Oceanography Committee

ICES CM 2000/C:06
Ref.:ACME, E

REPORT OF THE

ICES/IOC WORKING GROUP ON HARMFUL ALGAL BLOOM DYNAMICS

Barcelona, Spain

20–24 March 2000

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 WELCOME AND OPENING OF THE MEETING

The IOC-ICES Working Group of Harmful Algal Bloom Dynamics was convened at The Institute de Ciències del Mar, Barcelona, Spain, during 20-24 March, 2000. The meeting was organised by Elisa Berdalet and it was chaired by Kaisa Kononen (Finland). 31 scientists from 14 countries participated. The list of participants is in Annex 1. The meeting agenda is presented in Annex 2. During 22-23 March, a joint session on coupled physical-biological modelling was held jointly with the Working Group of Shelf Seas Oceanography. The agenda of the joint meeting is presented in Annex 3.

The meeting was opened by the local organiser, Elisa Berdalet followed by an introduction of the participants.

2 TERMS OF REFERENCE

At the 87th Statutory Meeting in Stockholm (Sweden) the Council resolved that (C. Res. 1999/2C06)

The **ICES-IOC Working Group on Harmful Algal Bloom Dynamics** [WGHABD] (Chair: Dr K Kononen, Finland) will meet in Barcelona, Spain from 20 – 24 March 2000 to:

ToR1) collate and assess national reports, update the mapping of HABs and summarise the information in the harmful algae event database (HAEDAT) on a regional, temporal and species basis

ToR2) prepare a retrospective and critical analysis of the work performed by the Working Group in the course of its existence;

ToR3) examine the possible ways of analysing historical data and fossil records with the help of an invited specialist;

ToR4) examine information on the possible implication of benthic species in toxic events and report on induced problems on monitoring procedures;

ToR5) assess current knowledge on the importance of physics in relation to harmful algal blooms as well as possible implications of modelling input on pelagic biological monitoring programmes (with WGSSO);

ToR6) compare model parameterisations for growth rates, nutrient uptake rates, nutrient limitation, predation rates remineralization rates and the physics of the turbulent fluxes and stresses (with WGSSO);

ToR7) review scenarios of toxic events developments;

ToR8) report and discuss new findings;

ToR9) consider the role of ICES in the new international programme GEOHAB

ToR10) consider, and where feasible, develop data products and summaries that can be provided on a routine basis to the ICES community via the ICES website;

ToR11) examine the 1999 Oceanography Committee Working Group reports 2000 TORs to identify where inter-group input could be provided or required with the view to formulating key questions requiring inter-disciplinary dialogue during concurrent meetings of the Committee's Working Groups in 2002.

The 5th Intergovernmental Panel of Harmful Algal Blooms, 22-24 November 2000, Paris (Res. IPHAB-V.2), decided to:

ToR12) present the draft IOC-APEC document 'Guidelines on Emergency Measures for Harmful Algal Events' for review by the IPHAB Members and the ICES-IOC Working Group on Harmful Algal Bloom Dynamics

3 SUMMARY AND CONCLUSIONS

Term of Reference 1: collate and assess national reports, update the mapping of HABs and summarise the information in the harmful algae event database (HAEDAT) on a regional, temporal and species basis

Country representatives presented summary reports of HAB occurrences in the respective sea areas. For the first time, the reports of HAB events were submitted directly to the HAEDAT data base through the internet. Those inputting data, however, found difficulties in submitting the information as requested, and some specific problems were found in filling in the forms. A sub-group discussed issues related to the new forms and made a proposal for improvement. Furthermore, a re-evaluation of the form is required during next year's meeting. This item should be included as a Term of Reference for the 2001 meeting.

Term of Reference 2: prepare a retrospective and critical analysis of the work performed by the Working Group in the course of its existence

The meeting examined the Working Group reports since its establishment in 1992. The following themes have been under discussion, review or other activity during the life time of the WGHABD.

Pilot studies. Two studies out of four that were originally planned for 1994-1996, were conducted. It was noted that no new international cooperation was undertaken. Nevertheless, a planning phase of case studies was very valuable in providing a framework to initiate discussions between physicists and biologists. For example, the planning exercise done for the Baltic Sea should facilitate the integration of a Baltic Sea project into GEOHAB.

Workshops on methods for determining in situ growth rate. Two workshops were organised in 1994 and 1996. Due to the difficulty of measure *in situ* growth rates of dinoflagellates and to the lack of established methodology, the workshops became experimental in nature and valuable as such. Conclusion of these two attempts are: 1) planning should have been more efficiently organised by preparation meetings 2) there should have been an organising committee for both of the workshops.

National reports and data base. This exercise was considered valuable and worth continuing.

New findings. The forum for presentations was considered useful, as it led to discussions about actual topics, and even to intersessional activity by participants on issues that were raised up during discussions.

Population scenarios. An attempt was made to collect information about population scenarios of HABs in different hydrodynamical regimes through a questionnaire. It appeared that this exercise was probably premature given the degree of understanding of the oceanographic features in the HAB monitoring community.

Theme sessions. WGHABD initiated two Theme sessions (Small-scale interactions 1997, Mitigation in 1999). High attendance and increased contributions were difficult to obtain due to the structure of ASC which was not seen by many scientists as a standard scientific meeting. The evolution foreseen in the ICES Annual Science Conference should improve and increase the attendance to theme sessions.

Dialogue between physicists and biologists. In addition to joint sessions between WGSSO and WGHABD, the dialogue between physicists and biologists has been enhanced by the regular attendance of physicists to WGHABD annual meetings.

Reviews of items relevant in HAB dynamics. Different members of the WGHABD have reviewed many topics. The group felt that ICES should encourage the production of reviews as well as publication (following peer-review), of some of the material presented during Working Group meetings.

Monitoring and mitigation strategies. The WGHABD recommended that a specific study group be established with the appropriate terms of referee.

Term of Reference 3: examine the possible ways of analysing historical data and fossil records with the help of an invited specialist;

André Rochon gave a presentation from Canadian research on the geological history of red tides on the Canadian Atlantic and Pacific coasts. This approach reveals changes in HABs in relation to geological and climatic time scales.

Results of the geological studies showed that total cyst production and bloom formation were higher than at present by one order of magnitude on both eastern and western coast of Canada during the early Holocene (*ca.* 10,000 years ago), despite a colder climate. However, summers were 8% warmer during that period due to increased insolation, which might have favoured late fall cyst production. On the continental shelf coast of eastern Canada, cyst production seems to have been lower during the mid–Holocene warm interval (ca. 6000 years ago) although production of *Alexandrium* was high in coastal waters (Miller *et al.*, 1984). Total cyst production also decreased during the mid-Holocene on the west coast, but PSP species increase during that period. During the last ca. 2000 years, the fossil record indicates that cyst production and bloom frequency increased on both the east and west coast, but not as much as that reported during the historical record.

Corresponding information is needed from other areas with regular blooms, therefore it is worth keeping this ToR for the meting next year.

Term of Reference 4: examine information on the possible implication of benthic species in toxic events and report on induced problems on monitoring procedures;

Benthic dinoflagellates and other potentially harmful algae such as the raphidophytes and some diatoms have received very little attention so far although they are widespread throughout the world. Many new species have been described in the last few years, but only a few have been cultured and/or analysed for toxicity. This is partly due to problems with culturing benthic species. The taxonomy of the benthic species is so far not well understood and particularly the taxonomy of the toxic species *Prorocentrum lima* is very confusing. The WG summarised information about the implication of benthic species in toxic events, needs for further research as well as methodology to study benthic species.

Term of Reference 5: assess current knowledge on the importance of physics in relation to harmful algal blooms as well as possible implications of modelling input on pelagic biological monitoring programmes (with WGSSO);

This Term of Reference was discussed in a joint session together with WGSSO. The session was comprised of an introduction and a series of scientific presentations and a sub-group meeting discussing improvements in our understanding of HABs in terms of modelling since the last joint session in Vigo, Spain (1994).

Most of the presentations given included the coupled physical-biological approach. Based on the presentations, the general feeling was that considerable progress had been made since 1994 in the development of a common language between modellers and biologists.

Term of Reference 6: compare model parameterisations for growth rates, nutrient uptake rates, nutrient limitation, predation rates, remineralization rates and the physics of turbulent fluxes and stresses (with WGSSO);

Parameters required for HABs modelling were listed and discussed. Accordingly, state variables and processes were determined for the different bloom phases - initiation, development and decline.

A following 4-class classification of the different models based on their utility, was prepared in order to determine the level of complexity required:

1. Very complex comprehensive community models (learning tool, long-term prediction, exploration of scenarios).

2. Less complex multi-species models (e.g. include algal growth, grazing rates).

3. More simple, single species models (e.g. physical model with algae as passive tracers).

4. Empirical models (e.g. models for statistical forecasting).

The participants also tried to rank by importance the parameters that need to be included in physical-biology models. The ones that came up the most often were: 1) the initial field (N_0 (x,y,z)), 2) the particular behaviour of the targeted species (e.g. swimming dinoflagellate, fast sinking diatoms, etc.), 3) the *in situ* growth rate, and 4) the factor(s) controlling toxicity.

In order to improve our modelling capacity of HABs, the discussion group members concluded that we need to improve data assimilation and real-time observing systems. In poorly known systems, new approaches such as inverse modelling and neural networking should also be tested. The level of definition required for the physical models was discussed and it was concluded that this was species specific. In some cases, physical models clearly require a fine resolution (e.g. eddy resolving models). This is particularly true for species forming micro-layers.

Regarding our predictive capacity, it is important to build on our current capabilities such as 3D currents and temperature forecasts. The value of experience-based relationships was also recognised (e.g. empirical relationships between wind or salinity and HABs). Whatever the level of complexity of the model, there was a general consensus that one should be cautious about the capacity of any model for long-term predictions.

Term of Reference 7: review scenarios of toxic events developments;

This ToR was not discussed by the WG due to the fact that no new input on this topic was available.

Term of Reference 8: report and discuss new findings;

Seven contributions were presented. In general, this ToR was regarded to be valuable as it gave an opportunity for free discussions and exchange of ideas.

Term of Reference 9: consider the role of ICES in the new international programme GEOHAB;
The WGHABD recommends that ICES play a leading role in the development and implementation of GEOHAB. This could be through planning and coordinating the implementation of regional studies, which address major research questions such as those identified in the GEOHAB Science Plan. As an example, the Baltic Sea is one region particularly suited for a cooperative GEOHAB study under the auspices of ICES. Several of the GEOHAB objectives are similar to, or have emerged from, issues delt with by the WGHABD since its beginning. The continued interaction between the WGHABD and WGSSO would also be of value in this context.

The WGHABD concluded that it would be desirable if, within the ICES framework, it would be feasible to plan and implement the GEOHAB regional components through a mechanism similar to the 'Cod and Climate Programme' including a project coordintor.

Term of Reference 10: consider, and where feasible, develop data products and summaries that can be provided on a routine basis to the ICES community via the ICES website;

Since 1997 WGHABD has produced decadal maps of HAB occurrences in the ICES area and these maps are published on the ICES and IOC web-pages. The continuation of this activity is relevant in terms of this ToR. New data products and summaries may be generated on the basis of HAEDAT.

Term of Reference 11: examine the 1999 Oceanography Committee Working Group reports 2000 TORs to identify where inter-group input could be provided or required with the view to formulating key questions requiring inter-disciplinary dialogue during concurrent meetings of the Committee’s Working Groups in 2002;

The interdisciplinary nature of HAB phenomena *per se* imply involvement of various approaches, all of which cannot be dealt with by the WGHABD alone. Dialogues including joint meetings has already been established between WGHABD and WGSSO and WGPE. Topics for broader interdisciplinary dialogue were identified, including possible joint sessions with SGGOOS, WGHO, SGPHYT, WGZE, SGPRISM.

Term of Reference 12: present the draft IOC-APEC document ‘Guidelines on Emergency Measures for Harmful Algal Events’ for review by the IPHAB Members and the ICES-IOC Working Group on Harmful Algal Bloom Dynamics;

The document was found extensive and easy to read. Some general and detailed comments were given.

4 NATIONAL REPORTS AND HAEDAT-DATABASE

Term of Reference 1: collate and assess national reports, update the mapping of HABs and summarise the information in the harmful algae event database (HAEDAT) on a regional, temporal and species basis.

4.1 National reports

Country representatives presented summary reports of HAB occurrences in their respective sea areas.

FINLAND Information based on Alg@line monitoring.

In summer 1999, the surface accumulations of blue-green algae extended over the whole Baltic Sea except the Bothnian Bay. The blooms were, however, not so intensive than in the record summer 1997. The blooms were most extent in late July and early August.

In the Gulf of Finland, the first surface accumulations were observed in late June. Then the non-toxic *Aphanizomenon* sp. was dominant. Later the toxic species *Nodularia spumigena* became abundant, especially in the open sea. The latest surface accumulations were observed in the end of August.

In the Northern Baltic Proper, the blue-green algae started to become abundant in the end of June and the first surface accumulations were observed in the beginning of July. The non-toxic *Aphanizomenon* sp. was the dominant species. During the first week of August, the surface accumulations were most extent. Then the toxic species *Nodularia spumigena* was abundant.

In the Bothnian Sea, the first surface accumulations appeared in the beginning of August and they persisted during the whole month.

In early August, scattered accumulations were also detected in the Åland Sea.

NORWAY

The occurrences of paralytic shellfish toxins (PST) in Norway were small in 1999. Concentrations above the quarantine level were recorded only at some few locations along the west coast and in northern Norway, in April-June and June-September respectively. Diarrhetic shellfish toxins (DST) were for the first time recorded in our northernmost county, Finnmark (September-October). As more or less normal, DST were also found along the Skagerrak coast from October throughout the year and at a couple of locations at the west coast. The harvesting of mussels was banned from July to December in two fjords at the west coast (Lysefjorden and Sognefjorden) due to yessotoxin (YTX). YTX was also recorded for shorter periods at other locations along the west coast and the Skagerrak. The source organism(s) to YTX in our waters is not known. A bloom of *Gymnodinium chlorophorum* in the Skagerrak in September-December was seen as patches of greenish water, but no acute effects were reported.

SWEDEN

During 1999 no major blooms causing a lot of harm or damage to the marine ecosystem occurred in Swedish coastal waters. Still there are some phytoplankton occurrences which should be mentioned. From March to October the three *Alexandrium* species *A. ostenfeldii*, *A. tamarense* and *A. minitum* were present in densities from a few cells up to 2000 cells/l along the Skagerrak coast. The PST content in shellfish was not measured and in August a warning was given to the public for harvest of mussels. From July and onwards DST was detected in mussels along the Skagerrak coast. This was, like in 1998, an early appearance of DST compared to what has been regarded as ”normal”. Maximum measured toxin level was 1250 µg Okadaic acid per kg mussel meat and harvest of cultivated mussels was periodically stopped as well as the public was warned to pick mussels.

