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REPORT OF THE  
**ICES/IOC WORKING GROUP ON  
HARMFUL ALGAL BLOOM DYNAMICS**

Lisbon, Portugal  
24–29 March 1998

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## 1 WELCOME AND OPENING OF THE MEETING

The ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) was convened at IPIMAR (Instituto de Investigaçao das Pescas e do Mar) in Algers, Portugal (25-29 March 1998). The meeting was organised by Maria-Antonia Sampayo and was chaired by Patrick Gentien (France). 26 scientists from 13 countries took part: they are listed in Annex I. The joint meeting between WGPE and WGHABD was held on the 24th of March.

Tom Osborn was appointed as a rapporteur for the whole session. In plenary session of the WGHABD, individual participants introduced themselves and their institute and gave a concise description of their major field of research.

A forum was organised to allow presentation of new results from research. Ten presentations were made. The meeting will be hosted by Pr. Berndt Lucas at Jena (Germany) from the 16-20 March 1999. At the term of chairmanship of P. Gentien, nominations took place and P. Gentien was renominated (17 nominations out of 20).

## 2 TERMS OF REFERENCE

At the 85th ICES Annual Science Conference in Baltimore (USA), the council resolved

(C. Res. 1997/2:53) that:

The ICES-IOC Working Group on Harmful Algal Blooms Dynamics (Chairman: P. Gentien, France) will meet in Lisbon (24-29 March 1998) to:

- 1) collate and assess National Reports and update the mapping of HABs;
- 2) prepare a review document on the population scenarios for the different harmful algae species;
- 3) examine the population dynamics and assess the role of harmful benthic microalgae in benthic and pelagic food webs;
- 4) review strategies that could be used to control harmful algae, identify the systems where bloom control may be possible and highlight promising methods which require further research in order to reduce the extent and effects of HABs;
- 5) review, in a joint session with WGPE on 24 March 1998, the results of the Workshop on Development of *in situ* Growth Rate Measurements of Dinoflagellates held in Kristineberg, Sweden in 1996;
- 6) review, in a joint session with WGPE on 24 March 1998, the status of taxonomic coding systems with a view to recommend the adoption of a single coding system for use in ICES;
- 7) comment on proposals made by IOC's Intergovernmental Panel on Harmful Algal Blooms (IPHAB) concerning expanded work programmes on harmful algal bloom;
- 8) consider the future work programme in relation to the remit of the Oceanographic Committee and the development of the ICES five-year plan, including co-operation with other groups.

The report on terms of reference 5) and 6) will be the object of the report of the Joint Session of the Working Groups on Phytoplankton Ecology and on Harmful Algal Blooms Dynamics.

## 3 SUMMARY OF THE CONCLUSIONS

**Term of reference 1:** collate and assess National Reports and update the mapping of HABs.

Country members presented in plenary session a summary of their respective national reports for 1996. It should be stressed that, among the ICES countries, some provide their national reports in due time every year. However, few others do not even forward their reports. While it is the chairman responsibility that reports be made available within the required time, it seems reasonable that ICES delegates ensure the necessary stimulation of the adequate national experts.

Decadal maps should be, in essence, comprehensive since it is now recognised that harmful trends cannot be easily detected at national scale. However, they were produced with the available data.

An analysis of previous national reports was made by the IOC-Communication centre in Vigo in view to establish a HAE-Data Base. It will encompass the former algal bloom reports but it should be expanded to contain relevant information on abiotic parameters during the bloom. The structure of the future database to be managed by IOC was discussed at great length: a reporting format was decided and should be implemented in the coming year.

**Term of reference 2:** prepare a review document on the population scenarios for the different harmful algae species.

An IOC – ICES questionnaire was produced and made available in January on the IOC Web page at the following address: <http://www.unesco.org/ioc/oslr/survey.htm>. The questionnaire originally produced by T. Osborn and P. Gentien was amended by a sub-group of the WG. The new version will be made available on the same Web page. A description of the responses to the date of the meeting is presented in the report. During the next year meeting, a synthesis of scenarios will be discussed.

**Term of Reference 3:** examine the population dynamics and assess the role of harmful benthic microalgae in benthic and pelagic food webs

This term of reference could not be addressed due to the lack of sufficient expertise in this field at the meeting. However, the working group recognises the extreme importance of this under-estimated topic and recommends that this term of reference be examined at the next WG meeting.

