease of HAB species.

No fish kills or other biological effects were observed in Latvian territorial waters. No recreational problems due to the HABs were reported. Toxicological studies show nodularin as the only hepatotoxin accumulated in mussels and benthic fish of the Gulf of Riga. Although usually *Nodularia spumigena* blooms are not intensive in the Gulf, relatively high nodularin concentrations were detected in the local clams and flounders.

8.1.10 Canada

PSP

PSP toxins were responsible for shellfish closures along the Atlantic Coast of Canada in the Bay of Fundy and St. Lawrence Estuary at "normal annual levels". In the Chaleur Bay, Northern New Brunswick (Gulf of St. Lawrence), PSP toxins above regulatory levels were detected in oysters and resulted in a suspension of marketing.

On Canada's Pacific Coast, there were shellfish area closures due to PSP.

ASP

There were no shellfish harvesting areas closed due to unsafe levels of domoic acid.

Fish Kills

Along Canada's West coast, there were a number of Atlantic salmon mortalities that occurred as a result of HABs in net pens: On 4 May and 5 June *Chrysochromulina* spp. affected fish at Quatsino Sound and Quadra Island when 2,000,000 cells/L were detected. On Aug 2 a bloom of *Heterosigma akashiwo* (17,000,000 cells/L) that lasted 4 weeks affected fish at Quatsino Sound. Another *Heterosigma* bloom affected fish at Salmon Inlet when 3,000,000 cells l^{-1} were observed for a 2 week period starting 21 August. Tofino Inlet was also affected when *Heterosigma* peaked at levels of 17,000,000 and persisted for a two-week period. *Cheatoceros concavicorne* was also implicated when salmon smolt mortalities occurred at Hardwicke Island near Johnson Strait on October 14. Maximum *C. concavicorne* cell densities observed were 5–10,000 cells/L.

8.1.11 United States of America

2006 was basically a "normal" year for HABs in the U.S., with several noteworthy or exceptional events.

PSP

Similar to previous years, Maine, Massachusetts, California, and Washington all recorded PSP events during 2006. In Maine, 2006 was a major bloom year – one of the highest in the last several decades. An outbreak also occurred on the north shore of Long Island – a localized bloom leading to closure levels of toxicity. It has long been known that *Alexandrium* cysts could be found on Long Island, but this is the first recorded outbreak of a bloom with sufficient magnitude to lead to shellfish closures. The magnitude of the southern California bloom was also unusual in distribution and magnitude. Unlike previous years, there were no PSP events in Alaska in 2006. There were also no PSP events in Oregon for the second year in a row.

ASP

ASP was recorded in California, Oregon, and Washington.

NSP

Karenia brevis blooms occurred in southwest and northwest Florida. The southwest Florida bloom lasted through all of 2005 and part of 2006 (beginning in early January 2005 and continued until March of 2006). The 2006 bloom has persisted from June of 2006 into 2007. Fish and mammals were killed; humans experienced respiratory problems. In addition, turtle strandings occurred at several times the ten-year average. Texas also experienced a *Karenia brevis* bloom along 175 miles of the coastline (Corpus Christi Bay, Aransas Bay, and Espiritu Santo Bay).

Brown tide

For the fourth time since 1985, there were no reports of brown tide this year in New Jersey or Long Island.

Pfiesteria

There were no reports of fish kills definitively attributed to *Pfiesteria* in North Carolina or Chesapeake Bay.

Karlodinium

A bloom of *Karlodinium veneficum* occurred in North Carolina causing fish kills.

Other Events

A *Cochlodinium* bloom occurred in New York state (Peconic Estuary).