Not causing any known harm, but visible as strongly green-coloured water was a bloom of *Lepidodinium viridi* alternatively *Gyrodinium cloroforum* which occurred in the Kattegat – Skagerrak area during October and November. In the same area *Pseudonitzschia* spp was also observed in abundances of up to $3 \cdot 10^6$ cells/l, but no management decision was taken.

In the Baltic no harmful events caused by phytoplankton was observed this year in the coastal areas. However, offshore in June larger abundances of *Dinophysis* than what is considered to be normal were observed. During summer large surface accumulations of the potential problematic bluegreen algae were observed offshore over large parts of the Baltic Proper. In the northern part *Aphanizomenon* sp was dominating while *Nodularia spumigena* was more common in the south.

GERMANY

Malte Elbrächter

(sea also MURSYS - Report, BSH)

North Sea: As each year, the non-toxic phytoplankton-species *Noctiluca scintillans* and *Phaeocystis globosa* caused water discoloration at the sea surface respectively foam production.

Due to *Dinophysis acuminata*, mussels in the North Frisian Waddensea off Amrum and Sylt contained DSP-concentrations about the maximum allowed level. Therefore mussel harvesting was closed for about 10 days in August 1999 in some of the mussel cultures. Imported mussels from Denmark (03. August 1999) had a DSP-concentration of 600 µg/kg. For the first time *Prorocentrum lima* was found in German waters in the Nord-Sylter Wattenmeer in the vicinity of an oyster-culture. The species has been isolated and clonal cultures are under investigation in respect to their toxin profiles.

Other toxic phytoplankton-species were registered in low numbers at various times of the year not causing problems. These species were the dinoflagellates *Alexandrium tamarense* and *A. ostenfeldii* and the raphidiophytes *Fibrocapsa japonica*, *Chattonella verruculosa* and *Heterosigma akashiwo*.

Baltic Sea: In German coastal waters of the Baltic Sea cyanoprokaryonta (blue green algae) were not so abundant as in the other years. During routine monitoring Nodularia spumigena was abundant (0.3 mm^3l^{-1}) only in the beginning of September 1999. Adverse effects were not registrated. The potentially toxic diatom Pseudo-nitzschia pungens or P. multiseries (no EM-determination) was abundant in the last two weeks of October and the first week of November (up to 0.4 mm^3l^{-1}), again adverse effects were not registrated.

DENMARK

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The phytoplankton in Danish coastal waters and fjords in 1999 was characterised by relatively high concentrations and biomasses in the spring and most of the summer period.

The following harmful/toxic and potentially toxic algae were registered in high concentrations:

Dinoflagellates *Prorocentrum minimum, Prorocentrum cf. triestinum, Prorocentrum micans, Dinophysis acuminata and Gymnodinium chloroforum.*

Diatoms *Pseudo-nitzschia delicatissima*-group.

The following toxic and harmful/potentially toxic algae were registered in low concentrations:

Dinoflagellates *Alexandrium pseudogonyaulax, Alexandrium ostenfeldii, Alexandrium tamarense, Dinophysis norvegica, Dinophysis acuta, Dinophysis rotundata, Prorocentrum lima, , Gymnodinium sanguineum, Noctiluca scintillans.*

Diatoms *Pseudo-nitzschia seriata*-group.

Others *Dictyocha speculum* (-"Si-skeleton"), *Phaeocystis pouchetii, Chrysochromulina* spp.

Intensified monitoring and/or closing of shellfishery due to elevated concentrations of *Dinophysis acuminata, Dinophysis norvegica*, *Alexandrium* species and *Pseudo-nitzschia*-species exceeding the concentrations in the veterinary guidelines, were imposed at several occasions in Danish coastal waters. DSP was registered in Ho Bugt - The Danish Wadden Sea in August. No other algal toxins were registered in shellfish in 1999 and there is no reports of human intoxication's caused by consumption of Danish shellfish in 1999.

Denmark 1999 - in brief

DSP was registered in Ho Bugt - The Danish Wadden Sea in august 1999. The causative organism was *Dinophysis acuminata*. No other algal toxins were registered in Danish coastal waters in 1999. During summer several spectacular blooms developed in the Kattegat/ Belt Sea area. N*odularia spumigena* was introduced from the Baltic Sea, *Prorocentrum minimum* bloomed due to in-situ growth in several fjords, *Pseudo-nitzschia delicatissima*-group bloomed in the south western Kattegat together with the green dinoflagellate *Gymnodinium chloroforum*. The bloom of *Gymnodinium chloroforum* (max. conc. 6 mill. cells/l; time: August-November) caused problems to the fish farmers because the fish stopped feeding for about a month - **no** increase in the mortality was observed.

ESTONIA

Summer 1999 was exceptionally warm in Baltic countries, being expressed in phytoplankton dynamics since early June by rapid increase in abundance of small flagellates (especially *Chrysochromulina* spp.) up to 10 mill. cells l^{-1} in the Gulf of Finland and to a less extent in the Gulf of Riga. The Baltic Proper was not monitored in summer 1999.

A vigorous blue-green algal bloom could be expected due to highly favourable meteorological conditions, but the level recorded in July 1997 was not reached. The mass occurrence of flagellates could be a factor suppressing the cyanobacterial development in a way. The surface accumulations, mainly formed by *Aphanizomenon* sp. and *Nodularia spumigena* have been still observed from late June until the mid August in the southern part of the Gulf of Finland. Although the toxicity analysis gave positive response, no intoxication effects were reported from Estonian coastal waters.

In September-October the mass occurrence (cell density up to 1 mill. l^{-1}) of potentially harmful dinoflagellate *Prorocentrum minimum* was for the first time observed in the western and central Gulf of Finland. The first records of *P. minimum* from that area have been described in 1993.

THE NETHERLANDS

In The Netherlands, several monitoring programmes are operational. They do not only differ in aims, performing institutes and geographical locations, but also in accessibility to the monitoring results. The phytoplankton monitoring programmes in The Netherlands are:

NICMM: Biomon-programme (general phytoplankton monitoring at ca. 30 estuarine and North Sea stations since 1989; inf. P.V.M.Bot@rikz.rws.minvenw.nl or L.P.M.J.Wetsteyn@.rikz.rws.minvenw.nl).

NIOZ: Phaeocystis monitoring in the Marsdiep since 1973 by Dr G.C. Cadee (inf. Cadee@nioz.nl).

RIVO: monitoring of toxic phytoplankton near and at shellfish production sites; monitoring of (shell)-fish for phytotoxins (inf. Miriam Collombom: miriamc@rivo.dlo.nl).

RIZA: freshwater monitoring of cyanobacteria and their toxins; started in 1997 in Lake IJssel (inf. B.Ibelings@RIZA.rws.minvenw.nl).

Here the 1999 results of the MONISNEL monitoring programme of the National Institute for Coastal and Marine Management/NICMM will be presented (inf.: L.Peperzak@rikz.rws.minvenw.nl). This is an early warning system for HAB species with 4 widely different monitoring stations (Oosterschelde, Dutch coast, Wadden Sea, central North Sea).

In general, the concentrations of potentially toxic phytoplankton species was remarkably low in 1999:

Gymnodinium mikimotoi: concentrations at all 4 stations were less then 10 cells per litre, the lowest abundance in 10 years.

Dinophysis spp.: low concentrations (less then 100 cells per litre) at all 4 stations.

Phaeocystis globosa: 15-20 million cells per litre in spring in the Oosterschelde and at the coast of Holland. In the Wadden Sea maximum P. globosa concentrations were 7 million per litre, and < 1 million per litre in the oligotrophic central North Sea.

Noctiluca scintillans: maximum concentrations were only 100 to 300 cells per litre at the Dutch coast.

FRANCE

Fifteen sites were affected by DSP toxins, and four sites by PSP toxins, along the French coast in 1999 (the whole coast is divided into 43 sites).

As in previous years, DSP toxins were detected in shellfish from southern Brittany and western Mediterranean. This year, DSP episodes also affected a large part of Atlantic coast, which is not often the case. The highest observed concentrations for *Dinophysis* were 6000 cells per litre.

PSP episodes have affected the four sites where toxic species of *Alexandrium* have been already observed. In northern Brittany, blooms of *Alexandrium minutum*, with concentrations up to 6 millions cells per litre, were associated with PSP episodes during the period from June to August. Toxins in shellfish reached maximum levels of 180 µg per 100 g of flesh. In the Mediterranean Thau lagoon, a bloom of *Alexandrium tamarense* occurred for the second time in October, with concentrations up to 260000 cells per litre. Toxins in shellfish reached maximum levels of 140 µg per 100 g of flesh.

For ASP, low quantities of ASP toxins (not more than 3 µg of domoic acid per g of flesh) were detected in western and southern Brittany, along the Atlantic coast, and in western Mediterranean. Many blooms of *Pseudo-nitzschia* regularly occur along the whole French coast with high concentrations (several millions of cells per litre), but we now observe the two toxic species *P. pseudodelicatissima* and *P. multiseries* at concentrations which seem to increase.

Very big blooms of *Gymnodinium chlorophorum* occurred along a great part of Atlantic coast, from June to September, forming big patches of green water. The maximum concentration observed was 16 millions cells per litre in Vilaine bay. The consequences of anoxia produced by the blooms were mortality of marine animals such as mussels, congers and grey shrimps. There were also blooms of this species along the Channel coast (Normandy), but of less importance.

SPAIN

Harmful algae events in Spain in the different autonomous communities during 1999 can be summarised as follows:

Andalucía: DSP outbreaks associated with *D. acuminata* in the Atlantic coast of Andalucia and PSP outbreaks caused by *Gymnodinium catenatum* in both the Atlantic and the Mediterranean coast.

Balearic Islands: Patches of *Alexandrium minutum* in Palma de Mallorca causing social alarm in an area with no shellfish exploitation.

Catalonia: As in 1998, PSP outbreaks associated with blooms of *Alexandrium catenella* occurredin different localities. A moderate PSP outbreak occurred in the Ebro Delta region associated with *A. minutum*. Moderate number of *Pseudo-nitzschia* species are observed in areas where neither shellfish exploitation nor toxin monitoring takes place.

Galicia: ASP outbreaks associated to *Pseudonitzschia australis* in the Southern and Northern Galician Rías from May to June, and a very late unusual outbreak in the Southern Rías in mid-December. DSP outbreaks caused by *D. acuminata* in differents pulses from May to September in all the rías. As in the previous 4 years, the absence of PSP outbreaks caused by *G. catenatum* continues.

CANADA

West Coast: Predictions were made early in the year, based on the record snow pack on the mountains of Vancouver Island and the mainland, that major blooms of *Heterosigma carterae* would occur. However, the unseasonably cool temperatures throughout the summer prevented the formation of warm water / high stratification conditions. So although the normal *Heterosigma* bloom appeared in English Bay, adjacent to Vancouver, and developed up the Strait of Georgia to Jervis Inlet in July, it as not extensive and dissipated by early August.

Heterosigma blooms were far from typical during this year, with blooms observed in areas where it had never been seen before, such as Clayoquot Sound, or it bloomed much later than usual, such as in Kyuquot Sound in October. Some *Heterosigma* was seen in these inlets on the west coast of Vancouver Island at the beginning of blooms of *Cochlodinium* sp. *Cochlodinium* sp., which had never been observed as a problem on the west coast of Canada, formed dense blooms in inlets on the west coast of Vancouver Island, causing mortalities to farmed fish in Kyuquot and Quatsino Sounds. Harmful *Cochlodinium* was observed in significant numbers, up to 60,000 cells/mL, in July and August in Holberg Inlet, Quatsino Sound, and in October in Clayoquot Sound. It appeared that some environmental factor(s) favoured *Cochlodinium* this year, as it quickly outcompeted *Heterosigma* in most areas. Interestingly, in live samples that were sent to the Pacific Biological Station, *Cochlodinium* cells were not able to survive in culture for long, and were replaced almost invariably by *Heterosigma*. All attempts to culture *Cochlodinium* for further experiments at PBS were unsuccessful.

Some sites near the mainland on the east side of Vancouver Island had diatoms dominant or blooming all summer, probably due to the slow constant melt of the snow pack. *Skeletonema costatum* was the dominant diatom in the Queen Charlotte Strait, on the northeast corner of Vancouver Island. Concentrations were observed up to 20,000 cells/mL. *Chaetoceros* species were also quite numerous, although little harmful *Chaetoceros* was seen in this area during the year. *Leptocylindrus minimus* was dominant in some areas on the west coast of Vancouver Island. Although implicated in fish mortalities in Chile, blooms of this species demonstrated no adverse affects on farmed fish. *Corethron hystrix*, another fish killer, was seen in concentrations up to 150 cells/mL in late July in Johnstone Strait, but again fish did not appear affected in this case.

Dinoflagellates formed several blooms during April to October. In addition to the major bloom of *Cochlodinium* sp. in Clayoquot, a thick bloom of *Heterocapsa triquetra* and a bloom of *Prorocentrum gracile* were also found to be associated with the *Cochlodinium*. *Prorocentrum minimum* bloomed in Quatsino Sound and in Jervis Inlet, on the mainland directly east of Nootka Sound.

Water nutrient analyses have yet to be completed at the time of writing. It will be interesting to compare this and future year's nutrient data, to determine if unusual levels of nutrient together with the cool summer and warm fall resulted in the atypical plankton conditions of this year.

East Coast: Although shellfish harvesting areas in the Bay of Fundy were closed to harvesting as a result of PSP toxins, it was for a short period. The *Alexandrium* cell concentrations were lower than during most years, with highest concentrations (6 000 cells L) observed in offshore waters. Domoic acid was not detected.

In northern Passamaquoddy Bay (southwestern Bay of Fundy), a *Prorocentrum minimum* bloom was implicated on Aug 4 following salmon mortalities. Two weeks later, a *Mesodinium rubrum* red tide occurred (Aug. 17-24) producing elevated oxygen levels and stress in salmon. Further salmon mortalities occurred in September as a result of *Chaetoceros socialis* embedded in gills and excess mucus secretions.