**Term of Reference 4:** review strategies that could be used to control harmful algae, identify the systems where bloom control may be possible and highlight promising methods which require further research in order to reduce the extent and effects of HABs

A detailed report of the general aspects of mitigation is produced in the report. Nevertheless, the WGHABD encourage ICES and IOC to co-sponsor a special theme session on HAB mitigation and control, hopefully leading to the formation of a study group on this topic. The contribution of the WGHABD to this diverse topic would be to identify critical elements of bloom dynamics which represent potential targets for mitigation and control strategies.

In any case, some sections on mitigation strategies in the ICES Co-operative Research Report "Management of the Effects of Harmful Algae on Mariculture and Marine Fisheries" prepared by the WG on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries" should be updated.

**Term of Reference 5:** review, in a joint session with WGPE on 24 March 1998, the results of the Workshop on Development of *in situ* Growth Rate Measurements of Dinoflagellates held in Kristineberg, Sweden in 1996;

Odd Lindahl presented the results of the ICES/IOC Workshop on the Intercomparison of the *in situ* growth rate measurements (Dinoflagellates) held at Kristineberg Marine Research Station, Sweden from 9–15 September 1996. Although the report has been discussed already during last years meeting of the WGHABD it still could not be finished due to some missing parts and because some information needed further elaboration. A shortage of the Workshop certainly was that some techniques were not yet established and were used for the first time. This includes risks which might be reduced with a more careful choice of available techniques.

It was decided to discuss the main shortcomings and missing parts in a smaller group of interested people of which many were attending in direct connection with the session (Anderson, Lindahl, Colijn, Gentien, Edler, Dahl and Sampayo). The main point which should be covered is to get calculations of growth rates even from those measurements which were only intended to give estimates. Also decisions were taken to finish the report within short time after the meeting. Information not available at that time will not be represented.

**Term of Reference 6:** review, in a joint session with WGPE on 24 March 1998, the status of taxonomic coding systems with a view to recommend the adoption of a single coding system for use in ICES;

The status of taxonomic coding systems with a view to recommend the adoption of a single coding system for use in ICES was introduced by Catherine Belin. She presented the common problems dealing with taxonomic coding

(synonyms, new names, etc.). She also emphasised that computer codes can be used as hidden codes and that there is no need to have complex numerical codes. It proves to be far more easy to use letter codes (acronyms) which resemble the species names. In France, therefore the data base Quadrige is used. A checklist per area should be made, and updated every 5-year.

**Term of Reference 7:** comment on proposals made by IOC's Intergovernmental Panel on Harmful Algal Blooms (IPHAB) concerning expanded work programmes on harmful algal bloom;

Some information was presented by Henrik Enevoldsen (IOC). The two recommendations adopted at the 1997 Vigo meeting of the IPHAB were discussed:

- 1) participation of non-ICES countries to the WGHABD: many enquiries were sent to the chairman from Latin America, Cuba, Australia and Philippines. However, for financial reasons, no extra participant could attend the meeting.
- 2) approaching the European Union for a generic action in the 5th Framework Program: a document joined in annex was sent to DGXII

Internationalisation of a program on harmful algae was discussed: A SCOR workshop will be held on before the end of 1998 in order to establish a science agenda.

**Term of Reference 8:** consider the future work programme in relation to the remit of the Oceanographic Committee and the development of the ICES five-year plan, including co-operation with other groups.

The WGHABD welcomes the development of a 5-year plan which will allow to keep continuity and to benefit from other working groups' expertise. Since the work programme will span on 5 years, the WG defined its remits in generic and broad terms of reference.

**Overall Goal:** To develop an understanding of the population dynamics controlling the development of Harmful Algal Events

**Proposed Terms of Reference:**

1. Develop a synthesis of the occurrences, similarities, and differences for HA species in the Global Ocean.
2. Identify critical needs for information and facilitate activities to fill the identified gaps in our knowledge.
3. Contribute to the establishment of a study group on mitigation and management of Harmful Algal Events
4. Time series analysis for status and trends of harmful events at different geographical scales
5. Develop links to other working groups
6. Support effectively the development of an international programme

### Term of Reference 1: *collate the National Reports in the usual form*

The compiled national reports are appended in Annex III. Country members presented in plenary session a summary of their respective national reports for 1996. It should be stressed that, among the ICES countries, some provide their national reports in due time every year. However, few others do not even forward their reports. While it is the chairman responsibility that reports be made available within the required time, it seems reasonable that ICES delegates ensure the necessary stimulation of the adequate national experts

