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REPORT OF THE

ICES/IOC WORKING GROUP ON HARMFUL ALGAL BLOOM DYNAMICS

Dublin, Ireland
12–16 March 2001

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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TABLE OF CONTENTS

1 WELCOME AND OPENING OF THE MEETING

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics was organized by the Marine Institute Fisheries Research Centre, Abbotstown, Dublin, Ireland and held in Dublin Castle during 12–16 March, 2001. The meeting was organized by Terry McMahon and chaired by Kaisa Kononen (Finland). Thirty-three scientists from 19 countries participated. The list of participants is presented in Annex 1. The meeting agenda is presented in Annex 2.

The meeting was opened by heartily welcome from the local organizer, Terry McMahon as well as by the introduction of the meeting participants.

2 TERMS OF REFERENCE

At the Annual Science Conference, Brugge (Belgium) the council resolved that (C. Res. 2000/2C03)

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics [WGHABD] (Chair: Dr K Kononen, Finland) will meet in Dublin, Ireland, from 12 – 16 March 2001 to:

1) collate and assess national reports, update the mapping of HABs and summarize the information in the harmful algae event database (HAEDAT) on a regional, temporal and species basis
2) evaluate the modified harmful event report form
3) continue examining the possible ways of analysing historical data and fossil records
4) evaluate and assess the use of remote sensing and *in situ* optical sensing technology in HAB dynamics studies
5) discuss the potential sensitivity of HABs to climate changes
6) review the implementation of the GEOHAB research programme in the ICES area
7) prepare a resolution for a workshop, possibly co-sponsored by regional programmes, such as GEOHAB, GLOBEC and GOOS, on 'Real-time observation systems applied to Harmful Algal Bloom Dynamics studies and global ecosystem functioning'

3 SUMMARY AND CONCLUSIONS

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

Term of Reference 2: evaluate the modified harmful event report form.

National representatives presented summary reports of HAB occurrences in the respective sea areas. The reports of HAB events were submitted directly to the HAEDAT database using the revised reporting format through the internet. In general, the new format was found to be clear and user-friendly. These modifications to the database allow input from IOC countries outside the ICES geographic area. A preliminary agreement was reached with PICES, such that PICES will become the first new partner in HAEDAT.

Term of Reference 3: continue examining the possible ways of analysing historical data and fossil records.

Two presentations were given on this subject. The first one described a Finnish project which aimed at providing a systematic, historical overview of the occurrence and intensity of cyanobacterial blooms in the Baltic Sea over the last centuries. The study utilized all available information, consisting of early historical notes and navigation logbooks from the Baltic area, as well as phytoplankton records published since late in the 19^{th} century. Paleolimnological studies of the pigment composition and resistant cyanobacterial cells in the Baltic Sea sediments were observed. Furthermore, a social science historical review of environmental discourses during the last two centuries was made. All three approaches ended up with the similar conclusion – cyanobacteria blooms have intensified and eutrophication was determined to be a problem following the World Wars (in 1960s).

The second presentation described a Canadian long-term phytoplankton-monitoring programme where phytoplankton data from the years 1988–1999 was collected. The time series includes 277 sample dates from one station from which 4 depths were sampled. Data was analysed by estimating the annual cycle of abundance separately for dinoflagellates, diatoms and “other” (which included smaller zooplankton, silicoflagellates and ciliates). Each of the groups yielded a strong seasonal signal that declined in magnitude from the surface to 50 m for the dinoflagellates and zooplankton whereas the diatoms tended to maintain a more consistent presence at all depths over time. This analysis suggests that samples taken from 10 m are representative of a broader depth range. It was, however, found that the sampling depth 10 m neither represents the species composition nor the water column. The researchers intend to pursue these analyses further and investigate individual species – especially HABs.

The WGHABD recommended including this topic in next year's ToRs.

Term of Reference 4: evaluate and assess the use of remote sensing and *in situ* optical sensing technology in HAB dynamics studies.

Many approaches are useful for the optical assessment of HABs and relevant aspects of coastal ecosystems. These include remote sensing of ocean colour from satellites and aircraft, the measurement of ocean colour *in situ* from moorings, drifters, and portable radiometers, and the measurement of attenuation coefficients using profilers or chains of sensors on moorings.

A strategy for the exploitation of remotely sensed data (particularly ocean colour) for understanding and prediction of environmental change within marine ecosystems with the special emphasis on monitoring and management of the effects of harmful algal blooms was presented. The potential and limitations of radiometers and optical sensors in moorings and drifters were reviewed.

In conclusion, no one approach is adequate for describing ecological processes in the coastal zone relevant to the dynamics of harmful algal blooms. Integrated observation systems are necessary, and optical measurements are key, but not sufficient. Several technical problems concerning sensors need to be solved, and techniques of optical-biological data assimilation into models need to be developed.

Term of Reference 5: discuss the potential sensitivity of HABs to climate changes.

Since harmful algal blooms (HABs) are closely tied to their surrounding environmental conditions, variations in climate such as in temperature, precipitation, freshwater run-off and wind conditions may potentially influence their distribution and bloom dynamics. A Canadian project on potential sensitivity of harmful algal blooms to climate changes was presented. The approach used is dynamical downscaling of physical processes, expressed as regional climate models (RCMs), nested in general circulation models (GCMs). Coupling of RCMs with Regional Oceanic Models (ROMs) will allow prediction of the influence of climatic change on oceanic environments. Ultimately, the coupling of the ROM with population models of harmful species will provide a powerful tool to explore the sensitivity of HABs to climate variability. An example was given of the role of climate variability on HABs in the Gulf of St. Lawrence (eastern Canada) over a 10-year period. The results showed a strong sensitivity of HABs to variations in summer precipitation, river run-off and local wind conditions.

Term of Reference 6: review the implementation of the GEOHAB research programme in the ICES area.

The IOC-SCOR initiative GEOHAB and its Science Plan was presented to the meeting. The WGHABD recognized the high scientific quality of the Science Plan and found it to be a valuable document for planning future research activities.

The outcome of the meeting of the Study Group of GEOHAB Implementation in the Baltic Sea, which was held during the two days preceding the WGHABD meeting, was presented. The WGHABD emphasized that the Baltic study should not be considered as a GEOHAB *regional* study only but as a model on how to address the problem of HAB dynamics in brackish water systems. The WGHABD recommended that the Study Group on the GEOHAB Implementation in the Baltic Sea prepare a short briefing or presentation to be given to the GEOHAB Scientific Steering Committee before their meeting in April 2001. The GEOHAB SSC should be urged to provide comments and guidance on the preliminary program in the context of GEOHAB.

Term of Reference 7: prepare a resolution for a workshop, possibly co-sponsored by regional programmes, such as GEOHAB, GLOBEC and GOOS, on 'Real-time observation systems applied to Harmful Algal Bloom Dynamics studies and global ecosystem functioning'.

The WGHABD recommends a workshop to be held in Europe, to consist of plenary and poster sessions as well as practical demonstrations and intercomparisons. John Cullen accepted the task of convening the workshop with the help of a steering committee.

The outcome of a publication based on WS presentations was considered very valuable. It was pointed out that the area of real-time observation systems is developing rapidly, while producing a paper publication in any of the existing publishing formats might take at least one year. Therefore the WGHABD recommends that the steering committee consider newer publishing models, e.g., the Internet.

Term of Reference 8: report and discuss new findings.

Five contributions were presented.

4 NATIONAL REPORTS AND HAEDAT-DATABASE

Term of Reference 1: collate and assess national reports, update the mapping of HABs and summarize 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.

Canada

West coast:

Blooms of *Heterosigma akashiwo* occurred during early July and late September on the west coast of Vancouver Island with the latter bloom being associated with salmon mortalities when 1,200,000 cells/L were observed in surface waters. The Vancouver Island area (Clayquot Sound) also experienced PSP closures of shellfish harvesting areas associated with *Alexandrium catenella*. Shellfish toxicities reached 580 µg/100g and cell concentrations exceeded 250,000 cells/L.

East coast:

ASP toxins (262 µg/L) were detected in scallop digestive glands on July 12 from the Magdaleine Islands (St. Lawrence region). As well, low-level toxicity (0.6–4.8 ppm) was detected in clams, mussels and razor clams. *Pseudo-nitzschia seriata* was dominant in the water (70,080 cells/L) and cells were isolated and produced domoic acid in culture. DSP toxins were also detected in shellfish from the same region and *Prorocentrum lima* was implicated in an earlier study to be the probable source of toxin. PSP toxins reached a level of 2900 µg/100g in the Sept Iles area.

The first record of domoic acid being detected in western Prince Edward Island (Gulf of St. Lawrence) was on Sept. 19. Prior to 2000, domoic acid had only been detected from the north and west coasts of PEI. The east coast episode determined that *P. multiseries* was the causative organism with 220,000 cells/L measured during late stages of the bloom.

Low levels of PSP toxins (95 µg/100g STX equiv.) were detected in shellfish in the Bay of Fundy. Maximum *Alexandrium fundyense* concentrations observed were 2400 cells/L in Passamaquoddy Bay.

A mass mortality of aquacultured salmon (*ca*. 2000 individuals) occurred in Shelburne Harbour, on the south-eastern coast of Nova Scotia at the end of May, extending into the first week of June, 2000. This event co-occurred with a massive bloom of *Alexandrium tamarense* (>800, 000 cells/litre), the probable cause of the mortality. At the peak abundance, *A. tamarense* represented >95% of the net plankton (>20 µm) and fouling mussels on the salmon cages contained >6,000 µg saxitoxin equivalents/100 g wet weight, as determined by AOAC mouse bioassay and HPLC-FD analysis.

China

In 2000, there were 29 HAB events documented from Chinese coastal waters. The Bohai Sea had 8 events (discoloured area: 2461 $km^{2)}$, the Huanghai Sea had 4 events (discoloured area: 850 km^2), the East China Sea had 13 events (discoloured area: 12,846 km^2) and the South China Sea had 4 HAB events. Due to the limited monitoring, the number of HAB events recorded may be an underestimate. HABs mainly occurred between May and September with the recorded HAB species primarily belonging to the group of dinoflagellates. Most causative species of HAB events were not identified and several events were recorded where fish were killed but the mechanism was not determined.