9 Term of Reference g)

9.1 Take part in intersessional work led by PGPYME in developing the mission and draft resolutions for a new expert group related to phytoplankton and microbial ecology

At the previous Annual Science Conference ICES had taken a decision to dissolve the WGPE due to a variety of issues including lack of commitment, and through a Planning Group on Phytoplankton and Microbial Ecology (PGPYME), lead by John Steele, Franciscus Colijn, and Ted Smayda, to form a new ICES Working Group on Phytoplankton and Microbial Ecology to report back for the 2008 ASC. The advice from OCC is that the Chairs of the PGPYME correspond with the WGPBI, WGZE, WGHABD, and WGRP to develop a firm proposal for the mission of the group, including a proposal for Chair, initial ToRs, date and venue, and supporting information

WGHABD discussed the formation of this new WG and recognised that the remit of this work would be distinct from the WGHABD which focuses on the dynamics of Harmful Algal Species only. The formation of the new expert group was supported and the integration of both Phytoplankton and Microbial ecologyy in the title of the group was also agreed as being a sound approach as the two areas are closely related. Contact with key people involved in generating the new PGPYME revealed that some progress had been performed in the interim into generating this new group. However, there was some concern at the meeting that the planning group at this stage had not progressed very far. The group reaffirmed the support towards giving any input requested towards the objective of setting up the new expert group.

The Chair of the WGHABD was actioned to write to Ted Smayda to receive an update of progress in the creation of this new group. The text of this letter is excerpted below.

> Dear Ted
> … Briefly to update you on the WGHABD position, we held our meeting in Riga and I am currently putting the report together, hopefully i will have this complete in the next week or so. We did have a TOR to take part in intersessional work led by PGPYME in developing the mission and draft resolutions for a new expert group related to phytoplankton and microbial ecology. We think WGZE may have also had a similar Term in their meeting. We did hold a discussion on the proposals and the establishment of a WGPME group was widely supported by our members. Our discussions basically endorsed your proposals in your initial document sent to Einar Svenson .
>
> While WGHABD have not to date provided any input to the intersessional work in setting up your group, we are happy to offer any advice that you may seek. In addition we support your proposal to hold a theme session in 2008 as I think that such an initiative would greatly benefit the start up of the WG by identifying the direction and terms that this group should assign their initial attention towards. One issue that I suggest merits consideration by the planning group is that of national support for the new group. While the WGHABD and WGZE have strong support and a core of regular members that attend to the work of these, one of the failures of WGPE was a certain lethargy among its members that lead to its failure. This may also be a risk to the the new group and I would suggest that the theme session should aim to identify the key areas where the work of WGPME is essential. I think that solid preparation in promoting participation at this proposed session should start in advance of the next ASC, and identification of experts in the areas of eutrophication, ecosystem interactions at different trophic levels, climate change, HABs and any other areas that might create impact and encourage ongoing participation in the group would be beneficial. I guess what I am proposing is whatever it takes to get over that "hang-over" you mentioned from WGPE and promote international participation both the working group and proposed theme session at the next ASC. Ultimately the PGPYME can only report and give recommendations, it is up to ICES through OCC to generate the will and enthusiasm to get this group up and running and WGHABD support this aim, it is imperative that an end to end approach to describing ecosystem dynamics in marine exploration start at the bottom trophic levels….

A response to this email was received from John Steele explaining the objectives of the planning group and the chronology thus far (excerpted):

> A Planning Group on Phytoplankton and Microbial Ecology (PGPYME) (Chairs: J. Steele*, USA, Franciscus Colijn*, Germany, and Ted Smayda*, USA) will be established and work by correspondence to:
>
> (a) consider the formation of a new expert group covering the field of microbial dynamics including phytoplankton ecological processes;
> (b) formulate initial ToRs for such a group;
> (c) suggest Chair and potential members.
>
> PGPYME will report by 1 February 2007 for the attention of the Oceanography Committee.
>
> Chronology
>
> In February 2006 Einar Svendsen (as Chair of OCC) noted the lack of interest in WGPE and proposed its decease unless there was a better response. He also said “I do not think today’s strong attention on the ‘ecosystem approach’ within ICES will survive if we do include the dynamics related to phytoplankton ecology”
>
> In spring and summer 2006 there was an email exchange between Einar Svendsen, Ted Smayda and others on the proposal to disband the WGPE. There appeared to be consensus that (i) the WG had lacked support from individuals and from governments for quite a long time (ii) reviving the WG did not seem likely but (iii) this was an important part of the ICES portfolio.