#### CANADA

The year 1996 was atypical for the St. Lawrence. Between 19 and 21 July 1996, more than 225 mm of rain fell over the Saguenay River area in the Province of Québec. This unusual weather resulted in the flooding of several towns along the Saguenay River. In the St. Lawrence estuary, the heavy rain caused a drastic decrease in surface water salinity accompanied by a bloom of the toxic dinoflagellate *Alexandrium tamarense* on 29 July. In mid August, red tide concentrations of  $3 \times 10^6$  cells l<sup>-1</sup> of *A. tamarense* were measured in a patch located along the north shore of the Gaspé Peninsula. In the same area, mortalities of sand lance (*Ammodytes hexapterus*) and herring gulls (*Larus argentatus*) were reported. Domestic cats who had eaten dead fish on the beach also exhibited symptoms characteristic of paralytic shellfish poisoning (PSP). Results from HPLC analyses revealed concentrations as high as 360 µg STX eq/100 g in the dead sand lances. Levels of PSP toxins reached 84 and 36 µg STX eq/100 g in the intestines and brains, respectively, of the dead herring gulls. Concerns for the potential transfer of the toxins from the sand lance to commercial fish prompted the Department of Fisheries and Oceans to advise the population not to eat the livers of fish, e.g. cod, caught in this area of the St. Lawrence. This episode made a strong case for the previously proposed relationship between freshwater runoff and *Alexandrium* blooms, but also highlighted our poor understanding of the dynamics of PSP accumulation and depuration in finfish.

The year 1997 was characterised by relatively low concentrations of *Alexandrium* spp. and low levels of PSP toxicity in the St. Lawrence and in the Bay of Fundy. In contrast with 1996, the summer of 1997 was dry. In the Bay of Fundy, *Pseudo-nitzschia pseudodelicatissima* cells were observed throughout the year with highest concentrations observed during June and August. Although *P. pseudodelicatissima* has been observed annually in the Bay of Fundy, the only years that shellfish harvesting areas were closed to harvesting were during 1988 and 1995.

#### DENMARK

Relatively low phytoplankton biomasses and concentrations were registered in most of the summer period in Danish waters. During the very warm and calm august/september blooms of dinoflagellates were observed. The biomasses were dominated by dinoflagellates (*Prorocentrum minimum* and *Gyrodinium aureolum*). Furthermore high concentrations of diatoms (e.g. *Skeletonema costatum* and *Rhizosolenia fragilissima*) were observed. Fishkills and kills of benthic invertebrates which were caused by *Gyrodinium aureolum*, were registered in the western and southern part of Kattegat in august-september 1997. PSP was registered in oysters from the western part of the Limfjord in may. No other algal toxins were registered in shellfish in 1997 and there is no reports of human intoxications caused by consumption of danish shellfish during 1997. Intensified monitoring and/or closing of shellfishery due to high concentrations of *Dinophysis acuminata*, *Dinophysis norvegica*, *Alexandrium* species and *Pseudo-nitzschia*-species were imposed at several occasions in areas at the east coast of Jutland, in the Limfjorden as well as in the Wadden Sea. *Alexandrium minutum*, in Vejle Fjord at the east coast of Jutland - max. conc. 1.000 cells/L in june.

#### FINLAND

The summer 1997 was exceptionally warm and shiny in the Nordic countries. In the Gulf of Finland cyanobacterial blooms (*Nodularia*, *Aphanizomenon*, *Anabaena*) were the most extensive and prolonged blooms ever recorded. The blooms were toxic (nodularin) everywhere, where tested. Two dogs died and weaker symptoms were reported for several humans and domestic animals. In an oligohaline coastal lake Vargsundet in Åland, SW Finland, a fish kill associated to the bloom of *Prymnesium parvum* was recorded.

## FRANCE

Like past years, two toxic species were observed in 1997 in the French coastal waters: *Dinophysis* spp. (DSP) and *Alexandrium minutum* (PSP). The map shows the areas which were closed for DSP toxicity and for PSP toxicity. The total number of affected areas is equivalent to the last year, but is superior to the average for the five past years. Two regions were mainly affected: Southern Brittany (Atlantic coast) and Normandy (Channel coast).