Main HAB events along the coastal waters of China during 2000

Time	location	Area	HAB species	Harmful effects
3–4 May	Zhoushan archipelago water, Zhejiang Province	*600 km^2*	*Prorocentrum sp.*	Fish mortalities
12–16 May	Taizhou archipelago water, Zhejiang Province	1000 km^2	Species unknown	No record
18–24 May	Taizhou archipelago water, Zhejiang Province	5800 km^2	Species unknown	No record
19 May	Shacheng Harbour, Fujian Province	200 km^2	Species unknown	No record
30 May	Xiangshang fjord, Zhejiang Province	200 km^2	Species unknown	No record
30 May	Shanmen Bay, Zhejiang Province	6 km^2	Species unknown	No record
1 June	Zhoushan archipelago water, Zhejiang Province	150 km^2	Species unknown	No record
7–8 June	Qianjiang Bay, Shantou, Guangdong Province	Small area	*Noctiluca* sp.	No record
26 June	West Sea area of Xiamen, Fujian Province	20 km^2	*Chaetoceros* sp.	Cultured fish mortalities
9–15 July	Liaodong Bay	350 km^2	*Noctiluca* sp.	No record
20–21 July	Huanghua water area, Tianjing	180 km^2	Species unknown	Commercial jelly fish mortalities
20–23 July	Jiaozhou Bay, Qingdao	2 km^2	*Noctiluca* sp.	No record
23 July	Centre area of Bohai Bay	1040 km^2	Species unknown	No record
23 July	Qinghuangdao area, Bohai	3 km^2	Species unknown	No record
2 August	East water area of Zhuanghe, Liaoning Province	827 km^2	Species unknown	No record
2 August	Shicheng Island water, Liaoning Province	Small area	Species unknown	No record
2 August	Dalian Bay, Liaoning Province	Small area	Species unknown	No record
13 August	Northern water area of Wentuan Island, Liaodong Bay	217 km^2	Species unknown	No record
13 August	Weastern water area of Changxing Island, Liaodong Bay	44 km^2	Species unknown	No record
17–20 August	Outou Sea area, Shengzhen	20 km^2	*Scrippsiella trochoide*a and *Peridinium quinquecorne*	Cultured fish mortalities
4 September	Zhoushang fishing ground, Zhejiang Province	70 km^2	Species unknown	No record
3–6 September	Daya Bay, Guangdong Province	30 km^2	*Scrippsiella trochoide*a	Fish mortalities
16 September	Coastal water of Jiangsu Province	200 km^2	Species unknown	No record

(Provided by Douding Lu)

Estonia

No cyanobacterial blooms were observed in Estonian coastal waters in the summer of 2000. This is probably due to the prevailed meteorological conditions: persistently high wind speed from eastern directions which caused vertical mixing and frequent upwelling events (low water temperature: 11–13°C) near the southern coast of Gulf of Finland. Southwest of the Gulf of Finland the dense concentrations (up to 5 million cells per litre) of *Chrysochromulina* spp. were detected in late June /early July.

Finland

No cyanobacterial or other harmful algal blooms were detected along the Finnish coastal areas. In late summer the Alg@line and other phytoplankton monitoring programmes revealed a typical species composition, with cyanobacteria observed in the community but not in bloom concentrations.

France

As in previous years, the detection of DSP and PSP toxins in shellfish led to shellfish areas closures, but the new event was the observation (for the first time) of ASP toxins in shellfish at levels above the regulatory limit of 20 µg domoic acid per g of flesh.

DSP

The areas that were not closed were not as many as during previous years. Those experiencing closures were: one in Normandy along the Channel coast, a few along the South Brittany coast (Atlantic), and one in a lagoon of West Mediterranean.

PSP

The two shellfish areas closed were: one in North Brittany along the Channel coast, which has experienced closures for a few years; and the other in Toulon Roads along the Mediterranean coast, a first time occurrence. In both instances, the implicated species was *Alexandrium minutum*, but the toxin profiles were different, with the Mediterranean species being much more toxic than the species from Brittany. The maximum concentration detected in mussels from Toulon was 140 µg STX equiv. per 100 g flesh.

Toxic episodes which occurred in 1998 and 1999 in a Mediterranean lagoon (Thau)- due to the development of blooms of *Alexandrium catenella* / *tamarense* did not occur in 2000.

ASP

Two areas were closed to harvesting in West Brittany, and two shellfish species were observed as toxic: mussels (*Mytilus edulis*) and *Donax trunculus*, with respectively 30 and 50 µg domoic acid per g flesh. Two toxic species of *Pseudo-nitzschia, P. pseudodelicatissima* and *P. multiseries* were observed during the past 2 - 3 years in several regions on the French Atlantic coast. Proportions of these toxic species of the total *Pseudo-nitzschia* population seem to increase each year (other identified species were *P. pungens*, *P. fraudulenta* and *P. delicatissima*).

Germany

North Sea

A dense algal bloom of a *Chattonella* species developed at the end of April and persisted to the beginning of May 2000 in the North Sea. Areas affected included; southern Norwegian waters, the west coast of Sweden, the Kattegatt area and the west coast of Denmark. This year, no fish kills were observed. Although the algal bloom did not reach the coastal waters of Schleswig-Holstein, high densities of cells were measured north-west of the islands of Sylt and around Helgoland (concentrations ranged from a few million to 10 million cells per litre).

At the end of April *Phaeocystis globosa* occurred between the islands of Lower Saxony, but colony numbers increased only slightly - up to 6.800 colonies per litre. This resulted in less foam along the shore and was followed by a rapid decline in *Phaeocystis* sp. This year no intense blooms of this species were detected along the German coast.

From April to September many surface water discolorations from *Noctiluca scintillans* were observed during regular monitoring programmes as well as by coast guard ships and navy aeroplanes. Size of water discolouration varied from a few square meters to a few square kilometres.

Baltic Sea

In the northern Baltic Sea some surface discolouration as a result of the blue green alga, *Nodularia spumigena,* was observed at the beginning of August, but it disappeared within the same day with the onset of winds.

Ireland

1) A bloom of *Alexandrium tamarense*, maximum cell count of 40,000 cells/litre, was recorded in Cork Harbour in late June. The presence of PSP toxins above the regulatory limit was detected in mussels and harvesting was prohibited for 2 weeks.
2) Domoic acid was first detected in scallops in November 1999 in both aquaculture and "wild fishery" locations on all coasts of Ireland. Throughout 2000 the concentration of domoic acid in the hepatopancreas of all samples tested was above the regulatory limit with the maximum concentration recorded being 2300 µg/g but the concentration in the adductor muscle and gonad was below the regulatory limit. The source of the toxin has not been clearly determined.
3) During 2000 some 2,500 samples of shellfish were tested using the Yasumoto (1978) mouse bioassay and approximately 18% of samples gave positive (at least 2 of 3 mice dead within 24 hours) results. This compares with 2% of positive results during 1998. Prolonged closures of shellfish production areas were enforced, particularly in the south west of the country where production areas in Banrty Bay and Kenmare Bay were closed from mid-May through to December. Prolonged closures were also enforced in production areas on the west and northwest coast. DSP toxins including okadiac acid and DTX-2 were detected, as was azaspiracid. The prolonged closures resulted in losses to the shellfish industry estimated to be IR£4.5 million (approximately US$5.5 million).
4) Blooms of *Gymnodinium mikimotoi* and *Noctiluca scintillans* were recorded in Banrty Bay in mid-August and early September respectively. There were no reports of fish kills or mass mortalities of other marine organisms.

Latvia

No visual observations of HABs were observed in Latvian waters in 2000 during regular monitoring and other studies of HAB dynamics in the Gulf of Riga (provided by Institute of Aquatic Ecology, University of Latvia). The absence of surface blooms could be explained by the cold and windy summer.

Nevertheless, high cell concentrations of several HAB species were detected in some regions in the mid-July. The highest abundance of the nitrogen fixing cyanobacteria, *Aphanizomenon* sp., was observed in the southern part of the Gulf. The maximal concentration of *Nodularia spumigena* was detected in the Eastern part of the Gulf. The maximal abundance of potentially mixotrophic *Microcystis* spp. was marked in the southern part of the Gulf, a region influenced by the River Daugava, where the highest concentrations of organic nutrients usually are detected.

No harmful effects or toxins were reported from Latvian waters.

Nigeria

Potentially toxic microalgae in Nigerian coastal waters:

During the months of November and December (1999) waters in the Bar Beach and the Lagos Lagoon, all in the Lagos State of Nigeria were sampled (by Cyril Ajuzie) and analysed for the presence of harmful algal bloom (HAB) species.

Preliminary results indicate that potentially toxic dinoflagellates (*Dinophysis acuta*, *D. caudata*, *D. tripos*, and *Prorocentrum lima*), diatoms (*Pseudonitzschia* spp), and cyanobacteria (*Anabaena* spp. and *Microcystis* spp.) are present in the Nigerian coastal waters. This is the first time that potentially toxic HAB species have been reported from the entire Gulf of Guinea, where Nigeria's coastal waters are located.

Other potentially dangerous HAB species observed included *Prorocentrum micans*, *Ceratium furca*, *Peridinium quinquecorne*, *Protoperidinium* spp, and *Chaetoceros* spp.

It should be noted that until about the time this study was undertaken, no individual(s) or research group(s) in Nigeria were involved with HAB studies. No monitoring of HAB species is carried out in Nigeria- awareness on this subject within the country seems to be lacking or very low. However, three Nigerians have so far benefited from the IOC-DANIDA Training Course on Taxonomy of Marine Phytoplankton at the Botanical Institute, University of Copenhagen, Denmark. It is hoped that many more Nigerians will participate in this and related courses in the future.

Once awareness on the HAB phenomenon is brought nearer to the people of Nigeria, this country will not hesitate to join the international community in efforts being made to understand HAB global dynamics, and to curtail its socioeconomic and public health problems.

The Netherlands

The 2000 results of the MONISNEL monitoring program of the National Institute for Coastal and Marine Management/NICMM are presented from an early warning system for HAB species with 5 monitoring stations: Oosterschelde, Grevelingen, Goeree6, Dutch coast (Noordwijk 10), and central North Sea (Ts135).

As in 1999, the concentrations of potentially toxic phytoplankton species were again unusually low.

Gymnodinium mikimotoi: no cells were detected.

Dinophysis spp.: low concentrations (less then 100 cells per litre); only in the central North Sea concentrations of *D.acuta* peaked in October with 650 cells/litre.

Phaeocystis globosa: the spring bloom of this colonial prymnesiophyte was absent; later in the year a small bloom with 12 million cells per litre occurred at the coast of Holland.

Noctiluca scintillans: maximum abundance at the regular monitoring stations was only 400 cells per litre. A small red tide occurred near the island of Ameland with 3.2 million cells per litre.

Pseudo-nitzschia species were sometimes abundant at all stations but no efforts were made to identify them to species level.

Coolia monotis: this benthic dinoflagellate was identified for the first time in a sample from saline Lake Grevelingen. It is known from the literature that certain strains of *C. monotis* are able to produce a toxin. No shellfish toxicity was detected though, and cultured isolates were sent to Professor Yasumoto in Japan for toxin analysis.

In a brackish lake (Binnenschelde) fish were killed during a bloom of the prymnesiophyte *Prymnesium* cf. *parvum*, when maximum concentrations detected were 100 million cells per litre.