1999 was a very unique year for the Gulf of St. Lawrence with respect to toxin outbreaks. First, shellfish harvesting areas were closed as a result of PSP toxins. Maximum *Alexandrium tamarense* concentrations (17 000 cells/l) were detected at Sept-Îles on the North shore of the Gulf. Second, high levels of domoic acid (DA) were recorded for the first time in the Magdalen Islands area (up to 550 µg/g in August) in digestive glands of scallops. Later on, low levels of DA were also measured in shellfish (blue mussels and soft-shell clams) collected in the lagoons of the Magdalen Islands. This DA outbreak coincided with an increase in abundance of *Pseudo-nitzschia seriata* (12 000 cells/l) and to a lesser extent *Pseudo-nitzschia delicatissima* (1 750 cells/l) in the Havre-aux-Maisons lagoon. We believe that these cells were advected from offshore where highest concentrations were probably present. The scallop digestive glands remained toxic for the whole summer, prompting the Quebec Government to alert the public as to the hazards of eating whole scallops. DA was also measured along the North shore of the Gulf, suggesting that the *Pseudo-nitzschia* spp. bloom covered a large portion of the Gulf at some period. Finally, for the second year in a row (first occurrence in 1998), low levels of DTX1 were measured in blue mussels and soft-shell clams harvested in the Magdalen Islands lagoon. *Prorocentrum lima* was found to be epiphytic on mussels suspended from socks, but there was no relationship between cell numbers and DTX1 concentrations. *Prorocentrum mexicanum* was also detected in the water column and in the guts of the mussels. This was the first record of detection of *P. mexicanum* in Eastern Canada.

U.S.A.

1999 was basically a “normal” year for HABs in the U.S. As happens most years, PSP was recorded in the New England states as well as California, Washington and Alaska on the west coast. ASP levels were measured at or below quarantine levels in Washington state. Brown tides were observed in New Jersey as well as Delaware's inland bays. The Florida red tide recurred as well, and was present on the Southwest, Northwest, and Northeast coasts of Florida during the same time period, causing fish kills, respiratory irritation, toxicity in oysters and dolphins, and possibly manatees. A *G. breve* bloom also occurred in Louisiana, but did not extend inshore to areas with oyster beds so there were no closures or reported problems. This year there were no reports of fish kills attributed to *Pfiesteria* in North Carolina or Chesapeake Bay.

4.2 Decadal maps

The **decadal maps** were updated by national representatives, and are presented as Annex 4.

4.3 HAEDAT database

The HAEDAT database has been available since October 1999 at the IOC web site (http://ioc.unesco.org/hab/data33.htm). National Reports from 1987 to 1998 have been entered (n=1109). A background page, the disclaimer note approved during the WGHABD meeting in 1999 (Jena, Germany, March 1999), and the database download page are included (Annex 5). The reviewed National Report forms and the instructions to fill them are also available (Annex 6).

Approximately 100 events are reported each year. 50% of these events are related to seafood toxins, 40% are due to water discolourations and high phytoplankton concentrations, 6% are related to mass mortalities, 1% corresponded with foam accumulations, and 4% did not correspond to any of these categories. In relation to toxicity, 37% of the events were related to PSP , 40% to DSP, 6% to ASP, 1% to cyanobacterial toxins, and the remaining 16% had other effects differing from the syndromes mentioned above.

National focal points will submit the national reports on harmful algae events to the IOC-IEO Science and Communication Centre in Vigo either by e-mail (vigohab@vi.ieo.es) or by ordinary air mail service. Future steps will include the development of a new automatic system (interactive, more user-friendly) for data entry of the National Reports, as well as for the linkage of the HAEDAT with other IOC-ICES data bases such MONDAT.

A sub-group met to discuss issues related to the new forms that have been developed for national bloom reports. The new form was the result of lengthy discussions from past WG meetings, but this was the first year that efforts were made to fill it out. National delegates reported mixed responses by those asked to complete the forms (including the delegates themselves). Some found the new form acceptable, but others found it too complicated and time-consuming. Some of the past respondents simply refused to send in information – the new form was enough of a bother that they chose not to fill it out. In the past, these individuals have been willing to send in the old form, which was much simpler.

The sub-group identified a number of specific problems with the new form. These included:

- The new form specifies that "precise" days must be given. This is not appropriate for many situations, such as those with extended blooms, or blooms which move from one area to another.

- The accessibility of the form was a problem. It would be desirable to have a form in Word that could be viewed in its exact layout and format, filled out, printed, saved, and sent via e-mail to a specific address, but for many, these steps were not clear on the web page for HAEDAT. It is recommended that some effort be made to make the web access more user-friendly. This is a straight-forward, technical problem compared to the nature of the form itself, but it does need attention.

- It was necessary for respondents to work through the entire form even if they were only filling out a few boxes. A more flexible format would be desirable.

- The form made it difficult to report on a bloom that extended over a large area (i.e., no precise location) or a long time (no precise time).

- Specifying a maximum cell concentration could be misleading. A range of cell concentrations would be more meaningful.

- The area of the bloom is also difficult to determine in some cases. Many would prefer to report the length of shoreline affected.

- The instructions for the form were not found easily. They should be downloaded with the form and should be very precise and clear.

The conclusion was reached that it would be useful to modify the form once again. However, since 14 years of data have already been entered into the HAEDAT database, the sub-group also recognised the need to maintain that database format. Thus the form can be modified, but the data fields should remain much the same. Some can be moved to new locations on the form, but critical fields should not be deleted. Fields that never are filled out could be deleted, however. The concept adopted was to devise a two page form, with the first page containing much of the same information that was collected in the old forms. After that section is filled out, the respondent is then able to enter more detailed information (e.g., nutrients, salinity, precise coordinates, etc.), but only if they wish to, and have the information. Most respondents will probably choose to stop at the end of the first page.

A modified form is presented in Annex 6. A Term of Reference was suggested for the WGHABD to re-evaluate this modified new form again at its next meeting. The IOC HAB Center in Vigo should explore means to automate the data entry, perhaps by making the new form interactive and directly accessible for input via the web, with appropriate control of access and quality. Results of these efforts should be reported to the WGHABD at its next meeting.

5 RETROSPECTIVE AND CRITICAL ANALYSIS OF THE WORK PERFORMED BY WGHABD

Term of Reference 2: prepare a retrospective and critical analysis of the work performed by the Working Group in the course of its existence;

Since its establishment in 1992, the SGHABD and then, the WGHABD focused on the key processes leading to a harmful event. This multi-faceted task has made necessary the detailed analysis of apparently unconnected topics which all contribute to experimental planning and eventually to the understanding of a toxic event, which will lead to prediction and management of some harmful events.

Since the beginning, it was recognised that the WGHABD should focus on one particular species (inoculation, cysts formation, growth, behaviour, interaction with physics, etc …) before considering the species in its own phytoplankton community.

Pilot Studies

In order to approach the oceanography of harmful algal blooms, some case studies were examined. It was hoped to initiate discussion between physicists and biologists by focussing on different hydrodynamical regimes and different species.

Four different pilot studies were selected :

- Kattegatt – Skagerrak area characterised by *Dinophysis*, *Alexandrium* and different ichtyotoxic species in a well-known hydrodynamical environment including buoyant jet circulation and coastal upwelling.

- Iberian Peninsula where upwelling regimes and especially relaxation play a major role in the control of shellfish to accumulate PSP and DSP toxins.

- Gulf of Maine where *Alexandrium* grows and is transported into a coastal buoyant jet.

- Baltic sea which is the location of recurrent cyanobacterial blooms and deep *Dinophysis* populations.

It should be noted that apart from the Gulf of Maine and the Gulf of Finland, which did not imply any new international cooperation, no other pilot study reached the implementation stage.

Nevertheless, these case studies were very valuable in providing a framework to initiate discussions between physicists and biologists.

It was also noted that difficulties in trying to implement pilot studies were due to the fact that national funding agencies appear to be concerned with HABs at the time a toxic event occurs. There is a need for securing sustained funding. This could be achieved through an international programme.

The planning exercise done for the Baltic Sea should facilitate the integration of a Baltic Sea project into GEOHAB.

***In situ* growth rate**

In 1994, a Workshop was held in Rio de Aveiro (Portugal) in order to compare methodologies for measuring in situ growth rates of toxic species in their natural assemblages. It resulted in a series of technical problems caused by inadequate specificity or limited applicability of the methods when applied to natural assemblages.

The attempt was repeated in Kristineberg (Sweden, 1996) on the basis of cultures and mesocosm experiments. Some advanced techniques were planned for use that revealed inadequately established methodology.

The conclusions of these two attempts were that:

- Planning should have been more efficiently organised by preparation meetings.

- Both Workshops should have had an organising committee.

The Workshop participants realised that it is truly a difficult undertaking to measure *in situ* growth rates for dinoflagellates. One problem was that there are no established methods that work for all species in all situations, and other methods were still under development at the time of the Workshop. Therefore, instead of an intercalibration of established methods, the Workshop became more experimental in nature. This was still valuable, since the interactions among participants helped with the experimental design and analysis. But it did mean that results would not be the same as they would have been if several established methods had been available for all Workshop participants to learn and apply. As it stands now, several published papers can be linked to the Workshop activities - either for work conducted in Kristineberg at that time, or work done subsequently, but based on the methods and approaches developed in Kristineberg.

National reports and data base

The WGHABD is the only forum in ICES where monitoring procedures can be documented and where results can be presented. It has been felt that reporting monitoring results should remain in the remits of WGHABD. Standard reporting presented some interest but original reports were neither kept for future use, nor synthetised.

IOC provided some support for the establishment of a database for harmful events. The Working Group advises on the format for electronic reporting and 1999 was the trial year for implementation of the procedure. It was reviewed during the 2000 WG meeting and should soon be available on the web site.

New findings

The WGHABD established a forum for presentation of new results. It provided an excellent opportunity for free discussions on subjects of general interest and to the opportunity to obtain real-time information from the other participants.

The format for informal presentations of new results has been very successful: on average, about 50% of the group reported on new findings. It demonstrates that the group, through its diversity is very active. One significant example was the presentation in 1999-WGHABD of the role that the benthic dinoflagellates play in DSP contamination. All participants agreed to check for the presence of *Prorocentrum lima* and related species in their own countries. Reports were presented in 2000 and demonstrate the ubiquity of these benthic species. This topic requires further work.

Population scenarios

A questionnaire was designed by the Working Group in order to collect information about the different hydrodynamical regimes into which HABs develop. A small number of fully documented cases were returned, most of them already known from literature.

Most of the answers concerned cases where the level of detail was very low and very often associated with the sole observation or measurement of toxin. One outcome of this exercise was the importance in terms of numbers of incidents of toxic events in coastal lagoons associated with cyanobacterial blooms.

It appears that this exercise was probably premature given the degree of understanding of the oceanographic features in the HAB monitoring community.

It stresses the need for this community to develop an awareness in oceanography and ecology.

Theme sessions

Two theme sessions have been organised under the WGHABD initiative:

The theme sessions, one on small scale interactions and the other on mitigation procedures, were organised by the WGHABD.

The theme session on *The role of small scale biophysical interactions in controlling HAB* s organised during ASC 1998 was highly successful. The session attracted papers from an international group of biological and physical oceanographers. Exciting new results from laboratory and mesocosm experiments were presented demonstrating that turbulence has highly species-specific effects on the growth and mortality of both diatoms and dinoflagellates. These results were clearly inconsistent with the classical paradigm that turbulence favours diatoms over dinoflagellates. In a similar fashion, results from field studies using new high resolution sampling techniques demonstrated that some harmful algal blooms can develop in highly concentrated layers that are too thin to be detected by standard methods. The field results indicate that the development of HABs in thin layers is highly sensitive to interactions with current shear and turbulence at the scale of the layer. These presentations of the new lab and field results were followed by an animated discussion that emphasised not only the importance of biological-physical interactions in HAB dynamics, but also the need to improve methods for measuring the underlying physical processes at relevant scales.

The theme session on management and mitigation for harmful algae was part of the 1999 ICES Annual Science Conference. About 20 participants listened to 6 oral presentations from 4 different countries (2 presentations were withdrawn). One presentation gave a general overview, 3 presented experiences from Norway and Sweden, and 2 contributions reported on parasites found in toxic algae. The rather low number of contributions and participants at the theme session may indicate that the topic, at least in the 1999 ICES Annual Science Conference context, was too specific.

The theme sessions did not receive many contributed papers and did not attract many participants from the HAB community as many scientists do not view these sessions as they do typical scientific meetings. This may in part be due to the structure of ASC. The evolution foreseen in the ICES Annual Science Conference should improve and increase the attendance to all theme sessions.

Dialogue between physicists and biologists

Besides joint sessions between WGSSO and WGHABD, the dialogue between physicists and biologists has been greatly enhanced by the attendance of physicists to the WGHABD annual meetings.

Pilot studies helped focus the discussion and participants generally agreed that biologists realised the need to rank the different processes influencing population dynamics as well as the need to attempt modelling through steps of increasing complexity. On the other hand, physicists were made aware of the complexity of biological systems and the difficulties with which biologists are confronted.

Reviews

Since 1992, a large number of topics have been reviewed by different members of the WGHABD. Topics include:

- Cyst phase (1993) revisited and new information disseminated in 1999: founding populations.
- Ability of certain HAB species to modify their microscale physical environment.
- Relations between HABs and zooplankton including effects on zooplankton, impacts of grazers on a given HAB species and impacts on grazer recruitment.
- Mixotrophy and heterotrophy.
- Role of benthic microalgae in benthic and pelagic food webs.
- An historical analysis of the brown tide case.
- Historical records.

Despite the lack of recognition and publication outside the Working Group, it should be noted that members of the Working Group are still volunteering to present specific reviews.

The group felt that ICES should encourage the publication of reviews and material presented during Working Group meetings following peer-review.

HAB transfer in ballast waters

In the context of WGITMO work, WGHABD advised on the transportation of cysts through ballast waters and shellfish transfer. The WGITMO was used in designing the IMO regulation on ballast waters.

Monitoring and mitigation strategies

The efficiency of regional monitoring procedures was discussed in 1994 and the results contributed to the IOC-ICES report on monitoring and the metadatabase.

A review of various mitigation strategies was presented in 1998. The WGHABD recommended that a specific study group be established with the appropriate terms of reference.

6 HISTORICAL DATA AND FOSSIL RECORDS OF HABS

Term of Reference 3: examine the possible ways of analysing historical data and fossil records with the help of an invited specialist;

Andrè Rochon gave a presentation highlighting Canadian research on geological history of red tides.

Two high resolution sedimentary sequences collected from the continental margins of eastern and western Canada were analysed for their dinoflagellate cyst content in order to document the occurrence of red tides during the last 10,000 years.