This matter was discussed by OCC at the ASC in Maastricht. Several people proposed a Theme Session and I drafted a rationale for one. Franciscus Colijn proposed a Planning Group “on the preparation of a Theme Session”.

In mid-December 2006 the above TOR’s for PGYPME were circulated. The TOR’s make no mention of a Theme Session. I contacted Dr Colijn who, unfortunately, was too busy to participate. My own response to Luis Valdes (now Chair of OCC) was that we are back to “square one”, with the question of the transition from WGPE in limbo.

In April 2007, at the urging of Luis Valdes, I sent an email to 40+ members of the ICES community and others (Annex I). I received eight responses.

The responses detailed problems in making the microbial food web relevant to ecosystem based management. The sense of the earlier correspondence, reinforced by these responses, is that establishment of a reconstituted WG, by itself, would not be successful.

They indicate two alternative actions for ICES:

(i) One approach is to relegate the complexities of the microbial food web to a subsidiary status within ICES and leave such integration to more research oriented organizations such as EUR-OCEAN or IGBP (IMBER). Specific requests, for example from OSPAR, could be met from ad hoc groups or by ICES staff.

(ii) The alternative, recommended by several respondents, is to explore the relevance of these components of marine ecosystem to ICES interests in a Theme Session that brings together ICES representatives and outside experts.

A full report of the intersessional activities by the planning group is expected at the next ASC and future activities in phytoplankton and microbial ecology will be recommended at this forum.

10 Additional presentations

GEOHAB Presentation including WGGIB

Patrick Gentien (France)

The state of development of the IOC-SCOR Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) programme was presented to the Working Group. Most of the documents related to GEOHAB such as the Science Plan, Implementation Plan and the different Core Research Plans may be found on the GEOHAB web site which has been completely redesigned. Scientific activities have been categorized in four (CRP) Core Research Programmes: Upwelling, Eutrophied, Fjords, Coastal Embayments and Stratified Systems. All CRPs held a specific Open Science Meeting. The two first programmes have already been published their Science Plan which are available for download.

Underlying the four Core Research Programmes, the general aim of GEOHAB is to understand a toxic bloom to a sufficient degree of detail which allows its prediction. To this effect, it is necessary to detail the species’ strategy and rank the processes controlling its dynamics. This single species model has to be embedded into an operational oceanography systems equipped with the appropriate observation systems (Gulf of Maine, Florida, Hong-Kong, Bay of Biscay) A direct collaboration between physicists and biologists is necessary in most cases. Working Group participants have been encouraged to seek GEOHAB endorsement of their research projects.

Because of the extreme importance of the Baltic Sea in terms of GEOHAB implementation, WGHABD upon request of the IOC and GEOHAB Scientific Steering Committee examined the progress in implementing GEOHAB in the Baltic. WGHABD considers that very little progress has been achieved since the production in 2000 of the Cooperative Plan for HAB study in the Baltic. There have been apparently some oceanographic cruises aimed at the study of changes induced in the ecosystem functioning by cyanobacteria blooms but those works have not been reported in the WG reports. They could have served to establish a basis for dialogue. Similarly, this field work could have been used as good opportunities to promote multinational cooperation by invitation of other scientists on board of research vessels.

Acknowledging that grandiose plans may fail due to a variety of reasons, WGHABD expresses a strong opinion that, unless some **realistic plan** for research is quickly established, with the aim of submitting to EU funding an integrated approach to HABs in the Baltic, the implementation should be delayed sine die and the Working Group on GEOHAB Implementation in the Baltic be dismissed.

11 Draft resolutions

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics [WGHABD] (Chair J. Silke, Ireland) will meet in Galway, Ireland in March 2008. The draft Terms of Reference for the next meeting is presented in Annex 3.