Norway

Diarrhetic shellfish toxins (DST) and paralytic shellfish toxins (DST) above quarantine levels are recurrent events along the Norwegian coast, although the temporal and spatial occurrence may vary substantially from one year to another. In the year 2000 the presence of DST in shellfish was well above average along the Norwegian coast from the Swedish border to Stad, on the northwest coast. It occurred in July along the Skagerrak coast and appeared later further west and north along the coast. The highest toxicity recorded was 100–200 µg OA/100g mussel meat. The toxicity along the Skagerrak coast persisted throughout the year and was associated with the occurrence of *Dinophysis acuta,* where up to 4 700 cells/L were recorded. PST, on the other hand, which in recent years has been most common in the northwest and northern coasts of Norway, was below average in 2000. Toxicity above the regulatory level was only measured at one location on the northwest coast, Cap Clara in Moere- and Romsdal county. The highest level recorded was 5 000 stx equiv./100g mussel in week 20 (the middle of May). During April-June, results obtained by mouse bioassay indicated the presence of yessotoxins (YTX) at some locations along the coast from the Swedish border to Stad. This was, for some locations, later confirmed by HPLC-technique. There were no blooms of icthyotoxic species along the Norwegian coast in 2000, but localized mortalities were reported from a couple of fish farms, most probably due to exposure to dense concentrations (red patches) of *Polykrikos* sp. Weekly information on the algae situation along the Norwegian coast is available at the web-site: http://algeinfo.iMrno/.

For the period 2000–2004 a strategic program funded by the Research Council of Norway has been established with the overall objective of providing scientific knowledge, competence and the capability of meeting the demands for expertise concerning marine algal toxins in seafood from the shellfish industry, regulatory authorities and shellfish consumers.

The sub-goals are (not prioritised):

- Introduce and further develop analytical methods (chemical and biochemical) for (known) relevant toxins at participating institutions.
- Isolate and identify “new” shellfish toxins that cause or can cause problems for the industry or for the shellfish consumers.
- Study the occurrence and ecology of potentially toxic algae and the variability in their toxicity.

- Perform toxicological and pathological studies related to the most relevant shellfish toxins in laboratory animals, identify the specific effects of individual toxins and contribute to the elucidation of the "gold" standard during the assessment of alternative essays. The studies will also serve as a basis for establishing regulatory levels ensuring consumer safety.
- Develop ELISA methods for screening shellfish for selected algal toxins and, in collaboration with an industry partner further develop these methods for use by shellfish farmers to screen shellfish prior to harvest.
- Initiate activities and sub-projects with the aim of supporting future research activities and monitoring programs and strengthening links between collaborating institutions.

The contact person is Professor Tore Aune, Norwegian School of Veterinary Science, Department of Pharmacology, Microbiology and Food Hygiene, Phone: +47 22964500, Fax: +47 22565704, E-mail: tore.aune@veths.no

Portugal

PSP was not detected in Portugal during 2000. DSP occurrences were less intense and for shorter periods of time that in previous years. Low levels of domoic acid and *Pseudo-nitzschia* cells were detected at various locations along the coast and also in sardines (*Sardine pilchardus*) – primarily in the guts.

Spain

The situation during year 2000 was not very different from 1999. Persistent outbreaks of DSP caused by *D. acuminata*, and of ASP caused by *Pseudo-nitzschia australis* are the main threat in terms of days of closure for bivalve marketing. In the middle and northern Mediterranean coast, the main problems are associated with high biomass-water discolouring blooms negatively affecting tourism. Since 1995, blooms of *Gymnodinium catenatum* in the Galician coast have apparently disappeared.

Andalucía: DSP outbreaks in late spring (May-June) associated with *D. acuminata* in the Atlantic coast of Andalucia (Huelva); very persistent (3 months in the spring and 2 months in the autumn) ASP outbreaks associated with *Pseudo-nitzschia australis*, and affecting the marketing of cockles and scallops in the Mediterranean coast (Alboran Sea); summer and winter PSP outbreaks, also in the Alboran Sea, associated with proliferations of *Gymnodinium catenatum*.

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

Catalonia: As in the two previous years, PSP outbreaks associated with blooms of *Alexandrium catenella* occurred in different localities of the Catalonian coast. Moderate PSP outbreaks occurred in the Gulf of Rosas (causing water discoloration) and in the Ebro delta associated with *A. minutum*. Moderate number of *Pseudo-nitzschia* species are observed in areas where neither shellfish exploitation nor toxin monitoring takes place. *Alexandrium taylorii*, *Gymnodinium impudicum* and *Gyrodinium corsicum* blooms caused water discoloration in enclosed beaches and negatively affected the tourist industry. *G. corsicum* also cause fish kills in fish ponds at the Ebro delta

Galicia: Very persistent and intermittent ASP outbreaks associated to *Pseudo-nitzschia australis* in the Southern and Northern Galician Rías causing closures of bivalve marketting in early spring, summer and autumn.ASP toxicity affected scallops recollection the whole year in the Rías Bajas. DSP outbreaks caused by *D. acuminata* in differents pulses from May to July in the Rías Bajas, and from July to December in the Northern Rías. Mild and brief PSP outbreaks, in the Northern Rías (late summer) and in the Rías Bajas (early spring), caused by *Alexandrium minutum.*

Scotland

Increased numbers of *Alexandrium* were recorded on the East Coast of Scotland in 2000 compared to previous years. This corresponded with high levels of PSP in mussels, which required the closure of mussel harvesting areas until toxin levels reduced. *Alexandrium* was also recorded in Orkney, Shetland and along the West Coast.

There was an extensive DSP outbreak during 2000 along the West Coast with local Voluntary Closure Agreements (VCAs) being in place from July to September. In contrast to previous years when *Dinophysis acuminata* was more commonly found, the dominant species of *Dinophysis* observed in 2000 was *D. acuta.* The highest number of *D. acuta* since the phytoplankton-monitoring programme began in 1996 (8040 cells l^{-1}) was recorded at Loch Ewe on the West Coast in August 2000.

Pseudo-nitzschia numbers in coastal areas were lower in 2000 than in previous years. Low levels of ASP toxicity were frequently recorded in mussels (*Mytilus edulis*) in coastal areas. Offshore scallops (*Pecten maximus*) showed high levels of ASP and in some areas extensive closures were put in place for up to five-months. An *ad hoc* survey of the offshore coastal waters showed *Pseudo-nitzschia* cells were present in the water column. EM analysis was not carried out on any of these samples so they were not identified to species level.

Sweden

Skagerrak and Kattegat

No major harmful algal bloom was observed during 2000 but the serious problems with diarrhetic shellfish toxins (DST) in blue mussels persist. Concentrations of DST in blue mussels were above the limits for harvest along the Swedish Skagerrak coast and the northern part of the Kattegat coast throughout the year except from mid March to July. The highest concentrations, ca 1900 µg/kg mussel meat, were observed in November but the highest abundance of the causative organisms, *Dinophysis* spp. (9000 cells per litre) was observed in July.

In the mouth of the Gullmar Fjord low numbers of the PSP-producing species *Alexandrium tamarense* were found in mid-May. In June *Alexandrium* cf. *minutum* (potentially PSP-producing) was observed in Brofjorden with an abundance of 7000 cells per litre. No PST-toxins in mussels were detected.

Baltic Proper

Despite the summers' unusually cold and windy weather, large assemblages of cyanobacteria were observed at the surface in most areas of the Baltic proper. However, persistent westerly winds kept the coasts of Sweden almost free from impact. Surface accumulations were observed from satellites from the end of June to mid August. In the beginning, *Aphanizomenon* sp. was the dominant species although the toxic *Nodularia spumigena* was present. In the end of July *N. spumigena* became a more important part of the plankton community. Densest surface assemblages of cyanobacteria were observed in an area from the central Hanöbukten to east of Öland and in an area west of Gotland. A toxicity test on a sample taken on 28 July in the archipelago of Stockholm (near Möja) showed that a hepatotoxin was present. Toxicity was 1+ on a scale from 0–3. A report of a dog dying from algal poisoning in the archipelago of Stockholm in the first half of October could not be confirmed.

More than 5000 marine birds from several different species died from the end of July to the beginning of August on the Southwest Baltic coast. Symptoms resembled those of PSP, although no toxins were found in the liver or in the flesh of the birds. One of the symptoms was that the birds could not keep their head above the water, which resulted in the birds drowning. Predominately unialgal blooms of a freshwater dinoflagellate were found in rock pools with salinities below 0.5 psu in the area. The dinoflagellate, which was similar to the marine species *Alexandrium ostenfeldii*, was shown to contain PSP toxins (HPLC analyses). If birds were drinking from the rock pools this dinoflagellate could have been the cause of death as the birds were feeding on different food types (grass, mussels, fishes) indicating that the food was not the cause of their death.

For the first time, okadaic acid was found in mussels on the southwest Baltic coast between September and October. *Dinophysis* spp., had, however, okadaic acid only in the sterified form. Humans generally do not consume blue mussels from the Baltic. The size of mussels is very small due to stress from low salinity.

Bothnian Bay

The reporting delegate did not receive any reports of HABs in the year 2000.

USA

This was an unusual year for the U.S., with a number of relatively significant HAB outbreaks. As happens most years, PSP was recorded in the New England states as well as in California, Washington and Alaska on the west coast. In the state of Maine, PSP levels were the highest in ten years. Washington State experienced an outbreak of PSP at levels greater than 13,000 micrograms per 100 g in mussels resulting in the hospitalisation of 9 people. Two of the consumers were placed on artificial respiration for about 1 week. One came very close to death, even with medical intervention. This was the most severe case of PSP poisoning in Washington State since 1942. Washington State also experienced a large fish kill, involving many fish species, attributed to *Heterosigma akashiwo*. California experienced extensive sea lion mortalities attributed to domoic acid from *Pseudo-nitzschia australis*. The detection of 29-ppm domoic acid in mussels was the highest concentration observed since the first documented DA event in California in 1991. An area of

New Jersey that has had brown tides in the past experienced a more significant event this year. New York State also experienced a brown tide, along the south shore estuaries. Texas experienced its largest *G. breve* bloom since 1986, causing massive fish kills and respiratory irritation that lasted several months. The bloom extended into Louisiana coastal waters, causing fish kills there as well. The Florida red tide recurred as well along the state's southwest coast, causing fish kills and respiratory irritation. This year there were no reports of fish kills or fish lesions definitively attributed to *Pfiesteria* in North Carolina or Chesapeake Bay.

4.2 Decadal maps

The decadal maps of HAB events were updated by national representatives, and are presented as Annex 3.

A subgroup discussed the current form for presenting the decadal maps on the web page. The group agreed to do the following slight changes, but no additional changes to the text on the Web pages.

- To the home page a paragraph should be added after the last paragraph on the page before the word "Coordination..."
- The paragraph that will be the last paragraph of the second page, called the Description page will have a disclaimer, which starts with the words:

> "The information available differs greatly.... and ends with.... and contributes significantly to health risks should be completely moved to the home page, position as described above..."

4.3 HAEDAT database and harmful event report form

Term of Reference 2: evaluate the modified harmful event report form.