Core 95-030-24 is from La Have Basin on the Scotian Shelf off southeastern Canada (Levac *et al.*, 2000: 43º45.46N; 63º42.06 W; water depth 256 m). It is a 9.5 m long sequence of bioturbated olive grey clay, which represents *ca.* 11,000 years of sedimentation based on the available ^{14}C ages. Sampling frequency and bioturbational mixing allow resolution at the decadal scale. Sediment samples were prepared using a standardised method described in Rochon *et al.* (1999),which involves sieving at 125 and 10 μm and repeated treatments in hydrochloric (HCl 10%) and hydrofluoric (HF 38-49%) acids. The residue is then mounted between a slide and cover slip.

The base of the core, between *ca.* 10,500 and 7500 ^{14}C years B.P. (before present), is characterised by high cyst concentrations ranging from *ca.* $1.6–4.5\times10^4$ cysts/cm^3. This interval is also marked by high cyst influx, in the order of 10^3 cysts/cm^2/yr, which no doubt reflects high primary productivity in surface waters. The dinoflagellate cyst assemblages are dominated by Gonyaulacales. The interval between *ca.* 10,500 and 10,000 ^{14}C years B.P. is marked by an abundance of cysts produced by the toxic dinoflagellate *Alexandrium tamarense,* with influx reaching as high as 1500 cysts/cm^2/year. Cysts from the toxic red tide dinoflagellate *Protoceratium reticulatum* (=*Operculodinium centrocarpum*) and non-toxic *Gonyaulax spinifera* group (=*Spiniferites* spp.) are the most abundant between 10,000 and 7500 ^{14}C years B.P. Those dinoflagellates are known to produce blooms that can discolor surface waters (e.g. Reinecke, 1967; Gross, 1988; Riaux–Gobin and Lassus, 1989). *Protoceratium reticulatum* is sometimes associated with PSP toxicity in shellfish (Reinecke, 1967) and has been identified as the biogenetic origin of yessotoxin (Satake *et al*., 1997).

The middle section of the core, between *ca.* 7500 and 2500 ^{14}C years B.P., is characterised by relatively low cyst concentrations, ranging from *ca.* $2.6–9 \times10^3$ cysts/cm^3. During this interval, protoperidinioid cyst taxa are dominant and constitute up to 60% of the assemblage. Cyst taxa produced by toxic and non–toxic red tide–dinoflagellates are either absent or present in low abundance, with influx <100 cysts/cm^2/yr, which indicates low productivity in surface waters during that interval.

The upper section of the core, from *ca.* 2500 ^{14}C years B.P. to present, is marked by an increased influx of cysts of *P. reticulatum* (=*O. centrocarpum*) and *Gonyaulax spinifera* group (=*Spiniferites* spp.) of the order of 10^2 and 10^1 cysts/cm^2/yr respectively. Cysts of *A. tamarense* are present sporadically and in low numbers in this shelf location, although blooms have been common in the coastal waters during the past 50 years.

The second core is an 80 m–long record of annual sediment deposits (varves) obtained from Saanich Inlet (Victoria Island, British Columbia) on the Pacific coast of Canada. This core was obtained during ODP Leg 169 (Mudie *et al*., 1999: 48º38.00N; 123º30.000 W; water depth 203 m). It provides a continuous record of red tides and dinoflagellate production in coastal waters for the past 10,500 years. The bottom sediments in Saanich Inlet are anoxic and organic microfossils, including thecal stage of dinoflagellates, are exceptionally well preserved. Sediment samples were treated with the acetolysis method, but due to the high organic content of sediments, protoperidinioid cysts were not destroyed, as is usually the case with acetolysis (Marret, 1993).

Initial results show that dinoflagellate cyst production was greater during the early Holocene (*ca.* 10,500 to 10,000 years ago) than at present. During this interval, total cyst influx to the sea floor reaches as high as 4×10^4 cysts/cm^2/yr, which indicates high primary productivity in surface waters. The most abundant cyst taxon (up to 1.5×10^4 cysts/cm^2/yr) is that of the toxic dinoflagellate *Protoceratium reticulatum* (=*O. centrocarpum*).

Paralytic shellfish poisoning (PSP) species *A. tamarense*, *Lingulodinium polyedrum* and *Gymnodinium catenatum* increased only during the warm intervals around 6000 years ago and in more recent times between 1800 and 1300 years ago (up to 1.5×10^3 cysts/cm^2/year). The cyst influx of the non-toxic dinoflagellate *G. spinifera* group also increased during those intervals. Work is still in progress but the fossil record suggests that although bloom frequency and number of PSP species has risen since *ca.* 2000 years ago, it has never been as high as that reported during the past 50 years.

Results of the geological studies show that total cyst production and bloom formation were higher than at present by one order of magnitude on both eastern and western coast of Canada during the early Holocene (*ca.* 10,000 years ago), despite a colder climate. However, summers were 8% warmer during that period due to increased insolation, which might have favoured late fall cyst production. On the continental shelf coast of eastern Canada, cyst production seems to have been lower during the mid–Holocene warm interval (ca. 6000 years ago) although production of *Alexandrium* was high in coastal waters (Miller *et al.*, 1984). Total cyst production also decreases during the mid-Holocene on the west coast, but PSP species increase during that period. During the last ca. 2000 years, the fossil record indicates that cyst production and bloom frequency increased on both the east and west coasts, but not as much as that reported during the historical record.

Work is in progress on the Saanich Inlet sequence in order to calibrate the fossil and historical data. Considering the annual nature of sediment deposition, we are hoping to establish a relationship between the number of cysts in the sediments and the motile cell concentration during known blooms from the historical record. This will provide valuable information on the magnitude of blooms from the recent geological past.

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7 IMPLICATION OF BENTHIC SPECIES IN TOXIC EVENTS

Term of Reference 4: examine information on the possible implication of benthic species in toxic events and report on induced problems on monitoring procedures;

Benthic dinoflagellates and other potentially harmful algae like the raphidophytes and maybe also some diatoms have received very little attention so far although they are widespread world wide. Only in the last few years, with the discovery of the ciguatera-producing tropical species *Gambierdiscus toxicus* Adachi & Fukuyo, is this situation changing slightly. Benthic living toxic species may detach or might be detached from their substrate and may be ingested by suspension feeding mollusks which subsequently can become toxic to the human consumer. Furthermore invertebrates browsing on surfaces might also ingest the toxic species and become toxic themselves.

In the mean time several toxic species have been detected, also in temperate waters belonging e.g. to the dinoflagellate genera *Ostreopsis* and *Prorocentrum.* Many new species have been described in the last few years, but only few have been isolated and grown in culture and/or analysed for toxicity. This is partly due to problems culturing benthic species. The benthic habitat is quite diverse as are the respective floral communities.

A simple classification of benthic habitats could be **interstitial** (where the water filled space of sandy sediments is subdivided according to grain size classes and organic content) and **epibiontic** (or epiphytic found on rocks and other hard substrates like shells of mollusks, sea urchins, corrals etc. but also on ropes of mussel cultures as well as on macro algae and floating detritus).

The attachment of the benthic species to the substrate may vary from species to species and may be dependent on environmental conditions. For example, *Prorocentrum lima* (Ehrenberg) Stein is normally living epiphytic on macro algae and other hard substrates, but can also be found detached and it was originally described from plankton samples. The taxonomy of the benthic species is not well described. The taxonomy of the toxic species *Prorocentrum lima* is particularly confusing (as is its' nomenclature) since at least 7 different taxa have been associated with this species complex. Specifically, two temperate species living in sandy habitats have been confused with *Prorocentrum lima* but these species are non-toxic.

In the recent years, potentially toxic *Prorocentum* species have been found either in the water column or as epiphytic in many ICES countries such as Canada, France, Germany, The Netherlands, Denmark, Ireland, Norway, Portugal, Spain, United States, and the U.K. Recent data from eastern Canada was presented and stimulated discussion among WG participants during the 1998 and `99 meetings. In 1999, seasonal variations in *Prorocentrum lima* abundance were studied in the Magdalen Islands (an archipelago located in the central part of the Gulf of St. Lawrence, Eastern Canada). This investigation was initiated as a result of a 1998 incident where a party of 20 people became ill and exhibited DSP-like symptoms following consumption of blue mussels collected from the Magdalen Islands lagoon. Although only trace levels of DTX1 were detected in the shellfish at that time, the observations of *P. lima* cells (low numbers) in net tows from the HAB monitoring programme in the Magdalen Islands lagoon indicated that this species could be a DSP producer in this area. *P. lima* was found as epiphytic on the macroalgae growing on mussel socks at the two aquaculture sites investigated. *P. lima* was also found in low concentrations in the water column as well as in mussel digestive glands. There was no correlation between cell concentration in the digestive glands, the water column and cells attached to the macroalgae. *Prorocentum mexicanum* was also observed (and the identification confirmed) at the same sites. This was the first documented sighting for this species in Eastern Canada. and this finding is interesting as this species produces toxins. It has previously been described as tropical or sub-tropical. *P. mexicanum* concentrations were low prior to early September when cell numbers increased both in the water column and mussel digestive glands. Results from this initial study suggests a link between toxicity outbreaks and *Prorocentrum* spp. in the Gulf of St. Lawrence. This suggests the significant impact that epiphytic (*P. lima*) and benthic-pelagic (*P. mexicanum*) dinoflagellates can have in these waters.

These finding show the importance and need to study the geographical distribution of the benthic potentially toxic dinoflagellate species, particularly in regions with aquaculture activities.

In addtion to taxonomic and toxicological studies there is a need for autecological studies of the different species, since understanding their behavior may be essential to understanding the different methods for accumulation of toxins in species such as mollusks. Preliminary results from experimental studies on two species were presented. Benthic species which can be cultured on agar-plates (not all benthic species grow on agar-plates) may have quite different growth patterns: *Prorocentrum lima* grows more evenly on the whole surface, in one layer, where as the species *P. belizeanum* Faust grows in patches, building large lumps of cells.

Methodology

Substrate: sediment; sandy – muddy.

The substrate is sampled and either fixed in the field, using Lugols or formaldehyde, or returned unfixed to the lab for extraction of live cells. Live samples must be kept in the dark, at in-situ temperature and for as short a time as possible.

Qualitative analysis: Taxonomic determination can be carried out on live cells or cells preserved in Lugols or formaldehyde using the same procedures as for plankton samples.

The samples can be obtained using several different approaches (Uhlig, G. (1964) : Eine einfache Methode zur Extraktion der vagilen, mesopsammalen Mikrofauna. - Helgoländer Wissenschaftliche Meeresuntersuchungen 11 : 178-185. (sea-ice method); Webb, M.G. (1956) An ecological study of brackish water ciliates. -Journal of Animal Ecology 25: 148-175.(cover slip method)),. Species can be extracted from sandy sediment samples using the Uhlig method , a method previously used for ciliates (apply ice on top of the sediment that is kept in a cylinder with mesh (20-60 um) in the bottom which is in contact with water in a petri dish). In the case of muddy sediments, the mud can be spread out in a petri dish and cover slips are placed on the surface of the sediment – some species will then attach to the cover slip and can be examined using light or electron microscopy.

Finally the sediment can be spread in a thin layer on a slide and investigated directly.

In the case of thecate dinoflagellates the fluorochrome Calco Fluor (works only at pH > 7; samples can be fixed in e.g. neutral lugols) can be added to the live samples or samples fixed in neutral lugols for identification using epifluorescence microscopy.

Quantitative analysis: It can be very hard or impossible to get a proper estimate of abundance for benthic species. Abundance of benthic species is measured as cells/cm^2 or cells/g dw of sediment.

The Uhlig method can be used on sandy sediments for some species.

Culturing using dilution series of sediment slurries can be used to get a rough estimate of abundance using the most probable number (MPN) technique. This only applies to species that can be cultured.

Vegetation and other ”surfaces”.

Vegetation: The substrate, e.g. macro algae, is placed in a plastic bag with filtered sea water and shaken briefly (approximately 1/2 minute) – the “shaking procedure” currently used for ciguatera species. The suspension containing the epiphytic species can then be investigated using either light, epifluorescence- or electron microscopy as described above.

Other surfaces: Cells can be “extracted” from other substrates either by rinsing with filtered sea water, brushing or scraping. If the material fits under a microscope the surface can be examined immediately using epifluorescence microscopy or SEM.

Quantitative analysis: The abundance of epiphytic species is measured as cells/cm^2 or cells/g dw substrate.

Epiphytic species can be roughly quantified from the suspension obtained from the “shaking procedure” described above followed by analysis by light microscopy using counting cells, Utermöhl sedimentation chamber, quantitative epifluorescence microscopy using appropriate fluorochromes or SEM.

If the material fits under a microscope the organisms on the surface can be quantified directly using epifluorescence microscopy or SEM.

8 IMPORTANCE OF PHYSICS IN RELATION TO HARMFUL ALGAL BLOOMS (WITH WGSSO)

Term of Reference 5: assess the current knowledge on the role of physics in relation to harmful algal blooms as well as possible implications for modelling in pelagic biological monitoring programmes (with WGSSO);

This Term of Reference was discussed in a joint session with WGSSO. The session included an introduction, a series of scientific presentations and a sub-group meeting discussing improvements in our understanding of HABs in terms of modelling since the last joint session in Vigo, Spain, in 1994.

Advances since 1994

This joint session revealed major advances in modelling of harmful algal blooms. During the 1994 meeting, a considerable amount of time was spent discussing pure biological models designed to predict growth rates based on responses to light and temperature. It was difficult to see how these types of models could be applied to understanding HAB dynamics in natural populations. This, plus the limited number of presentations on field models tended to limit meaningful discussion. In contrast, there were presentations this year on a variety of different types of models designed to be applied in the ocean. These models included coupled, 3-D coupled physical-biogeochemical models of regional eutrophication, biogeochemical box models of nutrient driven HABs, and simplified numerical models designed to address specific management issues. This diversity of model types (and their increase in field applicability) provided a rich basis for comparisons and discussions. There was a consensus that substantial progress had been made in using models to explain relevant processes leading to blooms of specific HAB species. This appeared to be particularly true in those cases where HAB experts worked closely with physical oceanographers to develop models designed to address specific issues. It was equally obvious that much less progress had been made in adapting large, complex, regional biogeochemical models to address HAB issues. Although there are multiple reasons for this limited progress, it was generally agreed that these models were not originally developed for HAB issues, and parameters in some models tended to make them difficult to validate and interpret. In addition, many of the HAB specialists questioned the relevance of using biogeochemical models to address the dynamics of HAB species that are not dominant or never reach concentrations that significantly affect nutrient budgets.