12 Recommendations

- It was proposed that contact with WGPBI would be initiated and the possibility for joint working group activities in the near future be investigated.
- Commenting on the WKEUT workshop, the WGHABD recommends that the use of HABs and toxin producing phytoplankton as indicators of eutrophication and the role of the NAO should be further evaluated
- The WGHABD recommends that the advice of the ICES statistician or WGSAEM on the most appropriate statistics for the analysis of phytoplankton time-series data should be employed for future ICES activities
- The REGNS approach could be strengthened with further attempts towards getting consistent and representative HAB-data from the different regions for an integrated analysis, and further aggregation of data should be considered.
- The WGHABD members would continure participate in a testing period of HAEDAT to check the last amendments, which allow online input of new reports by National Editors; browse and/or search of events; display of frequency maps based on searches; and download of data and maps directly from the web site by end-users.
- WGHABD would continue to support and offer assistance when requested to the PGPYME. Contact with key people would be continued and any assistance or advice would be made available.
- WGHABD considers that very little progress has been achieved since the production in 2000 of the Cooperative Plan for HAB study in the Baltic. WGHABD expresses a strong opinion that, in the absence of an integrated approach to HABs in the Baltic, the implementation of GEOHAB should be delayed sine die and the Working Group on GEOHAB Implementation in the Baltic be dismissed.

Annex 1: List of participants

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Annex 2: Agenda

Tuesday

Meeting opening 09:30

Meeting opening and Housekeeping Issues

Appointment of Rappateur

Introduction of participants

Adoption of the Agenda

1st Session 09:45

Reviews of Workshops held in 2006

Review of 2006 WGHABD report

TOR a) review outcome of the WKEUT workshop on Long term data sets and eutrophication held 11–15 September 2006 in Copenhagen;

TOR b) review progress and analyses that REGNS North Sea Group have done and report on the second REGNS workshop held in Copenhagen from 15 to 19 May 2006;

Lunch:12:30-13:30

2nd Session 13:30 -17:00

Group Self Assessment

1) Were the Terms of Reference properly addressed and completed?
2) Is the report clear and understandable?
3) Is the science quality adequate?
4) Are the conclusions well supported and acceptable?
5) Linkages to other topics, or work elsewhere in ICES?
6) Is the work suitable for an ICES publication?
7) How should the work be continued?
8) Other points to note or query?
9) Was attendance adequate?
10) Was the range of expertise appropriate or adequate?

Wednesday

3rd Session 09:30 - 12:30

HAEDAT and Decadal Maps

d) Review the on-line format of HAEDAT system and developments made towards developing an integrated system and evaluate the amendments made to update historical submissions and links to mapping. Perform user identification and plan the promotion of the system;

e) review the structure and composition of the decadal HAE maps for the ICES region with special reference to clarifying the distinction between harmful algal blooms and the harmful affects that are reported on the maps;

Lunch:12:30-13:30

4th Session 13:30 - 17:00

National Reports 1

f) collate and assess National reports and update the decadal mapping of harmful algal events for the IOC/ICES harmful algal database, HAE-DAT;

Thursday

5th Session 09:30 - 12:30

National Reports 2

c) 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;

6th Session 13:30 - 17:00

g) Take part in the Intersessional work led by PGPYME in developing the mission and draft resolutions for a new Expert Group related to phytoplankton and microbial ecology.

Friday

7th Session 09:30 - 12:30

Report Writing and Drafting of TORs for 2008
Selection of 2008 Venue
Summary of Meeting

Adjournment of meeting at 13:00: Lunch

Annex 3: WGHABD Proposed Terms of Reference 2008

The **ICES-IOC Working Group on Harmful Algal Bloom Dynamics** [WGHABD] (Chair J. Silke, Ireland) will meet in Galway, Ireland, from [date to date] March 2008 to:

a) review and discuss HAB events related to aerosolized toxins and the methodologies used to monitor them;

b) WGHABD to generate key questions for HAB models intersessionally, submit to the PBI group for their consideration with the potential for a ToR for the 2008 PBI meeting and a view to holding a joint meeting of both groups in 2009;