### *Dinophysis* spp.

Cell concentrations associated to presence of DSP toxins in shellfish, are very often below 500 cells.l<sup>-1</sup>. The first developments of *Dinophysis* were observed mid-May in Brittany and along the Atlantic coast, with closures from June to early August. On the Channel coast (Normandy), *Dinophysis* appeared in June, and closures were maintained until mid-September. In Mediterranean, only one pond in Corsica island was affected early August.

### *Alexandrium minutum*

Cell concentrations associated to presence of PSP toxins in shellfish, are 100 000 cells.l<sup>-1</sup> or more in Morlaix bay (Northern Brittany). This region is affected every year by blooms of this species.

What is new is that *Alexandrium minutum* may be observed now in other areas of Northern Brittany, in rather important concentrations (x.100 000 cells.l<sup>-1</sup>), but without PSP toxicity until now. Actually, the results of two campaigns, the first one a few years ago, and the second one last year, show that *Alexandrium minutum* cysts can be observed now in the sediment of these new areas. So it is obvious that there is a slowly extension of *Alexandrium minutum* along the Northern coast of Brittany.

The presence of *Alexandrium minutum* was also observed along the Atlantic coast, between the rivers Loire and Gironde, in cell concentrations of about 10 to 20 000 cells.l<sup>-1</sup>. These concentrations are the most important ever observed in this region. No PSP toxicity was detected in shellfish.

All these events show that *Alexandrium minutum* is becoming the main problem of the French Phytoplankton Monitoring.

### Discoloured waters

Very important blooms of *Gymnodinium chlorophorum* were observed late July and early August, along the whole French Atlantic coast, leading to green waters. There were no harmful consequences. Other discoloured waters were also observed in Brittany, but with very little extension (*Chaetoceros sociale*, *Prorocentrum micans*, *Kryptoperidinium* sp.).

## GERMANY

(see also report "MURSYS" distributed by Bundesamt für Seeschifffahrt und Hydrographie, Hamburg)

In the North Sea, the foam-forming prymnesiophyte *Phaeocystis globosa* developed moderate population densities, no large foam-formation was recorded. For the first time, a dense bloom of the diatom *Minutocellus pseudopolymorphus* Hasle, von Stosch & Syvertsen (Cymatosiraceae) was recorded at the beaches off Sylt, Schleswig-Holstein. This surf-zone bloom was restricted to the beach, it extended only about 20 m from the beach parallel to the coast over about 15 km. The water had a strong smell, visibility was reduced to less than 50 cm. Chemical analysis (HPLC) of samples revealed no PSP-, DSP- or ASP-toxins. At the East Frisian coast high densities of *Dinophysis* caused accumulation of DSP-toxins in blue mussels from August to November, but as there was no mussel harvesting at that time, no economic losses were registered. As each year, low number of *Alexandrium tamarense* occurred at the North Frisian coast off Schleswig Holstein, but cell numbers (< 100 dm<sup>-3</sup>) caused no PSP-accumulation in mussels. The raphidiophytes *Fibrocapsa japonica* and *Heterosigma akashiwo* seem to be increasing in number from year to year. Off Büsum, Schleswig-Holstein, *Fibrocapsa* reached cell densities up to 330 000 cells dm<sup>-3</sup>. No effects were registered but in cultures a new brevetoxin-like toxin was found (Rademaker *et al.*, Harmful Algal News, submitted).

In the Baltic Sea, cyanobacteria bloomed as more or less each year. Chemical analysis showed high contents of nodularin-toxins. In addition, *Prorocentrum minimum* (including the morphotype *P. triangulatum*) bloomed as more or

less each year in Kiel Bight, whereas in Flensburg Fjord the dinoflagellate *Heterocapsa triquetra* caused water discoloration. Adverse effects were not noted.

In the frame of a research project on toxic algae (TEPS) the German Research vessel „HEINCKE“ made a cruise to Scottish waters (Firth of Forth, Orkneys) in May 1997, in co-operation with SOAEFD. On board HPLC-analyses of PSP-toxins were made. Populations of *Alexandrium tamarense* were found with cell densities up to 7000 cells dm<sup>-3</sup> and up to 890 ng STXeq. dm<sup>-3</sup>. Clonal cultures were shown to be related to the eastern North-American clade by molecular genetic analyses but not to the non-toxic western European *A. tamarense* clade. Analyses of dredged mussels showed high toxin contents: *Modiolus modiolus* up to about 5 000 µg STXeq. kg<sup>-1</sup>, *Pecten maximus* up to 10 000 µg STXeq. kg<sup>-1</sup>.