The group felt that the joint meeting with WGSSO on HAB modelling was extremely useful and should be repeated in a few years. The focus on modelling was well attended and there was active participation from both Working Groups. In addition to fostering interdisciplinary understanding and collaboration so essential to the HAB problem, the meeting provided an opportunity to explore new modelling approaches and new ways to sample HABs on scales relevant to HAB dynamics and impacts. It also provided an opportunity for participants to identify areas of common interest and identify potential areas for future collaboration.

The following scientific presentations were given:

- Wolfgang Fennel, Physics, models and harmful algal blooms
- Percy Donaghay, The importance of microstructure, turbulence and mixing in relation to algal blooms
- Patrick Gentien, On the importance of thin layers
- Oleg Savchuk, Aspects of different bio-geo-chemical models as applied in the Baltic
- Kai Myrberg, The role of atmospheric forcing for ocean model resolution in the Gulf of Finland
- François Saucier, Ice-ocean modelling in the Gulf of St. Lawrence with applications to biology
- Eleonor Marmefeldt, SCOBI-3D biogeochemical model
- Einar Svendsen, NORWECOM – Norwegian Ecological Model System
- Anouk Blauw, Modelling blue-green algae dynamics in Lake Ijssel: biomass and flotation
- Donald M. Anderson, A coupled physical-biological model of toxic *Alexandrium* dynamics in the Gulf of Maine
- Hermann-J. Lenhart, Effects of river nutrient load reductions on the eutrophication of the North Sea, simulated with ecosystem model ERSEM
- Odd Lindahl, Changes in the plankton community passing a Mytilus edulis mussel bed
- Juliette Fauchot, Modelling of HABs in the context of regional climate models
- Kai Myrberg, Larval drift experiments in the Baltic sea, model results and measurements
- Oleg Savchuk, Parametrization of phytoplankton groups and communities in the Baltic sea biogeochemical models

The following abstracts were made available by the authors:

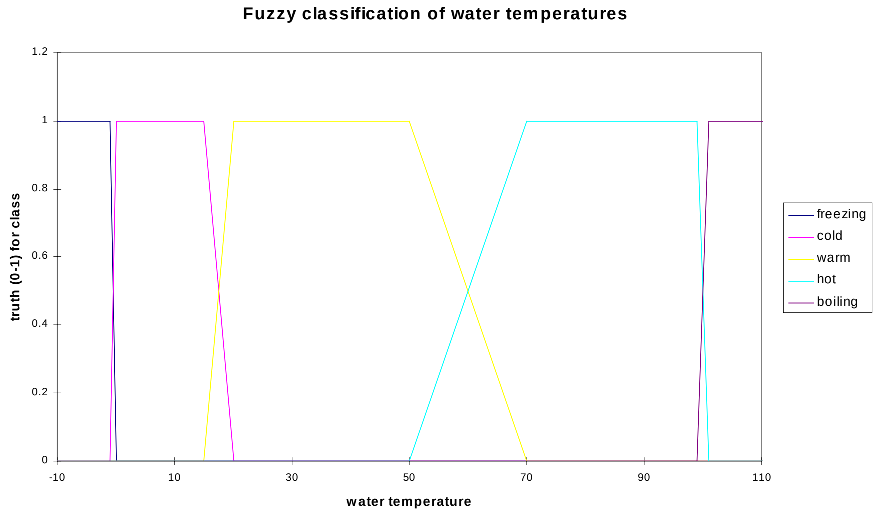
Modelling blue-green algae dynamics in Lake Ijssel: biomass and flotation
Anouk Blauw

Goal of the study. Scums of floating algal biomass, consisting of blue-green algae are a nuisance in many water systems. Lake IJssel, a big fresh water lake in the Netherlands is one of these systems. The scums cause bad odour, toxins and oxygen depletion in many harbours and recreational areas on the lakeshore. An early warning system is needed to give a warning when problems (could) arise, so mitigating measures can be taken in time. WL| Delft Hydraulics has worked on an early warning system for Lake IJssel, together with the research department for fresh water of the Dutch government.

Model set-up. The formation of scums of blue-green algae is the result of two processes: the growth of blue-green algae and their upward migration towards the water surface. The amount of biomass of blue-green algae varies largely over the years. Measurements of blue-green algae biomasses are not done frequently enough to base the early warning system upon measurements. The biomass is determined on the one hand by the amount of nutrients and light available for growth and on the other hand by the competition by other algae. These processes could be modelled using the model DBS, containing transport, nutrients and algae kinetics. The results of this model were used as a starting point for a predictive model to determine where scums of blue-green algae would appear.

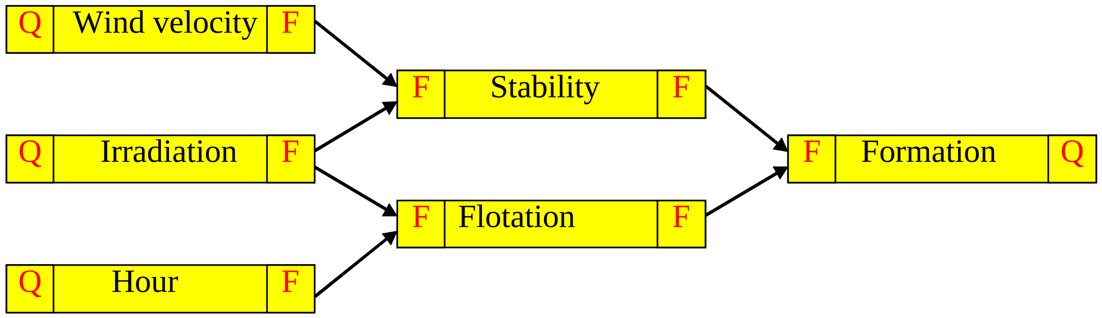
The upward migration of blue-green algae is determined by a complex interaction of physiological processes from within the algae and the measure of turbulence/ stability in the water column. These are hard to quantify in a deterministic model like DBS. Therefore the fuzzy-logic approach was chosen to describe in a coarse way the result of the various factors determining the vertical transport of the algae.

Fuzzy logic is often applied in several engineering techniques, but it can also be used for the modelling of physical biological coupling in algae modelling. The essence of fuzzy logic is that quantitative values of factors involved in a process are translated to more abstract parameters that correspond with the measure of understanding available on the process. In the figure below a fuzzy classification of water temperatures is shown as an example.



Cause-effect relationships can than be modelled using the abstract (fuzzy) parameters. For example:

When there is little wind and high solar irradiation the stability of the water column is high.
(The fuzzy parameters used in this logic reasoning are underlined).
In this way the factors determining the vertical transport of the algae are modelled with the following relations:



The quantitative 'measure of upward migration' is multiplied with the maximum upward velocity to estimate the actual upward migration at the actual wind velocity, irradiation and hour of the day. Combined with the estimate of the blue-green algae biomass in the water column, an upward flux of algae reaching the water surface and forming a scum could be calculated at each model segment.

Once the scums have been formed they are transported by the wind. This could be modelled, assuming transport in the wind direction with a velocity proportional to the wind velocity. At high wind velocities the scums disappear again. This was also modelled using the fuzzy logic approach.

Results

This combination of techniques resulted in a model describing the formation and transport of scums of blue-green algae:

- numerical transport and water quality and algae model to calculate biomasses of blue-green algae;
- fuzzy logic for the modelling of formation and disappearance of scums;
- transport modelling using the numerical transport model mentioned before and the wind.

The results were compared to remote sensing pictures taken from Lake IJssel. The occurrence of scums could be modelled reasonably well as is shown in the table below.

Total	Satelite picture without scum	Satelite picture with scum
Model result without scum	266	4
Model result with scum	20	19
percentage correct	93%	83%

Conclusions

- Fuzzy logic is a good way to overcome the difficulties in deterministic modelling of the coupling of physics and biology.

- The fuzzy logic approach is a robust way to reason and predict from available knowledge on cause-effect relations, with less sensitivity to unknown parameters.

- The combined effect of more parameters cannot be calculated; all outcomes of the model need to be explicitly added to the model. The model is just a reflection of existing knowledge.

First steps in the modelling of *Alexandrium* bloom dynamics in the St. Lawrence Estuary, Canada
Juliette Fauchot, Maurice Levasseur and François Saucier.

In July 1998, a red tide developed in the St. Lawrence Estuary (SLE). The causative organism was *Alexandrium tamarense*, a dinoflagellate known to cause PSP outbreaks in the SLE. Over a three day period, the red tide spread along the south shore of the estuary, with *A. tamarense* concentrations reaching $2.3 \cdot 10^6$ cells L^{-1}. The highest concentrations of *A. tamarense* were found in waters of lower salinity and higher temperature. Environmental data indicate that the development of the red tide occurred during a period of increased stratification of the water column due to reduced vertical mixing and warming of the surface layer. The surface water circulation, the distribution of surface salinities and the transport of passive tracers in the surface layer were simulated with the ice-ocean model of the Gulf of St. Lawrence developed at the Maurice-Lamontagne Institute (Canada). The results of the model simulations indicate that the red tide developed during a ca. 1 week-period of retention of surface waters in the estuary that allowed the accumulation of the growing biomass. Therefore, the red tide observed on the south shore of the estuary resulted from in situ growth and biomass accumulation close to the north shore followed by a north-south cross-estuary transport. Our results show that, during the red tide formation, a particular climatic condition prevailed in which the retention period coincided with a north-eastern wind.

To better understand the dynamics of red tides in the SLE, the development of a biological model of *A. tamarense* bloom dynamics, coupled with a circulation model of the SLE, is in progress. This model will take into account the growth rate of *A. tamarense* cells, the different stages of their life cycle (permanent cysts, vegetative cells), their behaviour (vertical migrations) and community interactions (grazing).

Effects of river nutrient load reductions on the eutrophication of the North Sea, simulated with the ecosystem model ERSEM

Hermann-J. Lenhart

The results of the reduction scenarios with the ecosystem model ERSEM by Lenhart (1999) and Lenhart *et al*. (1997) are similar to the conclusions from the ASMO modelling Workshop on eutrophication (OSPAR,1998). In the ERSEM studies the simulation of a standard year was compared with the one of a reduction scenario, where the river nutrient load of the inorganic and organic load was reduced by 50 %. The result of the ERSEM studies supported the ASMO conclusion, that a reduction of the river nutrient load by 50 % in N and P can not be transferred linearly to a 50 % reduction in the resulting net primary production. While the reduction scenario resulted in 40 % decreased winter concentrations of nitrogen and phosphorous , the decrease in net primary production was clearly lower. Reducing the inorganic and organic river loads in ERSEM by 50%, the largest effect on the net primary production was observed in the coastal zone with a reduction of approximately 20 %. Phytoplankton groups in ERSEM showed different reactions to the changed nutrient availability. While the biomass and production of diatoms did not show any effect on river load reductions, small changes were observed for the flagellates. However, these changes also included an increased biomass of flagellates for an extended period of time during the summer. This result is significant because the increase in algal biomass due to eutrophication was related primarily to an increase in flagellates, which did not increase proportionally in the reduction scenario. Generally all changes in the time series in modeled phytoplankton concentrations occurred after the spring bloom.. In addition, regional differences between primary production and nutrient uptake of algae were observed between the standard run and the reduction scenario. Greatest differences with regard to primary production were found downstream of the rivers Rhein and the Elbe. This is matched by the uptake of ammonium, while the uptake of nitrate and especially phosphorus showed the greatest differences in the mouths of the Rhein and Elbe rivers.

Lenhart, H.J., Radach, G., Ruardij, P. (1997): The effects of river input on the ecosystem dynamics in the continental coastal zone of the North Sea using ERSEM. J. Sea Res., 38: 249-274.

Lenhart, H.J. (1999): Eutrophierung im kontinentalen Küstenbereich der Nordsee. Reduktionsszenarien der Flußeinträge von Nährstoffen mit dem Ökosystem-Modell ERSEM. Thesis, University Hamburg, 169 pp.

OSPAR 1998. Report of the ASMO Modelling Workshop on Eutrophication issues. 5-8 November 1996, The Hague, The Netherlands, OSPAR Commission 1998, 86 pp.

Modelling of Ecosystem Dynamics in the Estuary and Gulf of St. Lawrence

F. J. Saucier

Three-dimensional baroclinic models of the Estuary and Gulf of St. Lawrence are developed to reproduce and investigate the hourly to seasonal variations in the ice-ocean conditions, exchanges with the atmosphere, and plankton dynamics. The Gulf and Estuary models have resolutions of 5 km/73 layers and 400 m/20 layers, respectively. The forcing includes detailed tidal, atmospheric, oceanic and hydrological data, at hourly to daily intervals. The model results are evaluated over hindcast periods in the 1980s using sea surface temperature, salinity-temperature profiles, water levels, and ice charts. The models reproduce well many of the features of the known circulation, transports, and the formation of water masses and sea ice. Tracer experiments aimed at investigating the fate of surface phytoplankton, and zooplankton with diurnal migration, over days to months show that the tidally, wind-driven and density-driven circulation contribute to gulf-wide dispersion. These experiments demonstrate the importance of well-resolved high-frequency forcing and currents in order to insure the appropriate precision in carrying tracers in the sea. A study of krill aggregation at the head of the St. Lawrence channel shows that the relatively small changes in the timing of the semi-diurnal tide with respect to the timing of surface excursion at night can lead to very different solutions, either patches of high concentration, or high dispersion and flushing from the system. The models are being applied by Fauchot *et al*. (this joint session) to examine the retention/dispersion process of a HAB that occurred in early July 1998 in the St. Lawrence Estuary.

A coupled physical-biological model of toxic *Alexandrium* dynamics in the Gulf of Maine: progress to date

Donald. M. Anderson, Biology Department, MS # 32, Woods Hole Oceanographic Institution, Woods Hole MA 02543 USA

A five-year programme called ECOHAB-GOM was initiated to address several fundamental issues regarding *Alexandrium* blooms in the Gulf of Maine: 1) the source of the *Alexandrium* cells that appear in the fresh water plumes in the western Maine coastal current (WMCC); 2) *Alexandrium* cell distribution and dynamics in the eastern Maine coastal current (EMCC); and 3) linkages among blooms in the WMCC and the EMCC. Utilizing a combination of numerical modelling, hydrographic, chemical, and biological measurements, moored and drifting current measurements, and satellite imagery, a team of 14 investigators from 9 institutions is attempting to characterise the structure, variability and autecology of the major *Alexandrium* habitats in the Gulf of Maine. This talk focussed on the modelling efforts that have been undertaken, with special emphasis on bloom initiation in the western Maine region.