c) to discuss the requirements for and, if agreed, plan the preparation of a draft outline an ICES Cooperative research report on new findings and developments relating to the distribution of phycotoxins and metabolites and recent findings on the distribution of HABs and toxin producing phytoplankton species in the ICES area;

d) review developments in knowledge pertaining to the development of *Verrucophora* and *Chattonella* blooms;

e) 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;

f) collate and assess National reports (Country Reports);

g) review the progress on intersessional updating and inputting data in the IOC-ICES-PICES HAEDAT database and developments made towards developing an integrated system;

h) review the structure and composition of the decadal HAE maps for the ICES region with special reference to the linkage between the decadal maps and the HAEDAT database and the need for new maps for specific algal species;

i) review intersessional work to generate a website to electronically archive past reports of the WGHABD and to facilitate intersessional work carried out by the group;

j) investigate and discuss the possibility of comparative studies that will use mesocosms to explore the dynamics of HABs subject to eutrophic pressures.

WGHABD will report by [date] 2008 for the attention of the Oceanography Committee and ACME.

Supporting Information

PRIORITY	The activities of this group are fundamental to the work of the Oceanography Committee. The work is essential to the development and understanding of the effects of climate and man-induced variability and change in relation to the health of the ecosystem. The work of this ICES-/IOC WG is deemed high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN	Action Plan No: 1.1, 1.2, 1.5, 1.7, 1.10, 1.11, 1.12, 2.3, 2.9, 3.2, 4.11, 5.10, 5.13, 5.16, 6.1, 6.2, 6.3, 6.4, 8.1, 8.2, 8.4. **Term of Reference a)** During recent years, there have been increasing reports of respiratory irritations affecting sun-bathers in coastal waters of Europe. The victims, sometimes in high numbers (up to 100), have required medical assistance. These events have been associated with toxic aerosols derived from epibenthic microalgae of the genus *Karenia* and *Ostreopsis*, that eventually colonize the water column. Current gaps in scientific knowledge are multiple, and concern: a) The hydrodynamic conditions that lead to the detachment of seaweeds and other substrates where the microalgae are attached leading to their resuspension in the water column; b) The seasonality of these microalgae and the environmental conditions promoting their numerical increase; c) The appropriate protocols to monitor epibenthic microalgae populations, whether attached or loose in the water column, and the toxic aerosols derived from them; d) The complex mechanisms underlying the passage of toxins from the whole cells to the irritatory aerosols. It would be beneficial to the group to compile the available information of these events, derived actions, and gain from the years-experience on respiratory irritation syndromes related with *Karenia brevis* events from the Florida coasts. **Term of Reference b)**