HAEDAT is the on-line IOC-ICES Harmful Algae Event database available at the IOC web site: http://ioc.unesco.org/hab/data3.htm#1which contains National Reports from ICES countries that date from 1987 to 1998.

This database is updated annually. Nevertheless, due to the modifications made to the National Report forms during the meeting of the WGHABD in March 2000, there was some confusion before the new format was adopted and only a few countries submitted 1999 reports. This has resulted in a one-year delay in data input.

The submission of data is critical to the database development, and National members of the WGHABD were asked to submit the national reports on harmful algae events to the "IOC-IEO Science and Communication Centre on Harmful Algae" in Vigo, (Spain) preferably by e-mail (vigohab@vi.ieo.es) but also by fax or ordinary mail service. In general, the deadline for submitting the National HAB report will be before each annual WGHABD. Those who have not yet sent the 1999 reports, should send them by 1 May 2001 at the latest.

During this year, further modifications were implemented in the "modified form" presented in Annex 6 of the WG Report from (Anon. 2000) that make it more user-friendly and directly accessible via internet. The new form, together with instructions and a practical example, are now available at the IOC web site http://ioc.unesco.org/hab/act6.htm

This form is a Word 6.0 document, but it can be opened with the more recent versions of MS Word and saved in the preferred format. It is a locked form, so it can be observed in its exact layout and format. Text can only be input in the grey fields and the tick boxes.

The changes introduced to the modified form were welcomed by the national members who tested them with their respective national monitoring laboratories. They agreed that the new form is clearer, self-explanatory and easier to fill in, although some notes were suggested for further improvements. These included:

- For a better identification of the event, it would be useful to add after the Country, the "Region" and "Year".
- In the "Bloom duration information" field, it is sometimes difficult to report the precise day. Perhaps it would be better to report the "Date of detection of quarantine levels" and give additional information, if any, (i.e., start and end date of the bloom), in "Additional information".

To avoid typographic mistakes when inputting microalgae species information, it would be useful to have a multichoice list for genus and species (with their synonyms). This list would be provided by the Task Team of Taxonomy of the Intergovernmental Panel on HAB (IPHAB, Chairman: O. Møestrup)

A special emphasis was put on the subject of species synonyms. If these are not introduced, it will hinder future searches for species by the name, which was recently revised and changed.

The IOC-IEO Science and Communication Centre on Harmful Algae in Vigo, should make an effort to develop an automatic system for a direct search into the HAEDAT through Internet, because the current system requires a full download of the database to personal computers, accompanied by the use of a specific database programme.

The main objective behind the use of the ICES annual harmful algal event reporting forms into a database in co-operation with the IOC was to use the existing developed forms and the experience of the WGHABD as the basis for a global harmful algal event database. Before being in a position to expand HAEDAT beyond the ICES area, the current HAEDAT form was developed and tested over.

That stage has now been reached, and a preliminary agreement has been reached with PICES, where PICES will be the first partner in the HAEDAT. This means that PICES members will adopt the HAEDAT format for HAE reporting.

The next step is to invite the two regional IOC groups on HAB, FANSA, and subsequently ANCA, to act as regional coordinators for collating data for South America and the Caribbean, respectively.

HAEDAT should be closely coupled to the mapping of HAB events both for ICES countries and new partners joining the HAEDAT.

5 HISTORICAL DATA AND FOSSIL RECORDS OF HABS

Term of Reference 3: continue examining the possible ways of analysing historical data and fossil records.

Two presentations of analysing historical data were given during the meeting.

History of cyanobacterial blooms in the Baltic Sea

Kaisa Kononen described a Finnish project aimed at providing a systematic, historical overview of the occurrences and intensities of cyanobacterial blooms in the Baltic Sea during the last centuries. The study used all available information, consisting of early historical notes and navigation logbooks from the Baltic area, as well as phytoplankton records published since the late 19th century. Paleolimnological studies of pigment composition and resistant cyanobacterial cells in the Baltic Sea sediments were made. Furthermore, a social science historical review of environmental discourses during the last two centuries was undertaken.

The first approach to this study was aimed at getting long-term information on possible changes in cyanobacterial blooms, formed mainly by *Aphanizomenon* sp. and *Nodularia spumigena*, on the basis of published records in historical (1887–1938) and modern (1974–1998) phytoplankton data sets. In order to compare data that was collected and analysed in different ways, old and new sampling methods and fixatives were tested in the study. A hundred years ago, plankton was more interesting because of its importance as a source of fish food, whereas eutrophication problems were only reported locally in coastal areas, mainly in southern embayments adjacent to larger cities. The first record of an open sea bloom is from a very warm August in 1854. Records on open sea blooms were scarce prior to World War II. Very low concentrations of *Nodularia spumigena* and *Aphanizomenon* sp. were reported in the old material and 137 summer samples from 1887–1938 did not contain any high concentrations. In the more recent samples high abundances existed and the numbers of both taxa have increased markedly compared to the old material. Since the 1960's, cyanobacterial blooms have been common phenomena in the open sea in the Baltic Proper and the Gulf of Finland, indicating a high availability of nutrients.

The second approach studied the presence and distribution of carotenoid pigments in recent and postglacial sediments. In all three areas studied (Gotland Basin, northern Baltic proper and eastern Gulf of Finland) echinenone was the dominant carotenoid in the upper sediments. In deeper sections of cores, myxoxanthophyl and zeaxanthin dominated. The decrease in pigment content in sediment depth coincided with a decrease in carbon content, which fits in with the general historical records for occurrences of cyanobacterial blooms in the Baltic Sea, supporting the conclusion that blooms were seldom recorded before the Second World War.

The third approach examined the discourses concerning environmental matters in the Baltic Sea region during the last centuries. Three major phases were identified: 1) the *Utilitarian discourse* that lasted until the 1960's, which mainly considered the sea as a source of welfare for mankind, and ideas about 'cultivating' the sea for more efficient production of food were presented. 2) Discourse of the *'vulnerable sea'* started along the rise of the general environmental consciousness in the 1960's. During that time the problem of cyanobacteria and eutrophication was discussed for the first time. Finally, 3) the problem of eutrophication and cyanobacterial blooms is today considered as an expression of the *risk society*.

In conclusion, all three approaches ended up with a similar conclusion. Published historical data on cyanobacterial blooms showed that the intensity of blooms has increased since the World Wars. The pigment analyses showed that cyanobacterial pigments show a clear increase in numbers in sediments dating to the 1960's. After the 2nd World War, the environmental discourse in the Baltic Sea area changed from a utilitarian discourse to a discourse of a vulnerable sea indicating that environmental problems, especially eutrophication, were conceived to be a problem. All three approaches resulted in the same conclusion - bloom intensities have increased since the 1960's.

References:

Terttu Finni, Kaisa Kononen, Riitta Olsonen and Kerstin Wallström. History of cyanobacterial blooms in the Baltic Sea. AMBIO 4–5/2001. In press.

Eeva-Liisa Poutanen and Kirsi Nikkilä. Carotenoid pigments in the Baltic Sea sediments as tracers of cyanobacterial blooms. AMBIO 4–5/2001. In press.

Analyses of plankton data from the Bay of Fundy, eastern Canada (1988–1999) by Jennifer Martin, Fred Page and Alex Hanke, Fisheries and Oceans Canada, Biological Station, St. Andrews, NB, Canada

A phytoplankton study was initiated in the Western Isles region of the Bay of Fundy (eastern Canada) in 1987. Purposes of the study were to: establish baseline data on phytoplankton populations since little detailed work had been published since the earlier studies by Gran and Braarud (1935); identify harmful algal species that could potentially cause harm to the aquaculture industry; provide an early warning to the salmonid aquaculture industry by sorting and identifying samples soon after collection; and determine patterns and trends in phytoplankton populations. In addition it could provide an early warning to regulatory agencies such as the Canadian Food Inspection Agency (CFIA) for the occurrence of species that produce toxins resulting in shellfish toxicities and closures of shellfish beds to harvesting, generally during the summer.

Four stations are monitored - Brandy Cove (#17 – a brackish site influenced by the St. Croix River estuary), Lime Kiln Bay (#3 – Letang estuary where a number of aquaculture sites are located), Deadmans Harbour (#15 – an open Bay with offshore influence, and the Wolves Islands (#16 – an offshore indicator site). Samples are collected from four depths (surface, 10, 25 and 50 m) at the Wolves Islands. As it had been suggested that samples be collected from a specific depth of 10 m, data from the Wolves Islands with results from several depths was examined to determine if results from 10 m are representative of a broader depth range.

The time series of plankton data from the Wolves Islands extends from May 1988 through December 1999. The series consists of 277 sample dates with results from 4 depths on each date. The total number of taxonomic groups since sampling was initiated was 191. Data was analysed by estimating the annual cycle of abundance separately for dinoflagellates, diatoms and "other" (which included smaller zooplankton, silicoflagellates and ciliates). Each of the groups yielded a strong seasonal signal, which declined in magnitude from the surface to 50 m for the dinoflagellates and zooplankton whereas the diatoms tended to maintain a more consistent presence at all depths, over time. Peak abundance for dinoflagellates occurred in August, zooplankton was July and diatoms peaked in May-June and August-September.

Results suggest that sampling at 10 m does not give a reliable indication of species diversity at other depths. Not only is sampling at 10 m particularly representative of the species composition at the surface, it is not highly representative of the water column. We intend to pursue these analyses further and investigate individual species – especially HABs.

6 REMOTE SENSING AND *IN SITU* OPTICAL SENSING TECHNOLOGY IN HAB DYNAMICS STUDIES

Term of Reference 4: Evaluate and assess the use of remote sensing and *in situ* optical sensing technology in HAB dynamics studies

Two presentations were given about this topic during the meeting.

John J. Cullen reviewed technologies for optical assessment of harmful algal blooms, with an emphasis on passive optical measurements *in situ*. Several approaches were explained and evaluated, and recommendations for the development of integrated observation systems were made.

Synopsis: Many approaches are useful for the optical assessment of HABs and relevant aspects of coastal ecosystems. These include remote sensing of ocean colour from satellites and aircraft, the measurement of ocean colour *in situ* from moorings, drifters, and portable radiometers, and the measurement of attenuation coefficients using profilers or chains of sensors on moorings. These passive optical sensing approaches are used to measure the fate of light in the ocean, which depends on absorption and scattering properties of water and its constituents, which include phytoplankton, suspended sediment, dissolved organic matter and detritus.

The influences of phytoplankton, which are generally distinct from those of other components, can be detected and quantified by using radiometers to measure reflected and fluoresced light in ocean colour, generally measured as up-welling spectral radiance, $L_u(\lambda)$ (W m^{-2} nm^{-1} sr^{-1}) and normalized to downwelling solar irradiance ($E_d(\lambda)$; W m^{-2} nm^{-1}) to calculate radiance reflectance (Rr; sr^{-1}). Spectral attenuation, which is strongly a function of absorption and which is sensitive to the presence of phytoplankton, is measured as the attenuation coefficient for downwelling irradiance ($K_d(\lambda)$, with units of m^{-1}).