In the western Gulf, *Alexandrium* blooms and patterns of PSP have been linked to a coastal current or plume of low salinity river outflow (the WMCC). One major project goal has been to investigate an area near Casco Bay implicated as the major "source region" for the toxic cells that populate that coastal current. Intensive, small-vessel field surveys in 1998 demonstrated that there may well be an offshore source of cells, possibly from cysts germinating from the deeper basins. A hierarchy of numerical models were described that are guiding project activities. These are based on a three-dimensional coupled physical-biological model of the regional circulation. The domain of that model is presently from Cape Cod to Penobscot Bay, but this is now being expanded up to the Bay of Fundy. This is a Blumberg and Mellor 3-dimensional primitive equation model, fully non-linear, with 12 vertical layers . Vertical mixing is internally generated from the Mellor-Yamada 2.5 turbulence closure model. The model is forced by various modelled inputs as well as land-based and shipboard observations.

Initial model results with *Alexandrium* populations originating in various “source” regions suggested that uniform cell input throughout the domain (i.e., cysts evenly distributed, with uniform germination) gave unrealistic results compared to cruise data, and shellfish toxicity patterns. Likewise, cell input only in the vicinity of major river/estuarine systems also gave unrealistic results. However, continuous cell input near Casco Bay gave results in excellent agreement with cruise and shellfish toxicity observations for 1993, but <u>not</u> for 1994. The latter discrepancy argues that cyst germination is not continuous throughout the bloom season, and that modelling efforts cannot proceed without better parameterization of the cell input function (i.e., <u>where</u>, <u>when</u>, and <u>at what rate</u> are cysts germinating). As a result, a cyst germination model was developed that is based on laboratory-derived germination rates and cyst distributions mapped during survey cruises. Data from this model are being incorporated into the three-dimensional model of the regional circulation in 1993. Initial conclusions from these simulations are that: 1) germination of cysts from deep waters is quantitatively more important than germination from shallow areas; 2) newly germinated cells in deeper, offshore waters can become entrained into the coastal current when the buoyant coastal current is pushed offshore by upwelling winds, then returned to shore by downwelling winds; 3) the westernmost cyst seedbed used in the simulations is too far south and west to account for blooms and toxicity in Casco Bay, or the offshore origin of the bloom observed in 1998; and 4) further refinement of the model is clearly needed (e.g., expanded domain, sensitivity analysis, grazing dynamics, nutrient effects, migration behaviour, encystment).

ECOHAB-GOM is thus a combined modelling/observational programme following an approach commensurate with the multiple scales and oceanographic complexity of paralytic shellfish poisoning phenomena in the Gulf of Maine. More details on this project, including an update of cruise activities and results can be found at the project web page at: http://crusty.er.usgs.gov/ecohab/

9 COMPARISON OF MODEL PARAMETERISATIONS (WITH WGSSO)

Term of Reference 6: compare model parameterisations for growth rates, nutrient uptake rates, nutrient limitation, predation rates remineralization rates and the physics of the turbulent fluxes and stresses (with WGSSO);

This Term of Reference was discussed in a joint session together with WGSSO. A sub-group chaired by François Saucier with Maurice Levasseur as a rapporteur summarized the information available as well the discussions in the plenary session.

The aim of the subgroup was to list and discuss the parameters required for HAB modelling. State variables and processes were thus determined for the different bloom phases: initiation, development and decline. A summary of the parameters and processes is presented in Table 1. When establishing this list, the participants had mostly planktonic HABs in mind. Although most parameters and processes listed here are applicable to benthic and epiphytic HABs, the modelling of these HABs may require specific parameters not adequately discussed in this report.

HAB initiation phases

A minimum knowledge of the initial field ($N_0(x,y,z)$) is essential. Parameters and processes required to adequately initialise the model runs vary depending on whether the species is cyst forming or non-cyst forming.

For cyst forming species, a basic knowledge of cyst spatial distribution (mapping of 2D cyst concentrations) is crucial. For different reasons, the total number of cysts per square meter may not be a good indicator of the potential cyst population since a significant portion of the cysts may not be able to germinate. Anoxia, has also been shown to prevent the germination of *Alexandrium sp*. cysts. It may thus be important to know their exact location (depth) in the sediment. For modelling purposes, cyst concentrations in the top 2 cm have been used in the past (Gulf of Maine model – ECOHAB-GOM). The potential presence of cysts in the nepheloid layer (organic matter-rich layer lying on the top of the bottom) has been mentioned as an area for future research. Finally, the distribution of cysts may be very dynamic. For example, they may move with the sediments, especially in estuaries. By redistributing cysts and oxygen in the sediment, the intensity of bioturbation may be important.

Once the cyst bed has been located, it is important to understand what controls germination. Newly formed cysts go through a mandatory dormancy period during which they cannot germinate. The length of this period, which is temperature dependent for *Alexandrium tamarense*, is a crucial parameter to know. After this period, cysts remain quiescent until their germination is triggered by either an internal or external signal. So far, the existence of an internal clock has been demonstrated for *Alexandrium sp*. cysts. On the other hand, environmental factors which may initiate germination of mature cysts are light, temperature, oxygen and bottom shear stress (induced by tidal current, wind, storm). Temperature may either affect the rate of germination or have a threshold-type effect. On the other hand, a single flash of light has been shown to trigger germination in some species.

The physiological characteristics of the newly germinated cells may also be important to know. Do newly germinated cells need light to divide? How long can they survive in the dark? How fast are they dividing? What is their swimming behaviour? What is their survival rate? These questions remain unanswered.

For non-cyst forming species, it would also be useful to know the initial 3D distribution of the founding population. This information may however be difficult to obtain since the over-wintering cells are most often present in extremely low abundance. The geographical limits for potential inoculation should at least be known.

Finally, it may also be important to take into account the physical, chemical and biological characteristics of the body of water receiving (for cyst forming species) or containing the founding population since inappropriate environmental conditions (irradiance, salinity, temperature, nutrients, circulation, co-occurring species, grazing, etc.) may limit cell growth and accumulation. For example, a minimum threshold of irradiance (J/m2/d) has been shown to be important for *Phaeocystis* spp.bloom initiation. Initial nutrients levels are particularly important when the harmful species represents a large portion of the community and consumes a significant portion of the nutrient pool.

HAB development phases

Temporal changes in the size of a population result from the difference between its gross growth rate (or cellular growth rate) and the sum of the different loss rates. Parameters and processes important to modelling the development of a bloom are those that affect the gross growth rate of the population.

Modelling gross growth rates - For autotrophic species, daily irradiance and factors controlling the light regime of the cells such the water column light attenuation coefficient and the mixed layer depth need to be known. Other factors that may affect gross population growth rates are water temperature and nutrient concentrations or regeneration rates. Algal gross growth rate may also be affected by the bio-availability of trace metals, vitamins and various organic compounds, which in turn may depend on the pre-conditioning influence of previous blooms. The frequent association between HABs and brackish river plumes has often been attributed to the presence of humic substances, which may either detoxify the water mass or serve as a nutrient (nitrogen, iron) source. For many HAB species, cell division may also be suppressed by turbulence. CO_2 concentration has also been shown to limit algal growth and biomass accumulation in colony forming *Phaeocystis* spp. It should be noted that a direct relationship between light, inorganic nutrients and algal growth may be blurred by mixotrophy, a wide spread phenomena in HABs.

Modelling net growth rates – Grazing may be the most important loss term during the bloom development phase. However, the inclusion of a grazing term in models requires an adequate understanding of the food web structure. It is crucial to identify the right grazer(s) (e.g. copepods, ciliates, heterotrophic dinoflagellates, etc.) and to have a basic knowledge of the grazing rate/prey relationship. It is also important to keep in mind that grazing may exert a strong control on population, especially at low cell number (e.g. initiation phase). Grazing by filter feeding organisms (shellfish) may also be important in controlling bloom development. For colony forming species, the rate of colony formation is also important to know since it has repercussions on predation and sinking rate. Aggregation behaviours are also important. Models must also include vertical migration behaviours. In order to improve models, we need to know the triggering factors (nutrients, light, other chemicals) and the vertical swimming speeds.

HAB declining phases

HABs enter their declining phase when loss rates overcome their gross growth rates. For non-cyst forming species, bloom development may stop due to a reduced gross growth rate and/or an increase in loss rate. The decrease in gross growth rate may result from a shortage of essential nutrients or light or a change in the physical environment (e.g. increase in turbulence). Natural mortality (i.e. genetically determined mortality) may also be more important than previously thought. However, this mortality rate is not well quantified for any species yet. Harmful algae populations may also collapse due to heavy grazing pressure (grazing rate > algal gross growth rate), parasites, fungi and viruses. A rapid sedimentation of the population may occur if the cells become physiologically stressed (high turbulence, nutrient limitation). This phenomenon is often dependent on cell density. The decline of the population may also be physically driven, with dispersion becoming greater than retention for a given area. Finally, the bloom may also collapse if cells enter their sexual cycle. This is, of course, extremely important for cyst-forming species. For these species, we need to know what triggers cyst formation (nutrient concentration, nutrient quota, population density, etc.). Gamete encounter rate is density dependent and may increase with turbulence. Cyst formation rate may thus vary from high to low from the centre to the edge of the bloom.

Conclusions

HAB models may obviously become increasingly complex. In a second step, the group members tried to classify the different models based on their utility, which in turn may help to determine the level of complexity required. In the HAB field, models may be required to predict 1) harmful effects, 2) minimum cell concentrations for harmful effects, 3) initiation time (occurrence), 4) duration, and 5) location (spreading or dispersion). Then, depending on what you need/want to deliver, the models may be grouped in 4 classes:

1. Very complex comprehensive community models (learning tool, long-term prediction, exploration of scenarios)

2. Less complex multi-species models (e.g. include algal growth, grazing rates)

3. Simpler, single species models (e.g. physical model with algae as passive tracers)

4. Empirical models (e.g. models for statistical forecasting)

The participants also tried to rank by importance the parameters that need to be included in physical-biology models. The ones that came up the most often were: 1) the initial field (N_0 (x,y,z)), 2) the particular behaviour of the targeted species (e.g. swimming dinoflagellates, fast sinking diatoms, etc.), 3) the *in situ* growth rate, and 4) the factor(s) controlling toxicity.

In order to improve our modelling capacity of HABs, the discussion group members concluded that improved data assimilation and real-time observing systems are required. In poorly known systems, new approaches such as inverse modelling and neural network should also be tested. To the knowledge of the group members, these methods have not yet been applied to the HAB field. The level of definition required for the physical models was discussed and it was concluded that this was species specific. In some cases, physical models clearly require a fine resolution (e.g. eddy resolving models). This is particularly true for species forming micro-layers.

Regarding our predictive capacity, it is important to build on our current capabilities such as 3D currents and temperature forecasts. The value of experience-based relationships was also recognized (e.g. empirical relationships between wind or salinity and HABs). Whatever the level of complexity of the model, there was a general consensus that one should be cautious about the capability of any model for long-term predictions.

Table 1. Summary of parameters and processes required to model HABs.

Phases of bloom	Parameters/processes	Remarks
Initiation		
Cyst forming species	2D cyst distribution	May change with time
	Cyst distribution in the sediment	Upper 2 cm have been used
	Length of the dormancy period	May be a function of temperature
	Internal/external factors triggering germination	May be an internal clock, a physical cue (light, temperature)
	Germination rate	May be a function of light, temperature.
	% germinating of population	
	Behaviour of newly hatched cells	Dark survival, trophisms, etc.
	Division characteristics of newly hatched cells	Rapid initial cell division rate?
Non-cyst forming species	3D distribution of the founding population	May be hard to determine. Geographical limits (boundaries (?) for cell inoculation may be sufficient.
Development	Irradiance (daily; J/m2/d)	Daily (J/m2/d)
	Water column coefficient of extinction	Will partly control the light regime of the cells
	Mixed layer depth	Will partly control the light regime of the cells
	Growth/irradiance curve	Species-specific
	Nutrient concentrations	Nitrogen, phosphate, silicate
	Nutrient uptake kinetics	Species-specific
	Grazing rates	Macrozooplankton, microzooplankton, shellfish, heterotrophic dinoflagellates, etc.
	Predator/prey relationships	
	Specific behaviours	(e.g. aggregation, vertical migration, etc.)
	Factors triggering aggregation or vertical migration	May be light, nutrient limitation
	Currents	
	Stratification	Affects light regime and nutrient supply
	Temperature	Affect growth rate
	Turbulence	May affect growth rate
Decline	Sexual cycle	Production of gametes or cysts
	Grazing rates	
	Parasites	
	Viruses	
	Fungi	
	Natural mortality	

10 SCENARIOS OF TOXIC EVENTS DEVELOPMENTS

Term of Reference 7: review scenarios of toxic events developments;

In order to collect information about the different hydrodynamic regimes into which HABs develop, a questionnaire was established by the Working Group in 1997. The outcome of this exercise is discussed in detail under Term of Reference 2.

11 NEW FINDINGS

Term of Reference 8: report and discuss new findings;

DSP in the Danish Wadden Sea - Ho Bugt August 1999. Tidal transport of *Dinophysis acuminata* from "off-shore" to a tidal area - implications for monitoring and management of the shellfishery
Per Andersen

DSP was measured in the Danish part of the Wadden Sea - in Ho Bugt - in the beginning of August 1999. The contaminated shellfish (*Mytilus edulis*) were not marketed as all shellfish were recalled and destroyed. Prior to the bloom, low concentrations of *Dinophysis acuminata* were observed from samples collected by local fishermen. The weather conditions in July and August were characterised by intense and long periods of sunlight in combination with easterly winds. It was hypothesised that the shellfish became toxic as a result of the tidal transport of an "off-shore" bloom of *Dinophysis acuminata* from the outer part of the Wadden Seainto the inner part where mussels are harvested. , This bloom was observed in a previous year.

A sampling programme was initiated to follow the bloom of *Dinophysis acuminata* during two tidal cycles at 3 stations located at the outer and inner parts of Ho Bugt and a middle station located in the harvest area.

Two very different communities of phytoplankton were observed:

1. A "tidal estuary" community dominated by small centric diatoms

2. An "off-shore" community dominated by North Sea classics such as dinoflagellates from genera such as *Ceratium*, *Prorocentrum*, *Dinophysis*, *Protoperidinium*, etc.

At low tide the phytoplankton community in Ho Bugt present was the "tidal estuary" community. As the tide came in, the concentrations of *Dinophysis acuminata* increased. At high tide the "off shore" community was observed with maximum concentrations of *Dinophysis acuminata* within the tidal period. The "off-shore" community reached the area where commercial mussel harvesting was taking place at high tide. Results from sampling phytoplankton at low tide did not reveal what the blue mussels consumed or was exposed to in terms of *Dinophysis* on a daily basis. Therefore, sampling at or near high tide resulted in maximum cell densities for *Dinophysis* sp to which the blue mussels were exposed. It was concluded that the hypothesis with high "off shore" concentrations of *Dinophysis acuminata* being transported into the estuary during high tide reflected what was actually happening.