	Current knowledge on modelling HABs and HAB physical-biological processes is limited. Improved knowledge on the validation of these models and the status of coupled physical-biological process knowledge is essential to improve models for HAB dynamics. WGHABD wish to pursue this by interdisciplinary work with WGPBI and development of joint TORs and potential joint WG sessions in the coming years. **Term of Reference c)** In 1992, ICES published a Co-operative Research Report "Effects of harmful algal blooms on Mariculture and marine fisheries". At the time, this document has proved to be extremely useful for scientists, policy administrators and those involved in operational management programmes. Recent years have seen significant developments in the detection of toxins, their distribution and the occurrence of HAB and toxin producing phytoplankton species and events. The WG consider it timely to discuss the need for a new CRP on new findings and developments relating to the distribution of phycotoxins and metabolites and recent findings on the distribution of HABs and toxin producing phytoplankton species in the ICES area. To this end, at its next meeting of the WGHABD, the requirements for and content of a review will be discussed and if agreed a work programme will be prepared. As a first step, the WGHABD will review the biogeography of phycotoxins and associated causative organisms. **Term of Reference d)** Harmful blooms of *Chattonella* spp. are known from many locations around the world. The first harmful bloom in European waters occurred in 1998. The blooming species was then first identified to *Chattonella* aff. *verruculosa,* but after comprehensive morphological and genetic characterization of the species, it turned out to be a new genus, named *Verrucophora.* Since 1998 it has bloomed recurrently in European waters, and seems, that many of the species belonging to the genus *Chattonella,* to be able to out-compete diatoms. The recent years much new knowledge on *Chattonella* and *Verrucophora* spp. and their blooming dynamics has appeared, from blooms, morphological and genetic studies, cultivation experiments and modelling. Thus it is timely to review the state of the art with respect to our common knowledge related to the blooming and dynamics of these widespread species. **Term of Reference e)** The forum for presenting new findings has been an excellent tool for promoting the discussions about topics of general interest. There are obvious reasons to continue with this topic as a term of reference. **Term of Reference f)** National reports HAEDAT is an extremely valuable dataset that is only now becoming extensively utilised. There are developments on the technical end that allow users to mount their data and query it through the Internet. This system was demonstrated to WGHABD in 2006 in a near complete version. It is requested that the finished version be presented in 2007, and potential uses be identified. **Term of Reference g)** The progress made during the last intersessional period in HAEDAT which allows the direct production of maps, entails the need of filling in location information (HAE-Areas) in old reports. WGHABD members have been asked to edit old reports, mainly focusing on location information, but also on editing or correcting other data when needed . After the HAEDAT testing period, some WGHABD members have submitted their comments to HAEDAT managers to improve the quality of the Database and to make the Harmful Event Information System web site more user-friendly. These modifications should be reviewed by WG members. **Term of Reference h)** The work of collating the national HAE reports and building up HAE-DAT and the associated maps is an activity which is unique to the WGHABD. HAE-DAT is not yet established enough to stand alone. A critical step forward is to make HAE-DAT operational with input from regions/countries outside the ICES areas as originally envisaged. PICES, South America, HANA and Caribbean countries (via IOC/FANSA and IOC/ANCA) are now included in HAE-DAT. It should be endeavoured to include HAE-DAT and the associated decadal maps as a contribution to GOOS, thereby embedding these activities in a permanent setting and securing continuity. **Term of Reference i)** The ICES website maintains an archive the recent reports produced by this working group, and the OCC area of the ICES website publishes the resolutions agreed at ASC. It was noted however, that many of the earlier WG reports, cooperative research reports and other documents are not available in electronic format. It was decided to develop a WGHABD web presence to address this with links to the ICES publications where online and to archive other reports that have not been available. In addition this will facilitate the circulation of other material between group members intersessionally.

	Term of Reference j) WGHABD has both participated in and organised several successful workshops in the past with IOC and ICES sponsorship. The working group wish to explore the possibility of organising another workshop on the topic of HABs subject to eutrophic pressures. The relationship between nutrient (both inorganic and organic) loading and alteration in nutrient supply ratios and many HABs is now recognized, but much remains to be understood. The GEOHAB core project on HABs and Eutrophication has recognised that eutrophication may have a significant effect on HABs and the role of mesocosms would be an appropriate means to study these effects. The workshop approach would allow a number of different investigators to converge on the same site and use their analytical tools and approaches to fully document effects at different trophic levels. The workshop experiments may initiate others, with the ultimate goal to have other mesocosm experiments occur in several locations to study comparative aspects consistent with the GEOHAB approach.
RESOURCE REQUIREMENTS	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.
PARTICIPANTS	The Group is normally attended by some 20–25 members and guests
SECRETARIAT FACILITIES	None
FINANCIAL	No financial implications
LINKAGES TO ADVISORY COMMITTEES	There are no obvious direct linkages with the advisory committees
LINKAGES TO OTHER COMMITTEES OR GROUPS	WGHABD interacts with WGZE, WGPE, SGGIB, SGBOSV, WGPBI.
LINKAGES TO OTHER ORGANISATIONS	The work of this group is undertaken in close collaboration with the IOC HAB Programme. IOC should be consulted regarding ToR or discontinuation of the WG prior to the ASC. There is a linkage to SCOR through the interactions of the IOC-SCOR GEOHAB Programme.