Where algal blooms occur at sufficient biomass, they may be detected by radiometers on moorings, ships, aircraft, or satellites. Passive optical sensors cannot detect toxic algae that occur as minor components of the phytoplankton, but estimates of total pigment and information such as spectral attenuation from these sensors can provide important data for biological-chemical-physical models of algal dynamics. Well-recognized limitations of satellite remote sensing, including interference by clouds, relatively coarse spatial resolution (for coastal processes), and discrete observation periods can be overcome by deployment of *in situ* ocean-colour radiometers on moorings or drifters and by using radiometers on aircraft for surveys during events or process studies. Passive optical measurements can thus describe biological variability on scales of minutes to years and a meter or so to thousands of km. One great strength of radiometric measurements is that they are well defined and calibrated quantities that retain their validity for long-term and wide-ranging comparisons over time or between sites (e.g., for resolving influences of eutrophication vs. climate variability). Interpretations of the measurements may change as new algorithms are developed, but the data should never become obsolete.

No one approach is adequate for describing ecological processes in the coastal zone relevant to the dynamics of harmful algal blooms. Integrated observation systems are necessary, and optical measurements are key, but not sufficient. Remote sensing is the cornerstone for linking biology to hydrography; it provides the only synoptic views on the horizontal scales of blooms. Information from satellite systems should thus be incorporated into coastal observation programmes; aircraft-mounted radiometers (imaging or transect) can provide more detailed surveys. Fog or partial clouds can be problematic, however.

Moorings with optical sensors could be centrally important for coastal observation systems. They can detect transient events, diel variability, and subsurface layers, all in relation to physical and chemical variability, with real-time transmission of data. Moored systems provide continuity that is unachievable from remote sensing. Passive optical sensors, at the surface and in vertical chains, are suitable for detection of blooms and for long term monitoring as discussed above. Active optical sensors, such as fluorometers, backscatter sensors, or absorption-attenuation meters, work day and night and provide exceptionally useful information when deployed on autonomous profiling units equipped with sensors for salinity, temperature, and perhaps nutrients. Similar systems can be installed on ferries or other vessels to provide critical descriptions of relationships between physical and biological properties on transects over long time series. It is also possible to measure ocean colour during the daytime transects.

Integrated coastal observation systems, and sensors appropriate for deployment in these systems, are under development in several locations throughout the world. Although much progress has been made, it is not yet a simple matter to purchase, deploy and use moored system for optical detection and assessment of phytoplankton and harmful algal blooms. Problems include biofouling, security of moored systems, and reliability of some components during long deployments, and immaturity of procedures to extract biological information from optical measurements. Also, assimilation the data into models of coastal processes is crucial for prediction of HABs, and the incorporation of optical-biological data is still a research topic under development. Nonetheless, prospects are very good and it is likely that efforts to use these systems will be rewarding.

Jim Aiken presented a strategy for the exploitation of remotely sensed data (particularly ocean colour) for understanding and prediction of environmental change within marine ecosystems with the special emphasis on monitoring and management of the effects of harmful algal blooms. For the marine environment the issues are: how do marine ecosystems vary with time and how are they regulated by ocean processes? Remote sensing data can help provide answers to all these questions.

Current issues of climate change and the sustainability of marine ecosystems, vulnerable to anthropogenically induced impacts (pollution) or natural events (harmful algal blooms) require large-scale, synoptic remotely sensed data of ocean colour, SST etc. The complexity of ecosystem processes and spatial heterogeneity of the oceans, shelf seas and coastal zones can only be observed comprehensively by satellite data. However, *in situ* data from ships and moored sensor systems will be needed to determine key rate parameters and provide continuity and information on the vertical dimension. Prediction of change needs to assimilate these data into hydrodynamic, biogeochemical or coupled physical-ecosystem models. Change in the marine environment, both short term (days to weeks) and longer term, can only be determined by time series data. Remote sensing missions have global coverage and provide long term data of many ecosystem variables with high temporal (1 day) and high spatial resolution (0.25, 1 km). By coupling data to models we can improve the accuracy of predicting the effects and responses of environmental impacts in the coastal zones.

A goal is to create and develop new scientific interpretations of marine biological properties and processes to extend potential applications and enhance exploitation. High precision determinations are essential. Empirical algorithms have restricted application and lack precision, particularly in the biogeochemically and physical complex coastal zones and shelf seas. Theoretical approaches that are based on the inherent physical properties and biological processes are needed to exploit the inherent information and achieve maximum precision.

For ocean colour (spectral water reflectance or water leaving radiance) this is the inherent optical properties, back-scattering and absorption:

$$Rrs = fn\ (bb/a).$$

Specific objectives are to develop and validate new algorithms.

- Provide observations of the inherent physical, optical and biological properties (IOPs).
- Retrieve marine biogeochemical variables: Chlorophyll *a*, Carotenoids (photosynthetic and photoprotectant), C-DOM.
- Determine production, dynamic production (rates).
- Determine species characteristics (absorption/scattering), type, whether blooming or senescent.
- Determine the precursors or predictors of algal blooms (HABs).

These interpretations will be possible only from bio-optical models, which determine the spectral absorption and back scattering from remotely sensed ocean colour with improved precision over current empirical algorithms.

Of particular utility is the measurement of the photosynthetic quantum efficiency ‘Fv/Fm’ from *in situ* measurements with the Fast Repetition Rate Fluorometer (FRRF).

Field observations (Ironex-2 and SOIREE) have shown that this parameter can increase rapidly when phytoplankton is stimulated into growth from a vegetative state (nutrient limited). In Ironex-2, Fv/Fm increased from 0.25 to 0.5 (dimensionless units) within 20 h of Fe-enrichment, but the biomass (chlorophyll concentration) maximum occurred several days later. The conclusion is that a rapid increase of Fv/Fm (from a relatively low value) may be indicative of bloom initiation and could act a precursor to a bloom event.

The detection of Fv/Fm from remotely sensed observations of water colour (from satellites or aircraft sensors) could be used to predict the occurrence of algal blooms. There is new evidence that correlates of Fv/Fm have both a pigment signature and an optical signature providing the basis for a remote sensing algorithm. Local algorithms are already possible but a global, universal algorithm may be more complex, involving other parameters of algal physiology (e.g., temperature, ambient light, nutrient status).

7 SENSITIVITY OF HABS TO CLIMATE CHANGE

Term of Reference 5: discuss the potential sensitivity of HABs to climate changes

Potential sensitivity of harmful algal blooms to climate changes by Maurice Levasseur with co-authorship of Andréa Weise and François Saucier.

Climate change has received increased attention in recent years. During the last century, several natural and anthropogenic processes are believed to have influenced trends in global climate. These include 1) changes in solar intensity, 2) changes in concentrations of stratospheric aerosols, 3) increases in concentrations of greenhouse gases (CO_2, CH_4, NO_x), 4) increases in concentrations of tropospheric aerosols (sulphate aerosols, soot, mineral dust, and particles from burning biomass), and 5) thinning of the ozone layer. Concentrations of greenhouse gases, which have increased substantially as a result of human activities during the past century, retard the rate at which the earth loses heat to space and thus contribute to the warming of the Earth's atmosphere. Although we cannot be certain of the extent to which this will happen, the potential of global warming and its multiple consequences on human activities is still one of the most important issue that scientists have to face in the next decades.

Projected changes in climate

In order to explore how present and future emissions of climatically active gases may influence the climate in the next century, several countries have developed General Circulation Models (GCM). The most current and plausible scenario used in climate change studies is the so-called 2× CO2 scenarios, which forecasts a doubling of 1980 concentrations of CO_2 over the next century. In spite of their intrinsic limitations, the projected changes from the different GCMs are usually in good agreement at the global scale. For example, most GCMs predict a greater frequency of extreme warm days, a lower frequency of extreme cold days, a decrease in diurnal temperature range, increased precipitation intensity, mid-continent summer drying, decreasing variability of surface temperature in winter, and increasing variability of northern mid-latitude summer temperature. Since harmful algal blooms (HABs) are closely tied to their surrounding environmental conditions, variations in climate such as in temperature, precipitation, freshwater run-off and wind conditions may potentially influence their distribution and bloom dynamics.

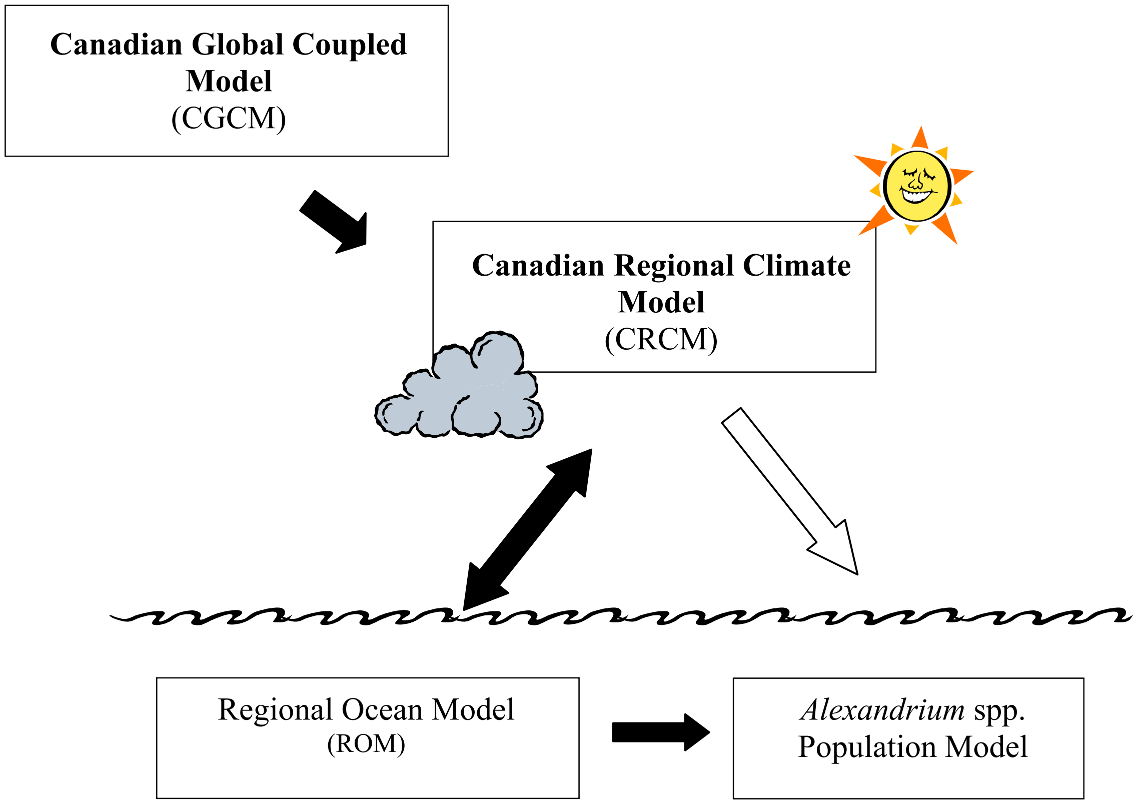
From the global to the regional scale

HABs are mostly restricted to coastal areas and are governed by factors acting at a mesoscale level (day, km). There is considerable variability between GCMs' simulations at the regional scale, particularly for precipitation, due to their relatively coarse spatial resolution (ca. 300 km). Furthermore, there is little agreement between the models on projected changes in storm events and in the variability and extremes of surface winds. Regional climate models (RCM) have been developed to overcome some of these weaknesses. A RCM represents physical processes in the same manner as a GCM but is nested within it. It is a one-way process with information flowing from the global model to the regional model but not in the opposite direction (Figure 1). This approach is called dynamical downscaling. RCMs offer a greater spatial resolution (e.g., 45 km in the Canadian RCM) and thus a more detailed prediction of projected climate changes.