## IRELAND

During 1997 blooms of *Phaeocystis* spp, *Gyrodinium aureolum*, *Prorocentrum micans*, *Prorocentrum balticum* and *Noctiluca scintillans* were recorded in Irish coastal waters. The bloom of *Noctiluca scintillans* recorded on the SW coast in early September, with a maximum cell concentration of  $2.4 \times 10^6$  cells/litre, was associated with mortalities of farmed Atlantic salmon. The blooms of *Prorocentrum balticum*, which were also associated with mortalities of farmed Atlantic salmon, were the first records of blooms of this species in Irish coastal waters.

Levels of *Dinophysis acuta* and *Dinophysis acuminata* recorded were very low and the presence of DSP toxins in shellfish was also low. These results were very similar to those recorded in 1996. In October several cases of human illness were associated with the consumption of mussels from Arranmore Island on the NW coast. The toxicity was due the presence of Spiramino acid. This is only the second known occurrence of this toxin, the source of which is as yet undetermined.

## NETHERLANDS

No report from Netherlands - The decadal maps could not be updated.

## NORWAY

In 1997 there were less harmful events than average even if the summer where the warmest in this century. After an unusual early spring bloom of diatoms along the southern coast of Norway in January-February, the phytoplankton biomass was rather low the rest of the year. At a few sites along the coast mussels got toxic from diarrhetic shellfish toxins for shorter periods (weeks), while the risk of PSP was larger than average. The most important new experience in Norway during 1997 was recordings of paralytic shellfish toxins in two northernmost counties from late August. Although not very high concentration found, about 800 MU or less, this represent a northward spreading of the risk for PSP in Norway. Now we could not declare any part of our coast or any time of the year for absolutely safe concerning risk of getting PSP from consumption of mussels. However, the it still remains that April-June is the most common time of the year for the problem, and the most hot spots are located at the north-west coast.

## PORTUGAL

For PSP 1997 was an even milder year, only the clam *Tellina crassa*, which is a by catch for more commercial valuable species was affected.

Unexplained toxicity was detected mostly in mussels, but also affecting other species, in the mouse bioassay for DSP, at several points of the coast.

DSP was only confirmed in *Spisula solida* at Algarve coast in summer and in mussels at Aveiro Ria, Lima and Minho Estuary, for short a time during the during autumn.

## SCOTLAND

No report from Scotland - The decadal maps could not be updated



## SPAIN

For a second year PSP was not detected in Galicia. In the Atlantic coast of the south, *Gymnodinium catenatum* was observed but did not reach enough concentrations to cause shellfish toxicity. Domoic acid over 20 ppm and produced by *Pseudo-nitzschia australis* was detected in Galicia and caused closures, specially long, in scallops. *Dinophysis acuminata* was related to the detection of DSP toxins in mussels in Galicia and in the Gulf of Cádiz causing several weeks of harvesting closures in some

areas. Blooms of *Alexandrium minutum* were observed in Majorca and in Catalonia causing toxicity in mussels in later place. A bloom of *Gyrodinium corsicum* caused mortality of wild fauna in the river Ebre delta. Other species that caused blooms but not harmful effects were reported, were *Alexandrium* cf. *catenella* and *Ostreopsis* sp. in Catalonia, and *Alexandrium taylori* in Majorca.

## SWEDEN

In 1997 several species of *Alexandrium* were observed in the Skagerrak coastal waters. During May and June *A. tamarense* and *A. ostenfeldii* were present in concentrations of about 5 000 cells.L<sup>-1</sup>. PSP concentrations analyzed by mouse assay were reported "high". In June and the beginning of July *A. minutum* was present in concentrations of 30 000 cells.L<sup>-1</sup> and PSP concentrations of 300 MU/100 g was measured. In June there was also DSP, ranging from 95 to 209 ug Okadaic acid/100 g mussel meat. At the same time the concentration of *Dinophysis norvegica* was about 25 000 cells.L<sup>-1</sup>.

In August the considerable cyanobacterial bloom in the Baltic Sea was also seen in the south part of the Kattegat and large surface accumulations were observed in Laholm Bay.