It was concluded that HAB sampling programmes in tidally influenced areas must consider temporal variations in water masses occurring in the area into account when phytoplankton sampling is used as "an early warning" for the occurrence of algal toxins in shellfish. It is very important to have a good "baseline" on hydrography as well as temporal and geographical occurrences of phytoplankton species within an area when monitoring HAB-species.

Practical implications: In periods at risk for *Dinophysis* blooming in off-shorewaters, the fishermen have been directed to sample at or near high tide - and label samples with sampling time.

North Atlantic Oscillation, primary production and toxic phytoplankton in the Gullmar Fjord, Sweden (1985-1996)
Odd Lindahl

Evaluation of the time-series data set (1985 - 1986) including measurements of primary production, chlorophyll a and toxic phytoplankton species abundance in the Gullmar Fjord (as a part of the Swedish Monitoring Program) revealed the importance of considering climatic and environmental forces among the factors that may be responsible for the observed fluctuations. The results suggested that the occurrence of toxic phytoplankton blooms in the Skagerrak might be related to changes in the phase of the North Atlantic Oscillation index (NAO). Linear regression analysis of three Dinophysis species, NAO, temperature and salinity indicated that higher densities of toxic phytoplankton species may be associated with positive oscillations of the NAO as, for example, during the late 1980s as well as during warmer sea surface temperature conditions and increased sea surface salinity. On average, 80% of the variance was explained by the changes in salinity and 90% by the NAO itself. Further, temperature explained about 65% of the variance. It was shown previously that salinity and temperature are also related to the NAO, but it is important to show how much of the variance could be explained by these different external forces. This is relevant information since good predictive models are often based on only a few exogenous variables. As presented earlier, the distribution patterns for phytoplankton blooms along the Swedish west coast suggests in general that offshore conditions combined with increased surface salinity are considered more favourable for the formation of toxic blooms than onshore conditions. Thus, the new findings on *Dinophysis acuta*, *D. acuminata* and *D. norwegica* confirmed and extended the hypothesis that the observed occurrence of these species in inshore waters may be the result of advection of populations from offshore.

The results so far indicate the possible direct and indirect links between changes in patterns of the NAO and the response of physical and biological processes to climatic forces with particular emphasis on toxic phytoplankton species and the occurrences of toxic blooms. Further modelling using non-linear, non-parametric statistical methods is a part of this ongoing research study for a better understanding of the mechanisms underlying these associations.

Reference:

Belgrano, A., Lindahl, O. and Hernroth, B. North Atlantic Oscillation primary productivity and toxic phytoplankton in the Gullmar Fjord (1985-1996). - Proc. R. Soc. Lond. B (1999) 266, 425-430.

New findings on various aspects of toxic species

Edna Graneli, Department of Marine Sciences University of Kalmar

1. Using 3 different nuclear microprobes it was possible to determine C, N and P concentrations in single *Dinophysis norvegica* cells sampled from the open waters of the Baltic Sea. The results showed that P concentrations were the same for all analyzed 26 cells while N varied a lot. C/N ratios indicated that the cells within this population were suffering from light to severe N limitation.

2. 1.Toxicity per cell is higher in ichtyotoxic *species (Prymnesium parvum, Chrysochromulina polylepis* and *Gymnodinium mikimotoi*) when the cells are grown under N or P deficient conditions.

2.2. Toxicity is higher in species producing N-rich toxins (*Alexandrium tamarense, A. fundyense, Nodularia spumigena*) under P-deficient conditions;

- for all the investigated species toxicity per cell is lowest when the cells are grown under N:P (16:1) balanced conditions.

2.3. Inhibition of toxicity is rapid. For *P. patelliferum*, P-deficient cells toxin concentration per cell decreased to half within one day following replenishing the cultures with PO4-P.

3. A not yet patented substrate (extracted from a seed of temperate plants) can penetrate the cell walls of *Glenodinium folyaceum* cysts killing the cysts within a few hours. The cysts in the control bottles (filtered sea water) maintained high red fluorescence indicating that the cysts were doing well in these bottles, with their chloroplasts intact. The thought is that this substance may be applied to treat ballast water should further experiments show that the substance rapidly degrades cysts contributing to loosing toxicity when ballast water is discharged in foreign harbours

12 THE ROLE OF ICES IN THE NEW INTERNATIONAL PROGRAMME GEOHAB

Term of Reference 9: consider the role of ICES in the new international programme GEOHAB;

The purpose and progress of IOC-ICES GEOHAB Global Ecology and Oceanography of Harmful Algal Blooms) was presented by P. Gentien (Chair of the SSC). The general objective and the different programme elements were described. They are available at the IOC web site. The Science Plan will be available during the summer.

The WGHABD recommends that ICES play a leading role in the development and implementation of GEOHAB. This could be through planning and coordinating the implementation of regional studies which address major research questions identified in the GEOHAB Science Plan. Several of the GEOHAB objectives are similar to, or have emerged from, issues delt with by the WGHABD since its inception. Therefore, it seems appropriate that the ICES Working Group on HABD act as the focal point and take a lead role, for regional GEOHAB research projects. The continued interaction between the WGHABD and WGSSO also be valuable in attaining this goal.

By taking the lead role in planning and implementing these regional cooperative research programmes which address the GEOHAB Science Plan, ICES will play a significant part in GEOHAB and would provide a model for regional organizations such as PICES and others.

As an example, the Baltic Sea is one region suitable for a cooperative GEOHAB study under the auspices of ICES. The previous work of the WGHABD on HAB Pilot Studies could be revisited and form a foundation for ICES/GEOHAB projects.

The WGHABD concluded that it would be desirable if, within the ICES framework, it would be feasible to plan and implement the GEOHAB regional components through a mechanism similar to the 'Cod and Climate Programme' including a project coordintor. As a first step to this process it was agreed that a draft resolution be prepared by correspondence which would propose a joint ICES/GEOHAB/GLOBEC workshop on a relevant theme. It was expected that this resolution be presented to the Oceanography Committee at the September 2000 Statutory Meeting

The Chair of the WGHABD, who is also member of the Scientific Steering Committee for GEOHAB, will, pending approval by the ICES ASC, ensure that the role of ICES in GEOHAB is included and specified in the GEOHAB implementation plan which is expected to be drafted during the second half of 2000/first half of 2001.

The WGHAB also recommends that ICES commits itself to GEOHAB as outlined above at the 2000 IOC Executive Council and SCOR General Meeting respectively.

13 DATA PRODUCTS AND SUMMARIES VIA ICES WEBSITE

Term of Reference 10: consider, and where feasible, develop data products and summaries that can be provided on a routine basis to the ICES community via the ICES website;

Since 1997 WGHABD has produced decadal maps of HAB occurrences in the ICES areas and these maps are published on the ICES and IOC web-pages. The continuation of this activity is relevant in terms of this ToR. New data products and summaries may be generated on the basis of HAEDAT.

14 REVIEW OF OCEANOGRAPHY COMMITTEE WORKING GROUP REPORTS 2000 AND PROPOSALS FOR THE INTERDISCIPLINARY DIALOGUES

Term of Reference 11: examine the 1999 Oceanography Committee Working Group 2000 TORs to identify where inter-group input could be provided or required with the view to formulating key questions requiring inter-disciplinary dialogue during concurrent meetings of the Committee's Working Groups in 2002.

The group examined the 1999 Oceanography Committee Working Group 2000 ToRs. In general, the group felt that due to the interdisciplinary nature of HAB phenomena *per se*, various approaches for analyses need to be applied, all of which cannot be dealt with by WGHABD alone. Therefore, a dialogue including joint meetings has already been established between WGHABD and WGSSO and WGPE.

In addition to discussions that have already been established, the meeting identified the following questions relevant to understanding HAB dynamics, on the basis of the 2000 ToRs:

WGHABD, WGSSO, SGGOOS, WGOH
- review the current status of operational use of new oceanographic instrumentation with specific reference to collection of data suitable for HAB dynamics studies

WGHABD, WGOH
- information exchange concerning North Atlantic climatological oscillations

- review and check for time-series emerging from the HAEDAT database

WGHABD, SGPHYT
- information exchange concerning the development of the ICES/IOC Check-list of Phytoplankton

WGHABD, WGZE
- review the diversity of zooplankton in the North Atlantic with special reference to the North Atlantic Oscillation

WGHABD, SGPRISM
- establish the principles of optimal strategies for sampling grids for phytoplankton in physically dynamic environments

15 REVIEW OF THE IOC-APEC DOCUMENT 'GUIDELINES ON EMERGENCY MEASURES FOR HARMFUL ALGAL EVENTS'

Term of Reference 12: present the draft IOC-APEC document 'Guidelines on Emergency Measures for Harmful Algal Events' for review by the IPHAB Members and the ICES-IOC Working Group on Harmful Algal Bloom Dynamics;

A sub-group reviewed the IOC-APEC document 'Guidelines on Emergency Measures for Harmful Algal Events' . The sub-group report is presented in Annex 7.

16 DRAFT RESOLUTION FOR 2001 WGHABD MEETING

The **ICES/IOC Working Group on Harmful Algal Bloom Dynamics** [WGHABD] (Chair: K. Kononen, Finland) will meet in Dublin, Ireland, 19-23 March 2001 to:

a) collate and assess national reports and update the decadal mapping of HABs, and summarize the information in the harmful algae event database (HAEDAT) on a regional, temporal and species basis;

b) evaluate the modified harmful event report form;

c) continue examining the possible ways of analysing historical data and fossil records;

d) evaluate and assess the use of remote sensing and *in situ* optical sensing technology in HAB dynamics studies;

e) discuss the potential sensitivity of HABs to climate changes;

f) review the implementation of the GEOHAB research programme in the ICES area;

g) report and discuss new findings.

WGHABD will report to the Oceanography Committee at the 89th Statutory Meeting, and to ACME.

Supporting Information

Priority:	Work essential to the development of understanding of the effects of climate and man-induced variability and change in relation to the health of the ecosystem.
Scientific Justification:	a) Besides their collation, the assessment of national reports should take into account the possible use of data (numbers) from algal monitoring for management purposes from different countries. The HAEDAT database includes reports of HAB occurrences in the ICES area since 1987. 14 years time series should be examined for possible temporal trends or regional distributional patterns. b) National reports of HAB occurrences are submitted to the HAEDAT database through the internet on specific forms. The year 2000 was the first year for the new system. Those who filled in the form gave several complaints concerning the reporting format. Some data was not submitted due to difficulties found in filling in the form. The group indicated that data submission is a critical step in database development, and should be made as easy, yet as accurate as possible. Therefore, a re-evaluation and updating of the form is necessary during the upcoming years. c) The occurrence of HABs has frequently been associated with human activities in the marine environment. Recent reports on fossil pigment records from the Baltic Sea and Arabian Sea, however, show a relatively stable phytoplankton community structure in the time scale of >1000 years. Many HAB species form highly resistant resting stages, which can be identified from sediment

	layers. Canadian studies indicated that on the eastern and western coasts of Canada dinoflagellate cyst production has been higher ca. 10.000 years ago than today by an order of magnitude . It is useful to review information about this topic from different sea areas where HABs are recurrent. d) In research on HAB dynamics, synoptic studies of HAB distributional patterns over large areas are necessary. Several types of HABs are observable by satellite sensors, and therefore remote sensing has potential. On the field mesurement campaigns, new optical *in situ* sensing technologies may provide information on taxonomic composition of algae, and therefore may be useful in HAB dynamics research. During recent years, considerable advances have been made in these fields. This item was included as ToR in WGHABD 1997 meeting, but was not discussed due to the lack of expertise. The topic is still relevant. e) Several examples indicate a strong relationship between the occurrences of HABs and climatic forces. These forces include freshwater runoff, wind-induced mixing, precipitation and water circulation. Examples of these climate/HAB connections for the Gulf of St. Lawrence and the Gulf of Maine were presented at the joint session for the WGHABD and WGSSO. In addition, a potential relationship between the 1985 - 1996 North Atlantic Oscillations (NAO) and the occurrence of *Dinophysis* in the eastern Skagerrak was discussed. Variations in the abundance of dinoflagellate cysts in deep sediment cores also indicate important changes in the amplitude and frequency of HABs during cold and warmer periods. Although the exact nature of climate/bloom developments is not always known, these results clearly show that future natural or man-induced changes in regional climates may significantly impact the occurrences, distributions and amplitudes of HABs. It was thus felt that the WGHABD should address this question in light of recent findings. f) The work done by WGHABD has been one of the pathways leading to the establishment of GEOHAB. The previous work of the WGHABD on the HAB Pilot Studies as well as several reviews done by the WG on topics relevant to ecology/oceanography address directly the central research approch of GEOHAB. The ICES expertise to review the implementation of GEOHAB in its region is centred around this working group and therefore it makes sense for the WGHABD to follow the implementation of GEOHAB in the ICES area. g) The forum for presenting new findings has been an excellent tool for promoting discussions about topics of general interest. There are obvious reasons to continue with this topic as a Term of Reference.
Relation to Strategic Plan:	This work is relevant to the quantifying of human impacts on the marine ecosystem. Especially in terms of the evaluation of the ecosystem consequences of contaminants and eutrophication.
Resource Requirements:	None specific.
Participants:	The 1999 meeting attracted 32 participants, demonstrating the imporatnce and interest of this Group within ICES.
Secretariat Facilities:	None
Financial:	None
Linkages To Advisory Committees:	ACME
Linkages To other Committees or Groups:	None
Linkages to other Organisations	The work of this group is undertaken in close collaboration with IOC's HAB programme. There is also a growing relation with SCOR in relation to the GEOHAB Programme.