In parallel with the development of RCMs, Regional Oceanic Models (ROMs) are also becoming available for most coastal areas. The coupling of a RCM with a ROM will allow a better prediction of the influence of climate change on oceanic environments. Ultimately, the coupling of the ROM with population models of harmful species will provide a powerful tool to explore the sensitivity of HABs to climate variability. An example was given of the role of climate variability on HABs in the Gulf of St. Lawrence (eastern Canada) over a 10-year period. The results showed a strong sensitivity of HABs to variations in summer precipitation, river run-off and local wind conditions.

The future development of atmospheric-oceanic-biologic models will improve our understanding of the influence of climate variability on HABs.

Figure 1. Example of a coupled Climate-Ocean-Biological Model used in Canada to explore the potential impact of climate change on *Alexandrium tamarense* blooms in the St. Lawrence system.



8 IMPLEMENTATION OF GEOHAB RESEARCH PROGRAMME IN THE ICES AREA

Term of Reference 6: review the implementation of the GEOHAB research programme in the ICES area.

On behalf of the Scientific Steering Committee, Adriana Zingone introduced GEOHAB, presenting the motivation, overall goals and specific objectives of this SCOR-IOC science initiative. She gave an overview of the structure and content of the recently completed GEOHAB Science Plan. A discussion followed clarifying the focal topics of the programme, and the next steps of the implementation of GEOHAB. Participants were invited to revise and update the map of PSP global distribution in 1970 and 2000, which is included in the GEOHAB Science Plan.

The WGHABD recognized the high scientific quality of the Science Plan and found it to be a valuable document for planning future research activities. It was pointed out that although marine scientists have addressed the question of HAB dynamics for decades, there might be some value in consulting the freshwater plankton literature where similar issues such as the regulation of species diversity have been discussed.

Kaisa Kononen reported on the meeting of the Study Group on GEOHAB Implementation in the Baltic Sea (SGGIB), which was held during the two days preceding the WGHABD meeting. She introduced a proposal for a cooperative HAB study in the Baltic Sea. This proposal will be presented to the GEOHAB Scientific Steering Committee as a contribution to the GEOHAB Implementation Plan, and is presented as Annex 4. During discussion of this proposal it was emphasized that the Baltic study should not be considered only as a GEOHAB *regional* study only but also as a model on how to address the problem of HAB dynamics in brackish water systems.

The WGHABD recommends that the Study Group of the GEOHAB Implementation in the Baltic Sea prepare a short briefing or presentation to be given to the GEOHAB Scientific Steering Committee before their meeting in April 2001. The GEOHAB SSC should be urged to provide comments and guidance on the preliminary programme in the context of GEOHAB.

9 WORKSHOP ON REAL TIME OBSERVATION SYSTEMS APPLIED TO HARMFUL ALGAL BLOOM DYNAMICS STUDIES AND GLOBAL ECOSYSTEM FUNCTIONING

Term of Reference 7: prepare a resolution for a workshop, possibly co-sponsored by regional programmes, such as GEOHAB, GLOBEC and GOOS, on 'Real-time observation systems applied to Harmful Algal Bloom Dynamics studies and global ecosystem functioning'.

The issues of topics, potential participants, practical organization and possible publication of the workshop was discussed thoroughly. It was questioned, whether the workshop (WS) should focus only on systems and methods relevant to HABs or if a broader perspective should be adopted. In the latter case, the HAB community may benefit from the experience of other partners, especially the GLOBEC community.

It was decided that the topic would be real time observation systems, with the focus on HABs. Dates, location and names will be defined before September 2001: 15 months of preparation between approval and the workshop are required.

The scope and objectives of the workshop are consistent with the objectives of WGHABD, GEOHAB, GLOBEC, and C-GOOS.

The format includes:

a) Plenary sessions with overview lectures which will be complemented by contributed oral presentations. The scope of these presentations will extend beyond observation systems to real-time modelling and prediction.
b) Poster sessions over several days. Computer-based presentations of real-time observations would be encouraged.
c) Practical tutorials with demonstrations. Each tutorial is presented several times to a different group of about 10 - 12 participants.
d) Intercomparisons and practical demonstrations of instruments. Sustained simultaneous deployment of instruments throughout the workshop would be encouraged. As far as is practical, manufacturers would be given the opportunity to demonstrate instruments or systems.

The workshop will address the following objectives:

Through plenary lectures, contributed presentations, demonstrations and practical tutorials:

a) Review real-time and near real-time sensing systems applicable for observation, modelling and prediction of HABs.

   i) Remote sensing of coastal waters (ocean colour and other properties).
   ii) *In situ* optical measurements (passive -- active)
   iii) Automated methods for detection of plankton species or toxins
   iv) Integrated observation systems, including moorings and autonomous vehicles
   v) Continuous underway sampling systems (e.g., from ferries)
   vi) Tools for characterizing distribution of plankton in relation to physical and chemical properties.

More through the plenary lectures and demonstrations than through the practical tutorials:

b) Explore approaches for integrating data from various sensing systems to describe ecosystem processes in support of HAB research, monitoring and prediction.
c) Review and consider interaction between HAB observations and modelling
d) Review data assimilation techniques

Publication

Proceedings of the workshop will be distributed in one or more formats. An editorial committee will evaluate the feasibility of publishing a peer-reviewed book with contributions on the principal topics. This option will be pursued if a strong commitment from a lead editor is obtained and adequate resources are secured.

The committee would also develop an alternate model of publication to be implemented in parallel or in place of the book:

Recognizing innovations in digital communications, increased access to the Internet, rapid progress in the field of ocean observation and modelling, and the nature of the topic (real-time presentation of large amounts of data, including innovative visualization techniques), publication of the proceedings would follow a new format.

Speakers would be encouraged to use PowerPoint or similar software to prepare digital presentations. Annotated versions of the presentations with links, animations, etc. would be compiled in a CD-ROM and posted on a web site and maintained for a minimum of two years. Illustrated extended abstracts of posters would also be included.

Technical guidelines will be provided, and presentations will be edited for consistency. A web site would be developed to allow easy access to the presentations, and would be organized according to the meeting agenda.

This new model would require careful development through consultation. Resources would be required for technical aspects of the digital material.

Potential Conveners (if the location is Europe, at least one should be from Europe):
John Cullen, Dalhousie University, Canada

Potential members of a steering committee:
Bengt Karlson, SMHI, Göteborg, Sweden
Percy Donaghay, URI
Patrick Gentien
Jim Aiken

Potential members of editorial committee

????? Chief Editor
L. Peperzak
John Cullen

The resolution:

A workshop on **Real-time observation systems in coastal ecosystems for studies of harmful algal blooms** will be held in ????, ????, sponsored by ICES, GEOHAB, GLOBEC and possibly COOP (GOOS), with Dr NN and Dr NN as Conveners.

Priority:	ICES should take an active role in developing the implementing plan of the GEOHAB programme. The topic of real time observations is relevant for GEOHAB and also fits well to ICES profile. This also fits in directly with the objectives of the Coastal Ocean Observation Panel of C-GOOS.
Scientific Justification:	The development of a harmful algal bloom is a result of interactions between the physiological characteristics of the species as well as physical and chemical processes in the environment in which it grows. Therefore dynamics of these blooms cannot be studied without the integration of different observation approaches, instrumentation and methodologies. Real time observations form the basis for adaptive sampling in field studies. Data from various sensing systems need to be integrated into models - data assimilation is a crucial step in model development. There is a great deal of interest throughout the world in the installation of coastal ocean observation systems with capabilities for detection and prediction of HABs. However, many of the approaches are unfamiliar to potential users.
Relation to Strategic Plan:	Implementation of the GEOHAB programme is relevant to quantifying anthropogenic impacts on the marine ecosystem (e.g., eutrophication) . This workshop will allow progress to be made in the development of predictive models of toxic events, on the basis of GLOBEC implementations.
Resource Requirements:	Conveners and lecturer’s time is required. Travelling and accommodation costs are needed for meeting participants. Conference room and facilities are also required during the workshop. Convenient access to coastal waters, with support for deployment of instruments on a mooring and off a pier would be desirable. Technical support would be required for electronic publication.

Participants:	Experts in relevant fields from around the world would be invited to present overview lectures and to hold tutorials/demonstrations. Other participants would apply for positions at the workshop. Criteria for selection would include direct involvement in the planning for or deployment of coastal observation systems.
Secretariat Facilities:	The Secretariat will be involved as normal in general professional and secretarial support, and the Secretariat as usual should provide direct assistance during the Symposium. Additional secretarial support will be requested from GEOHAB and GLOBEC programme offices (COOP??). The Secretariat might provide web space for the proceedings.
Financial:	Travelling support is needed for presenters and participants. Funds will be asked from SCOR and other relevant organizations.
Linkages To Advisory Committees:	Harmful algal blooms and eutrophication effects are continuing issues in ACME.
Linkages To other Committees or Groups:	Support can be anticipated from Baltic Committee and Marine Habitat Committee. Coastal Ocean Observation Panel of GOOS?
Linkages to other Organisations	GEOHAB is sponsored by IOC and SCOR.

10 OPEN FORUM FOR PRESENTING NEW FINDINGS OR OTHER RELEVANT TOPICS

Term of Reference 8: report and discuss new findings.

Bloom of Chattonella sp. in the German Bight
Douding Lu and Jeanette Göbel

New finding 1:

An extensive bloom caused by the potentially toxic raphidophyte, *Chattonella* spp., occurred in the German Bight from late April to mid May. This bloom extended almost to north Skagen. On the 2nd and 15th of May, 2000, two helicopter flights performed observations and sampling along the North Sea coast of Schleswig-Holstein. On the first flight a reddish discoloration of coastal water was observed 10 kilometers north-west of Sylt Island. The dominant species was *Chattonella* spp. with more than 10 million cells per litre observed on the first sampling date. *Chattonella* spp. cells contain numerous chloroplasts and the corresponding chlorophyll concentration was 80.17 µg/l. On the 15th of May, some *Chattonella* spp. cells still could be observed. However, the bloom had disappeared.