In the Baltic Sea the cyanobacterium *Aphanizomenon* sp. formed a surface accumulation east of Gotland in early June, which is unusually early in the summer. Later, in July-August massive surface accumulations, dominated by *Nodularia spumigena*, but also large amounts of *Aphanizomenon* sp. and *Anabaena* spp., were distributed all over the Baltic Sea. Several dogs were reported intoxicated and eventually died. There were unconfirmed reports of human reactions after having swum in the sea.

From the end of July to the end of September the potentially toxic dinoflagellate *Prorocentrum minimum* formed a bloom in the southern part of the Baltic Sea. There are no indications that the bloom caused any harm.

In connection with the arrival of the flooding water from the rivers Wisla and Odra in Poland in the Gdansk Bay and Pomeranian Bay blooms of diatoms, e.g. *Coscinodiscus* spp. and *Cyclotella* spp. developed between 20 of July and 20 of August.

Between 25 August and 10 September a bloom of bioluminescent dinoflagellates was observed on the east coast of the island Öland. Among the different species *Peridiniopsis* sp. and *Alexandrium ostenfeldii* were found. This is the first report of the presence of *Alexandrium ostenfeldii* in the Baltic Sea.

## UK

There were no major blooms of any toxic species in England and Wales in 1997. *Alexandrium tamarense* occurred at 4 sites at lower peak cell concentrations than in previous years and persisted for much shorter periods. *Dinophysis* spp. and *Prorocentrum lima* were widespread, but the concentration of *Dinophysis* only exceeded the action limit (100 cells per litre) at one site (Blyth). No toxic forms of *Pseudonitzschia* were found.

## U. S. A.

PSP levels along the US east coast were lower than normal, with only limited closures in the state of Maine, and no closures in New Hampshire, Massachusetts, and Connecticut. On the west coast, PSP occurred in several regions of California, with the only unusual finding being low levels of toxicity between January and March in Los Angeles and San Diego counties. The causative species was observed to be *Alexandrium catenella*. These areas of southern California rarely report PSP toxins. Further north along the west coast, PSP caused shellfish harvesting closures along the Washington state Pacific coast and within Puget sound. In Alaska, one person died and about 12 became ill from consuming PSP-contaminated shellfish. Alaska has closed the vast majority of its shellfish beds permanently to

recreational harvesting due to the logistical difficulties of monitoring the extensive and remote coastline. As a result, every year, there are illnesses and occasional deaths due to PSP, since the public tends to disregard the closures.

Other major HAB outbreaks in 1997 included: 1) moderate levels of brown tide (*Aureococcus anophagefferens*) in New York and New Jersey; 2) red tides with fish mortalities, toxic shellfish, and toxic aerosols in Florida and Texas (the latter linked to the mortality of 14 million fish); and 3) kills of farmed salmon (100,000 fish) in Puget Sound, Washington during a bloom of *Heterosigma akashiwo*.

Another significant event was the emergence of *Pfiesteria* in the Chesapeake Bay during August and September. Five tributaries were closed to fishing and recreational activities after numerous fish were observed to have open bleeding sores, and several fish mortality events occurred (about 50,000 total fish). A medical team documented human health problems in fishermen who worked in the affected tributaries, and in others exposed during ferry transport across the areas with the fish kills. The problems involved cognitive impairment, including confusion, memory loss, and disorientation. Skin lesions on humans were reported, but they have not yet been directly linked to *Pfiesteria* exposure. The publicity given to the Chesapeake Bay outbreak was extraordinary and brought HAB problems to the attention of politicians and the public. As a direct result, over \$10 million was authorised for *Pfiesteria* research. It is also of note that taxonomic studies have revealed that there is a *Pfiesteria* complex which includes at least 3 morphotypes, some of which may be a different genus tentatively named *Cryptoperidiniopsis*. It presently requires scanning electron microscopy to distinguish between the different *Pfiesteria*-like organisms

## DECADAL MAPS (ANNEX V)

The purpose of plotting events on maps is to obtain a global and visual overview of harmful events for the preceding ten years. Information which is plotted on the maps includes indication of regular monitoring sites (phytoplankton and / or phycotoxins), and indication of the frequency of harmful events during the last ten years. Each map represents one type of event, and the different types of events are: DSP, PSP, ASP, NSP, CFP, animal and plant mortality, and cyanobacteria toxicity. The information plotted is the presence of toxins, or observations of mortality. Blooms of potentially toxic species with non detectable levels of toxicity do not appear on maps.