ANNEX 1: LIST OF PARTICIPANTS

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ANNEX 2: AGENDA OF THE WGHABD MEETING

Monday 20 March

Time	Activity/ToR
9.30	Meeting in the hotel lobby; walking to the Institut de Ciencies del Mar.
10.00	- opening the meeting; - practical information; - introducing the participants; - information about new ICES Guidelines for preparing draft resolutions; - agreement about the meeting schedule
10.30 until lunch	Retrospective and critical analysis of the work peroformed by WGHABD
LUNCH	
after lunch till coffee break	Summary of the information in the harmful algae event database (HAEDAT) on a regional, temporal and species basis Collating and assessing national reports, updating the mapping of HABs
COFFEE	
after coffee until the end of the session	Examining the possible ways of analysing historical data and fossil records with the help of an invited specialist; Reviewing scenarios of toxic events developments;

Tuesday 21 March

Time	Activity/ToR
9.00	Considering the role of ICES in the new international programme GEOHAB.
COFFEE	
	Examining information on the possible implication of benthic species in toxic events and reporting on induced problems on monitoring procedures;
LUNCH	
after lunch	Reviewing a draft IOC-APEC document 'Guidelines on Emergency Measures for Harmful Algal Events' Considering, and where feasible, developing data products and summaries that can be provided on a routine basis to the ICES community via the ICES website; Examining the 1999 Oceanography Committee Working Group reports 2000 TORs to identify where inter-group input could be provided or required with the view to formulating key questions requiring inter-disciplinary dialogue during concurrent meetings of the Committee's Working Groups in 2002.
COFFEE	
after coffee until the end of the session	Reporting and discussing new findings

Wednesday 22 March

- joint session with WGSSO

Thursday 23 March

- joint session with WGSSO

Friday 24 March

Time	Activity/ToR
9.00	ToRs for the 2001 meeting
	Agreement about the report sections
	Agreement about the next meeting place
SHORT LUNCH	
14.45 at the latest	Closing the meeting

ANNEX 3: AGENDA OF THE JOINT WGHABD- WGSSO MEETING

Wednesday 22 March Joint session of WGHABD and WGSSO

Time	ToR	Activity	Notes/annotation
09.00		Welcome	Kaisa Kononen and Björn Sjöberg
09.30		Physics, models and harmful algal blooms.	Introduction by Wolfgang Fennel
10.30		COFFEE	
11.00		The importance of microstructure, turbulence and mixing in relation to algal blooms	Percy Donaghay
11.30		On the importance of thin layers.	Patrick Gentien
12.00		Aspects of different bio-geo-chemical models as applied in the Baltic.	Oleg Savchuk
12.30		The role of atmospheric forcing in the accuracy of salinity and temperature simulations. The needed horizontal resolutions of the numerical models- a study of the internal Rossby radius in the gulf of Finland.	Kai Myrberg
13.00		LUNCH	
14.00		Ice-ocean modelling in the Gulf of St Lawrence with applications to biology.	François Saucier
14.30		SCOBI-3D biogeochemical model	Eleonor Marmefeldt
15.00		NORWECOM- Norwegian Ecological Model System	Einar Svendsen
15.30		COFFEE	
16.00		Modelling blue-green algae dynamics in Lake IJssel: biomass and flotation.	Anouk Blauw
16.30		A coupled physical-biological model of toxic Alexandrium dynamics in the Gulf of Maine	Don Anderson
17.00		Effects of river nutrient load reductions on the eutrofication of the North Sea, simulated with the ecosystem model ERSEM	Lenhart
17.30		Changes in the plankton community passing a Mytilus edulis mussel bed	Odd Lindahl

Thursday 23 March

Time	Activity/ToR	Notes/annotation
09.00	Modelling of HABs in the context of regional climate models	Maurice Levasseur/ Juliette Fauchot
09.30	Larval drift experiments in the Baltic sea, model results and measurements	Kai Myrberg
10.00	COFFEE	Kaisa Kononen/Björn Sjöberg
10.30	Parameterization of phytoplankton groups and communities in the Baltic biogeochemical models; nutrient uptake, mortality and sedimentation.	Oleg Savchuk
11.00	Inter-comparison of three parameterisations of nitrogen fixation using Gulf of Riga box model.	Oleg Savchuk
11.30	Introduction to sub-group work	Kaisa Kononen / Björn Sjöberg
12.00	LUNCH	
13.00 -	Working in sub-groups	
17.00	Evaluation, discussion, conclusion and recommendations	

ANNEX 4: DECADAL MAPS OF HAB EVENTS IN THE ICES AREA

These maps can be accessed from http://www.ices.dk/status/decadal/

ANNEX 5: MODIFIED BACKGROUND AND DOWNLOAD PAGES FOR HARMFUL ALGAE EVENT DATA BASE (HAEDAT)

Background:

ICES-IOC has annual records of harmful events associated with harmful microalgae since 1987. This activity was initiated by the Working Group on Phytoplankton and the Management of their Effects (*CONFIRM NAME)*and continued by the Working Group on Harmful Algal Bloom Dynamics. Since then, a National Report form has been designed and implemented by national representatives in order to organise data for each year from the member countries.

Interest in data analysis led to a proposal in 1997 to create a computer database for recording these events: the Harmful Algae Event Data Base (HAE-DAT). This proposal identified recent advances in computer software, easy flow of information (Internet), and data analyses. The main purpose of HAE-DAT is to develop a structure for data storage allowing easy integration of data, efficient search tools, and potential for conducting data analysis.

Several steps were proposed to develop HAE-DAT. Initially, an analysis of past National Reports was conducted to determine content. Although information was diverse, it was felt that additional information would be of benefit, where available. Therefore, a new Harmful Event Data Input Form was proposed and discussed with members of the WGHABD prior to implementation. This form has recently been revised to make it more 'user-friendly' without losing important information.

This new format was designed to respond to the interests of managers and scientists working in fields related to harmful algae. The intent was to facilitate the task of individuals reporting events. The information is input in a database. Additional information can also be added in the form of text, files (Graphs, maps, ...) and web-links.

It is important to state that <u>all</u> information included in each report is useful and that every report need not provide information at the same level of depth. Respondents submitting the report may come from very different areas and have different types of information.

HAEDAT runs under the Access 97© program, using the standard Windows 95 © operating system. For information on how Access works, please refer to your Windows 95 © or Access 97 © documentation.

In order to read the data contained in the present database, open the file HAEDAT.mdb. Once you have opened the file, click on the ‘General form’ located in the forms section.

TO ACCESS HAE-DAT CONTINUE TO NEXT PAGE

HAEDAT Database Download Page

There are two different ways to download Haedat Database:

1.- A large file with Haedat Database, maps and all complementary information.

Click here to download the entire package (23Mb)

2.- A small file with Haedat Database and internet hyperlinks for complementary information and maps.

Click here to download just the database (651Kb)

Click here to download the questionnaire.

Files are winzip compressed, to get Winzip compressor/decompressor click here.

Note:When you use the WinZip you must check the option:"Use Folder Names"

Disclaimer warning

This database contains information on harmful events from 1987-1998. The information is based on yearly national reports submitted by ICES member states. The available information from individual events varies greatly from event to event or country to country. Monitoring intensity, number of monitoring stations, number of samplings, stations, and etc. also vary greatly and therefore there is not always a direct relationship between recorded events and actual occurrences - for example, toxicity in a given region. Areas with numerous recorded occurrences of HAE's, but with efficient monitoring and management programmes, may have very few problems and a low risk of intoxication, whereas rare HAE's in other areas may cause severe problems and represent significant health risks.

Therefore, HAEDAT maps should be interpreted with caution regarding the risk of intoxication by seafood products from respective areas/regions/countries.

The IOC and ICES are not liable for possible misuse of this information.

ANNEX 6: MODIFIED FORM FOR THE NATIONAL HAB REPORTS

Instructions For Filling Out The Forms

PLEASE only report information about harmful events (according to the following definition).

A harmful algal event is defined as:

- a water discolouration, scum or foam causing a socio-economic impact due to the presence of toxic or harmful microalgae
- biotoxin accumulation in seafood above levels considered safe for human consumption
- any event where humans, animals or other organisms are negatively affected by algae

As indicated on the form, you may not be able to fill in all the data fields. However, all information is valuable.

When reporting location, do so according to geographic region. For example: *Area:* Ria de Vigo; *Region*: Northwest Spain. The ICES region can be obtained from the IOC web site *or* your country representative will enter the appropriate code.

We feel that the form is self-explanatory. If, however, you have problems, contact your country representative.

Following completion of the forms, please return them to your national representative.

ICES National HAB Report

COUNTRY

GENERAL INFORMATION

Please note: NOT all information requested on this form is required. Some respondents may choose to stop at the end of the first page, but others may wish to add detailed bloom information, as requested on page 2. Any information you provide is of value.		
Indicate the nature of the reported harmful event: Water discoloration High Phyto concentration Seafood toxin Mass mortalities Foam/mucilage in the coast Other		
Has the event directly affected? Planktonic life Benthic life Shellfish Natural Fish Aquaculure Fish Aquatic mammals Birds Other terrestrial Humans		
Has any toxicity been detected?	Yes No	If yes, approximate range
Associated syndrome	PSP DSP ASP NSP Other	
Unexplained toxicity	Yes No	If yes, comments
If intoxications occurred, please indicate the species implicated in the transmission of toxins (Transvector):		
Additional comments		
Is this report the outcome of a monitoring programme? Yes No		
If yes, which programme(s)?		
Has this event occurred before in this location? Yes No		If yes, comments
Individual(s) to contact (name, address, e-mail, web page, etc.)		

LOCATION AND DATE

		Location (if a single site)	N-S/E-W	00º	00.0'
		Latitude			
		Longitude			
General location information		Name of the area: Region: ICES Area code:			
Additional location information (i.e., length of covered shoreline or aerial coverage of bloom)					
Bloom duration (dd/mm/yy)		Initial date:	Final date:		
Additional information:					
Causative organism known?		Yes No			
Causative species	Causative species/genus	Taxonomical class	Cells/L	Comments	
Co-occurring dominant species	Species/genus	Taxonomical class	Cells/L	Comments	
Chlorophyll concentration, if known (µg/l)					
Additional Bloom Information (text)					
Event-related Bibliography					

Thank you for your contribution. If you have more detailed information to offer on this HAB event, please continue to the next page. Fill in only what information is available.

ENVIRONMENTAL CONDITIONS

The information herein provided should correspond to the environmental conditions at a reported location and day of an event,. Complimentary information can be provided if possible in the "Additional Environmental Information" field.					
Weather		Turbidity (NTU)		Wind direction:	
Stratified water	Yes No	Oxygen content (mg/l):		Wind velocity:	
Temperature		Oxygen saturation %:		Current direction:	
Secchi disk (m)		Salinity		Current velocity:	
Nutrient information:					
Please, if available, indicate here maximum/minimum temperature and salinity recorded during the whole duration of the event:	Maximum Temperature (ºC):		Maximum Salinity		
	Minimum Temperature (ºC):		Minimum Salinity		
ALGAL BLOOM	Location in the water column	Whole water column	Subsurface bloom	Surface bloom	
	Advected or in situ growth				
	Additional environmental information				

16.1.1.1.1

TOXIN ASSAY INFORMATION

Species containing the toxin	Toxin type	Toxin details	Concentration (specify units)	Assay type	Use of a kit (if yes, what type of kit)
					Yes No
ADDITIONAL INFORMATION (e.g. positive animal assay, chemical details...)					
ECONOMIC LOSSES (production value, direct loss, indirect loss...)					
MANAGEMENT DECISION					
ADDITIONAL HARMFUL EFFECT INFORMATION					

ANNEX 7:
REVIEW OF THE IOC-APEC DOCUMENT
'GUIDELINES ON EMERGENCY MEASURES FOR HARMFUL ALGAL EVENTS'

General comments

The guidelines was found extensive and easy to read. However, the presenting style and extension of each subject area is heterogeneous. Each chapter should follow uniform structure on how to organise the information. For example, some areas quote references and/or examples and some do not; the level of details in the discussions is also very variable.

The guidelines are intended for non-specialists, in some cases too many details, including Latin names on algae open for confusions, ex. *Gyrodinium aureolum/Gymnodinium mikomotoi.* have been expressed. The version reviewed by WGHABD members was a draft one, and probably some parts indicated as missing will be added later and further technical editing will be made.

It was noted that Chapter E is the most advanced and well written.

Section A should be more detailed, incuding some examples of case studies or regional events;

Chapter A.2

Adverse effects

DSP are cancer promoters (not carcinogenic in strict sense)

Commercial fisheries

Some fish physiologists do not believe in clogging of fish gills by algae, rather any kind of damage of the gills.

Ecosystem and environment

Chrysochromulina bloomed in Scandinavia (not only Sweden)

Chapter A.4

One should add that toxins often are accumulated in specific organs, and thus fish flesh usually do not contain toxins even if fish has been exposed to toxic algae.

Examples of zooplankton grazers and fish are needed (references attached below).

Chapter A.7

Our limited basic knowledge on possible causes to blooms may complicate risk assessments.

Chapter B

The aim of the monitoring must be well defined, and cost/benefits of the monitoring should be regularly evaluated. An open and efficient communication between participating institutions/agencies and industries is crucial. Monitoring should support industry, management authorities and science. This Section should include recommendations, or at least some references on sampling design.

Chapter B.3

It is essential to emphasise that in the case of bivalve toxicity, plankton monitoring can be a good complement but NEVER a substitute of toxin monitoring, and give reasons for it.

Chapter C

Information and motivation are important elements of a monitoring strategy as well as education, training and quality assurance. One should, however, not overdo efforts spent on monitoring of algae.

Chapter D

Analytical methods and action limits should as far as possible be harmonised among countries, and currently updated based on sound scientific assessments.

The last Section on action limits needs improvement. This is one of the most important reasons of conflicts for imports and exports between countries, and there is hardly anything said in here. For PSP, some recommendation on pH values should be given, narrowing the range of values if convenient. DSP is probably the most conflictive group in Europe and in many other places in the world. There are not many toxicological data available, but it should be mentioned what is being used these days. It is also important to mention that it is compulsory now to regulate ASP levels in EU, Canada...and that the lack of reports from other places does not necessarily mean that they do not have them there.

Chapter E

This chapter is much larger than the others and contains a lot of interesting information, including a long list of references. It is written almost with the level of a scientific review. The style is very different form the other chapters. Some of the information is to speculative for the purpose of the guidelines.

Chapter E 1

It is mentioned that nutrient ratios, in addition to the quantity of nutrients discharged into the coastal waters is an important determinant of species composition. It is worth noting that N:P ration becomes important when either N or P becomes limiting. Furthermore, more emphasis should be placed on the N:P and N:Si ration influencing cell toxicity during nutrietn-limited growth of potentially toxic species (Alexandrium, Pseudonitzschia)

fifth par.: should say "some experiments showed..", because these are mainly results from culture experiments, and not always using the same conditions; the results are controversial because there are also contradictory results by other authors.

Chapter E 3

first par.: "not" is probably lost after could (first sentence): "...

the species could (can?) NOT be eliminated entirely from...

second par.: Shirota (1989) is not in the reference list. Include the reference of the paper presented by

Lindahl (WGHABD, Barcelona 2000) on bloom control by filter feeders; add new results on

parasites (Parvolucifera infestans).

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