MOS also detected this extensive bloom and SeaWiFS satellite images in cloud free conditions. The extent and progress of the bloom in the sea surface could potentially be observed by a series of remote sensing pictures in near real-time. However, the peak concentration of the bloom could be situated beneath the surface of the water column especially in sunny weather conditions and thus, may not visible from the satellite data.

The *Chattonella* spp. cells in the bloom were 12 - 30 µm in length. They varied from being elongated ovoid to irregularly ovoid in shape. Thus it appears unlikely to be *Chattonella verruculosa.* These cells contained numerous chloroplasts as well as mucocysts. Living cells were very sensitive and could die after a few minutes under the light microscope.

The pigment profiles of both species show that they contain large amounts of 19'-butanoyloxy-fucoxanthin as previously described in only one genus of Raphidophytes-Haramonas. In addition to 19'-butanoyloxyfucoxanthin, the *Chattonella* spp. from the North Sea contains three unidentified carotenoids, which *Chattonella verruculosa* does not have.

Observations from microscopy and the pigment profile from HPLC suggest that this *Chattonella spp*. from the North Sea could be a new HAB species.

The recorded history of *Chattonella* in the North Sea is very brief. As cells of this genus are so small, fragile and difficult to preserve, they can be overlooked if cell density is low. However, *Chattonella* species were never found in such high cell concentrations or formed large blooms in this area before 1998. It appears that they have established an ecological niche and have the potential to form recurring blooms in the North Sea. It is not known if this phenomenon may indicate that some kind of environmental change has occurred.

New finding 2:

An intensive bloom caused by *Prorocentrum* spp. in the Estuary of the Yangtze (Changjiang) River, East China Sea was observed in May 2000. The brownish red discolouration of the surface water caused by this species could be observed in both SeaWiFS and Chinese satellite FY images. This bloom caused both cultured and wild fish kills. The pathology of these fish kills is as yet unknown. However, detailed microscopic observations and comparisons with different *Prorocentrum* species suggest the causative organism is likely to be a new species. These cells are 16–22 μm long, 9.5–14 μm wide, about 7–9 μm thick. The anterior end is slightly excavated and the posterior end is rounded. Trichocyst pores are distributed around the edge of the valves.

This species has been observed to form blooms with *Noctiluca scintillans.* It may serve as food source for *Noctiluca* similar to *Prorocentrum minimum*. It is usually distributed in the coastal waters of Zhejiang and convergence zone of the Yangtze (Changjiang) River Estuary during spring.

Understanding algal blooms – developing monitoring strategies

Silke Kröger

Silke Kröger presented an overview of the current CEFAS programme on HAB monitoring and related research. The activities can be divided into four topics:

1) Monitoring coastal waters (algal identification in water samples and toxin analysis in divers matrices)
2) Automated *in situ* observations from different platforms (optical detection of e.g., chlorophyll fluorescence and measurement of relevant environmental control factors including nutrients, salinity, temperature and light)
3) Physical processes (examples: sediment transport, cyst disturbance through human activities, and drivers of ocean currents influencing algal distribution, thin layer investigation)
4) Development of new tools (BioSense- automated taxonomy based on molecular probes, additional sensors for chemical and biological variables, anti-biofouling devices)

Under topic 2 the *Smart Buoy* moored platform equipped with a range of modular instruments tailored to particular monitoring needs and it's application as a tools for improved measurement of environmental status was described. Current and planned deployment locations were outlined and examples given of the data obtained using these moorings in conjunction with satellite telemetry. Data collected in the Southern North Sea highlighted the interesting relation of nitrate concentration (NAS-2E, WS Ocean Systems Ltd.) and chlorophyll fluorescence (Seapoint, Chelsea Instruments) during the spring bloom. Discrete samples collected *in situ* using an Aqua Monitor (WS Ocean Systems Ltd) and analysed using traditional methods (Skalar nutrient analyser) were used to verify the automated nitrate measurements. Of importance is the shift in emphasis towards high-resolution temporal measurements and integrated monitoring strategies. The aim is not only to evaluate the UK water nutrient status, as currently covered by the National Marine Monitoring Programme, but also to foster an understanding of the ecosystem response and achieve ecological quality objectives. Data collected is telemetred in near real-time employing ORBCOMM satellite telemetry and data will is viewable on the internet. (www.cefasdirect.co.uk).

To further improve the capabilities of collecting detailed *in situ* observations of harmful algal bloom development and composition, the BioSense project was outlined (topic 4). The aim of this project is the development of an automated instrument based on molecular biological probes for phytoplankton speciation. BioSense is based on fundamental molecular taxonomic advances made in research groups around the world (notably the work by Chris Scholin *et al* at MBARI on the use of RNA-targeted hybridisation probes) and explores the use of electrochemical detection methods as part of an analytical procedure. The vision is to have an instrument that can be customised using an array of relevant recognition elements to give an indication of presence/absence of selected target species and to integrate such an instrument into the described monitoring platforms.

OA and DTX-1 occurrence in two fjords in western Sweden

Odd Lindahl

The occurrence of DST in shellfish has been a recurrent problem along the west coast of Sweden during the last 12–15 years. The typical distribution of DST during periods of toxin occurrence has been in moderate to high concentrations in shellfish along the outer archipelago, while shellfish at more sheltered sites in fjords have, at the same time, had low concentrations. This situation has been apparent in the open-ended fjord-system inside and north of the island of Orust. Here, low or zero toxicity and few *Dinophysis* cells have been recorded, although high levels of toxins and cell concentrations were found in the mouth area of the fjord system. This fjord-system has a counter-clockwise net circulation and surface water exchange of about 130 m^3/s depending on a consistent salinity difference between mouth areas as well as small tides. The retention time of the surface water in the fjord-system has been estimated to be 1 month. In fact, the most northern part (most down-stream) of the fjord system, the Koljo Fjord, has been used by the mussel industry for storage and harvest of long-line farms, which had been tugged into the fjord during toxic episodes along the outer archipelago. This situation changed in 1999 when shellfish in the Koljo Fjord became DST-toxic for the first time,. This situation was repeated in the autumn 2000 when the toxin concentration reached 1900 ug/1000 gr. mussel meat. As well as this change in toxin distribution, an additional new finding was that the toxin content in the shellfish was composed mainly of DTX-1.

In order to study this new toxin situation a sampling programme was set up at two sites: in the Koljo Fjord and in the nearby situated Gullmar Fjord. The Gullmar Fjord is hydrodynamically much more active compared to the Koljo Fjord and is representative of the situation in the outer archipelago in respect to both *Dinophysis* occurrence and DST content in shellfish. The sampling was made up of basic hydrographical parameters, plankton samples for both *Dinophysis* species identification (5 l concentrated) and DST toxin analysis (minimum 200 l filtered) and, finally, blue mussels for toxin identification. Toxin analysis was performed using HPLC instrumentation. In total six sampling campaigns were carried out during October and November 2001.

The results clearly demonstrated that there was a statistically significant and persistent difference in occurrence of DTX-1 between both sites in the plankton samples as well as in the shellfish during the sampling period. However no significant differences in the concentration of Okadaic acid (OA) between the sites was recorded. Furthermore, there was no major difference between sites in the relative abundance of the dominating *Dinophysis* species, which were *D. norvegica, D. acuta and D. acuminata*. However the total number of *Dinophysis* cells was, as a mean, about 4 times higher at the Gullmar Fjord site. When comparing *Dinophysis* cell numbers and DST occurrence over time it was apparent that *D. acuta* was the species responsible for the occurrence of OA at the Gullmar Fjord site and for the occurrence of DTX-1 at the Koljo Fjord site. From these results it was concluded that different environments in the two fjords most likely had stimulated different toxin production at the two sites.

1999 (the first time DTX-1 was observed in shellfish in the Koljo Fjord) had the highest rainfall in 100 years in the area. Furthermore 2000 was the second wettest year in 100 years. A comparison of the salinity before and during the occurrence of DTX-1 between the sites showed that salinity of the surface water in the Koljo Fjord was 20 PSU or slightly lower while surface water at the Gullmar Fjord site was around 25 PSU. However, there is no evidence from the literature that salinity itself may have caused the observed results. On the other hand the low salinity may indicate that some factor(s) co-occurring with the increased land run-off most likely was the cause. Further studies based on this knowledge will be carried out.

Coastal foam is correlated to *Phaeocystis* blooms in the North Sea

Louis Peperzak

A conspicuous feature of *Phaeocystis globosa* blooms is the production of large amounts of foam. However, so far quantitative relations between *Phaeocystis* concentrations and the observations of foam have never been established. Using data from 1993 to 1997 from two independent monitoring programs, the correlation between *Phaeocystis* blooms and foam on the Dutch coast was investigated. In the first program *P. globosa* cell numbers in the North Sea were counted; in the second foam was monitored on the beaches of Holland. Taking into account a two-week delay between *Phaeocystis* blooms and foam observations a significant ($r = 0.85$, $P < 0.001$) correlation between the two was found. *Phaeocystis* cell numbers greater than 1 million cells per litre resulted in an 90% chance of observing foam in the following two-week period with a mean frequency of 0.5 (i.e., at 5 out of 10 shore locations). This is the first report that quantifies the link between *Phaeocystis* blooms and foam production.

Azaspiracid in Irish Shellfish

Terry McMahon

In November 1995 at least 8 people became ill in The Netherlands following the consumption of mussels (*Mytilus edulis*) produced in Killary Harbour, on the west coast of Ireland. The symptoms of the illness included severe diarrhoea, vomiting, nausea, stomach cramps, headaches and chills, which persisted for 3 – 5 days. The toxicity persisted in the shellfish for 8 months and a ban on harvesting of mussels was enforced in Killary Harbour for that period. It was subsequently shown that the illness was caused by a previously unknown toxin which has been called azaspiracid. Similar mussel toxicity and associated human illness, affecting approximately 20 people, was recorded in the Arranmore Island region of Donegal, on the northwest coast of Ireland in September / October 1997 and on this occasion the toxicity persisted in shellfish from October 1997 through to April 1998. Since that time the toxin has been detected in several other shellfish production areas on the northwest, west and southwest coasts of Ireland. Additionally there have been reports, as yet unpublished, of the detection of the toxin in other European countries including the United Kingdom and Norway.

The structure of azaspiracid and 2 analogs has been characterised (Satake *et al,* 1998; Ofuji *et al,* 1999a) and an additional 3 analogs have been identified. The available toxicological data has shown that, unlike Okadaic acid and DTXs, which exclusively target the digestive tract, azaspiracid, induces pathological changes in the liver, pancreas, thymus and spleen, in addition to the digestive tract (Ito *et al,* 2000).

The toxin can persist in shellfish for many months and closures of shellfish growing areas in Ireland of 8 – 12 months have been enforced. The persistence of the toxin may be related to the fact that the toxin appears to "migrate" from the hepatopancreas into shellfish flesh.

There are as yet few data available on the concentration of azaspiracid in shellfish during a toxic event. During the Arranmore Island event described above the maximum measured concentration of azaspiracid was 10.7 µg/g hepatopancreas.

A risk assessment of azaspiracid has recently been conducted by the Food Safety Authority of Ireland (unpublished). Based on the available data, an interim threshold concentration of 0.1 µg/g of whole shellfish has been proposed as a regulatory standard in Ireland. It is proposed to review, and if necessary revise, this value as new data becomes available.

While a threshold value has been proposed there are some practical considerations to be considered for its implementation. One of the most commonly used methods for toxicity screening is the mouse bioassay. The limit of detection of azaspiracid using this method is in the region of 0.5 – 1.0 µg/g which is above the proposed threshold. A sensitive LC-MS method for azaspiracid detection has recently been published (Ofuji *et al,* 1999b). Quantification of the toxin concentration in shellfish is, however, hampered by the lack of calibration standards, certified reference materials and purified toxin.

The biogenic source of azaspiracid and analogs has yet to be unambiguously determined although an organism belonging to the genus *Protoperidinium* has been suggested. In order to understand the factors that determine the occurrence of azaspiracid in shellfish it is vital the source of the toxin is known.

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The BALTIC programs regarding HABs

Bernd Luckas

Introduction

Many efforts have been made by several IOC groups to elucidate the formation of HABs and to predict the dynamics of bloom development. To achieve this, these studies focused on microorganisms (e.g., dinoflagellates or cyanobacteria) that have a potential for toxin production.

Thus, most program reports only contain data referring to HAB formation and the presence of different potentially toxic species. Information concerning the actual toxin production and data regarding the distribution of the different toxins during the bloom are rare. However, there is a need to obtain such information to mitigate the effects of HABs irrespective of the region where they occur.

HABs and Toxin analysis

During the TEPS project (supported from 1996 to 2000 by the German Ministry for Research and Technology) a scientific and technical basis was provided to analyse the different toxins during a bloom, directly on board a research vessel.

It is now possible to install analytical equipment (common HPLC as well as LC/MS) on a ship and, consequently, analytical chemists can work as an integrated part of an interdisciplinary team.
There is no delay in determining whether a bloom with a high toxic potential is in fact toxic. Any assumptions of bloom toxicity, based on the phytoplankton analysis can be confirmed using the results of toxin determinations. This is a great advantage in comparison to HAB research in the past.

HAB research in the Baltic

The type of toxicity that can occur depends on both the region and the phytoplankton species involved in the bloom. The Baltic represents a complex ecosystem with regions showing great differences regarding their bloom characteristics.

The Northern Baltic with low salinity is strongly influenced by freshwater and the most abundant harmful species are cyanobacteria. In the Western Baltic cyanobacteria are only present in higher concentrations in brackish waters. In the Skagerrak and Kattegat, as in the North Sea, many dinoflagellates are present. This fact has been taken into account by planning HAB research in the Baltic.

11 PROPOSED TERMS OF REFERENCE FOR WGHABD 2002 MEETING WITH JUSTIFICATIONS

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics [WGHABD] (Chair K. Kononen, Finland) will meet in Bermuda, during ??? March, 2002, to:

a) collate and asses national reports and update the decadal mapping of harmful algal events for the IOC-ICES harmful algal event database, HAE-DAT, on a regional, temporal and species basis, and specifically examine the 15 years time series for possible temporal trends or regional distributional patterns;
b) review GEOHAB implementation in the ICES area.
c) review existing data on the identification, distribution and toxicological significance of new and emerging phycotoxins and the causative organisms, in terms of human health significance, HAB population dynamics and effects on marine food webs.
d) continue examining the ways of analysing historical data.

e) review progress in the organization of a workshop on real-time observation systems in coastal ecosystems for studies of harmful algal blooms. The WG should provide comments and suggestions to assist in the planning process.

f) evaluate progress in the application of molecular probe technologies to: a) taxonomic and genetic studies, b) the detection and enumeration of HAB species; and c) investigation of their physiological condition.

g) report and discuss new findings.

WGHABD will report by 4 weeks April 2002 for the attention of the Oceanography Committee and ACME.

Supporting Information

Priority:	
Scientific justification:	a) The work of collating the national HAE reports and building up HAEDAT and the associated maps is an activity which is unique to the WGHABD. HAE-DAT is not yet established enough to stand alone. A critical step forward is to make HAE-DAT operational with input from regions/countries outside the ICES areas as originally envisaged. In 2001–03 the aim is to include PICES and possibly South America (via IOC/FANSA) in HAE-DAT. It should be endeavoured to include HAE-DAT and the associated decadal maps as a contribution to GOOS, thereby embedding these activities in a permanent setting and securing continuity. b) The work of the WGHABD has provided a major contribution to the development and establishment of GEOHAB as an international research programme. The broad interdisciplinary participation in the WGHABD and the experience and focus on GEOHAB issues makes the WGHABD a platform appreciated by the scientific community to review issues emerging from GEOHAB, advise on the implementation of GEOHAB in and outside the ICES area (via the IOC co-sponsorship), and as a nursery for new GEOHAB initiatives. At the moment there is no alternative forum or mechanism for these tasks. c) Technological advances in analytical and assay methods for marine phycotoxins, and their application in scientific survey and monitoring programs, have led to the recent discovery of new groups of toxins and more analogues of known toxins. Many challenges remain in correlating the ecological and toxicological significance of these new and emerging toxin problems. In some cases, the causative organisms of particular toxin syndromes are unknown or perhaps incorrectly attributed. There has been no comprehensive review of the distribution, biogeographical variation, and potential effects on marine fauna and human health of these new toxins. An integration of relevant biological, chemical, and oceanographic knowledge with toxin measurement techniques for *in situ* natural populations and consideration of the implications for monitoring programs and seafood quality regulations is required. d) Studies show that all phytoplankton populations, including HABs, have great interannual variations in bloom intensities. Analyses of total community structure for trends and patterns as well as physical and chemical parameters are necessary to advance the current knowledge of HABs. As longer data sets become available it is becoming possible to determine impacts of occurrences, distributions and amplitudes of HABs. It was therefore felt that that the dynamics of HABs required different analyses approaches to data from long term studies. e) Many approaches are useful for the optical assessment of HABs and relevant aspects of coastal ecosystems. These include remote sensing of ocean color from satellites or aircraft, as well as in situ measurements of ocean color using moorings, drifters, portable radiometer buoys and other new technologies. Progress has been rapid, and exchange of information is thus needed to bring these technologies to the application stage in HAB research and monitoring. A workshop is thus needed to foster communication among developers of these technologies, and to advance application of these approaches in natural waters. The overall goal of the workshop would be to review real-time and near real-time sensing systems applicable for observation, modeling, and prediction of HABs. f) There has been considerable progress in the development of molecular techniques that can be used to investigate and monitor HABs. In particular, probes are now available that allow rapid and accurate detection and enumeration of individual HAB species within a mixed plankton assemblage. Likewise, indicators or markers are being identified which can be used to assess a species' nutritional or physiological status, and some of these can be quantified using molecular techniques. The challenge has been to move these technologies from the laboratory to the field. Several laboratories are making this transition, and their experiences will be of great use in guiding others conducting HAB

Priority:	
	research or monitoring programs. 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 in quantifying the human impact on the marine ecosystem.
Resource requirements:	none specific
Participants:	The 2001 meeting attracted 33 participants from ICES and IOC, demonstrating the continued interest and need for the group.
Secretariat facilities:	none
Financial:	none
Linkages to Advisory Committees	ACME
Linkages to other Committees or Groups	SGPBI, SGGIB
Linkage to other organizations:	The work of this group is undertaken in close cooperation with the IOC HAB Programme. IOC should be consulted regarding ToR or discontinuation of the WG prior to the ASC. Through interaction with the IOC-SCOR GEOHAB Programme relation to SCOR has also been established.

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ANNEX 2: AGENDA OF THE MEETING

WORKING GROUP OF HARMFUL ALGAL BLOOM DYNAMICS
The Bedford Hall Suite of Dublin Castle

MONDAY, 12 MARCH

13:00	**Opening of the meeting. Practical information.** Introduction of the meeting participants. Information from ICES. Oceanography Committee Review of the 2000 WGHABD Report. Agreement about the meeting schedule.
13:30	**GEOHAB** Presentation of the GEOHAB Science Plan by Adriana Zingone, Member of the Scientific Steering Committee.
15:00	**Coffee break**
15:30	**EUROHAB (Cancelled)** Presentation of the EUROHAB Science Initiative by Elizabeth Lipiatou, European Commission, Directorate-General Research
16:30	**Possible ways of analysing historical data and fossil records.** Kaisa Kononen will give presentation about a Finnish study of the history of Cyanobacterial blooms in the Baltic Sea. Meeting participants are invited to bring any relevant information about this topic.
18:00	**Closing for this day**

TUESDAY, 13 MARCH

9:00	**Presentation of the stage of the GEOHAB Implementation Plan** Progress achieved by the Study Group of the GEOHAB Implementation in the Baltic Sea will be presented by Kaisa Kononen.
10:30	**Coffee**
11:00	**Potential sensitivity of HABs to climate changes.** Maurice Levasseur will give an introduction to the topic. Meeting participants are invited to bring any relevant information about this topic.
12:30	**Lunch**
14:00	**Use of remote sensing and *in situ* optical sensing technology in HAB dynamics studies.** Jim Aiken and John Cullen will give presentations. Meeting participants are invited to bring any relevant information about this topic.
15:30	**Coffee**
16:00	**Forum for presenting new findings**
18:00	**Closing for this day**

WEDNESDAY, 14 MARCH

9:00	**Preparation of a resolution for a workshop on 'Real time Observation Systems applied to HAB studies'**
10:30	**Coffee**
11:00	**Writing the report chapters**
12:30	**Lunch**
14:00	**National reports and updating the decadal maps** Meeting participants are invited to present a short description of HAB events in their country in 2000. Dr Catherine Belin will collect information for updating the decadal maps.
15:30	**Coffee**
16:00	**Forum for presenting new findings**
18:00	**Closing for this day**

THURSDAY, 15 MARCH

9:00	**Opening for this day**
	Summary of information in the harmful algae event database HAEDAT on regional, temporal and species basis
	Monica Leon will give a presentation
	Discussion about the harmful event report form
10:30	**Coffee**
11:00	**Report writing.**
13:00	**Lunch**
14:00	**Subgroup and plenary sessions to be decided on 'ad hoc' basis**

FRIDAY, 16 MARCH

9:00	**Adoption of the report sections.**
11:00	**Agreement about the ToRs for 2002.**
	Agreement about the meeting location for 2002.
12:00	**Lunch**
13:00	**Any other business**
14:00	**Closing the meeting.**

ANNEX 3: DECADAL MAPS OF HAB EVENTS IN THE ICES AREA

Available from http://www.ices.dk/status/