Last year, maps were made for the period 1987-1996. This year, maps are updated for the period 1988-1997. It appears that some ICES countries did not provide the necessary information. Every effort should be made by ICES national delegates to ensure that existing data are forwarded to the WG, in the correct format. These new maps will be included in the IOC Web pages, as soon as possible.

## DEVELOPMENT OF A COMPUTER DATA-BASE ON HARMFUL ALGAL OCCURRENCES WORLDWIDE: "HABDAT"

The WGHABD discussed the present format of annual national reports (Annex III) and the development of a computer data base to incorporate future information as presented to the WGHABD in 1997 (Annex IV).

All participants acknowledged the value of the data base and appreciated the results from the first analysis, presented by Jorge Diogène. However, the analysis of the present format (Annex III) showed that it was inadequate in many respects, in particular the difficulties in extracting quantifiable information, and of accessing and searching the data. The new national report format is presented in Annex IV.

It was recognized that there was a need for the development of a searchable database that was easily accessible and which could be updated on a regular basis e.g. as new HAB events occur so that up to date information is available to all potential users of the data. These users include the scientific community, shellfish industry, public health officials as well as the general public.

The format of the new data base should allow the organization of data to facilitate mapping and further analysis that could favour long-term studies to evaluate trends in HAB occurrences world-wide. Information to be reported should be tiered to allow initial the minimum information to be recorded, and provide the structure to allow subsequent additional information to be linked.

### Steps accomplished at this meeting:

- It was agreed that a new event report format was needed.

- The new event report format was presented and accepted (Annex IV).
- The name of the data-base will be the ICES-IOC Harmful Algae Event Data Base (ICES-IOC HAEDAT)
- National focal points were chosen and will be contacted
- The responsibilities of these national focal point nominees will be to gather the event reports in their countries, to classify them (assign the event number) and submit them to the IOC Science and Communication Centre on Harmful Algae for the update of the HAEDAT. Renewal of the data-base should be possible all year round.
- The distribution of event forms and implementation of HAEDAT should be extended to non-ICES countries through IOC.
- An *ad hoc* group for development of HAEDAT has been established to work on the general presentation and use of the HAEDAT and to implement it using existing data for future evaluation. Members of this *ad hoc* group are: Jorge Diogène (Coordinator, IOC), Catherine Belin (France), Lars Edler (Sweden), Malte Elbrachter (Germany), Maurice Levasseur (Canada), Terrence McMahon (Ireland), Maria Antonia Sampayo (Portugal) and Elisabeth Wikfors (USA).
- Future actions to be taken are presented in the tentative timetable.

Developing step	Due
Update and introduction of previous records into the HAEDAT.	During 1998-1999
Presentation of the data input form to national focal points.	May 1998
Submit questionnaire for the evaluation of the form to national focal points. These will be responsible for the distribution and collection of evaluation forms.	May 1998
Gathering of comments from questionnaires.	November 1998
Analysis of data from the HAEDAT.	During 1998
Interface of HAEDAT to the World Wide Web	June 1998
Displaying of HAEDAT in the web pages of ICES and of IOC.	June 1998

#### Recommendation:

The WGHABD recommends that:

- the *ad hoc* working group work inter-sessionally as specified in the tentative time table of developing steps. This group will prepare a report on the HAEDAT for presentation at the next meeting of the WGHABD in 1999.
- the use of the HAEDAT should be encouraged.

**Term of Reference 2:** prepare a review document on the population scenarios for the different harmful algae species;

In its 1996 meeting the WGHABD initiated a global survey to collect descriptions on oceanographic processes/circumstances leading HAB's in different parts of the world. The aim of this survey is to document similarities and differences for the same species and to discover mechanisms that extend across species boundaries. During the first months of 1998 a questionnaire was distributed to ICES-IOC community through internet. Until the time of the working group meeting 18 descriptions concerning 14 species by 10 rapporteurs were submitted.

Table XX: List of species and geographic areas, for which bloom development scenarios were described according to the questionnaire.

Species	Geographic area
<i>Gyrodinium cf. aureolum</i>	Norway coastal waters/Skagerrak
<i>Gyrodinium cf. aureolum</i>	Ireland
<i>Gyrodinium cf. aureolum</i>	Southern Brazil
<i>Chrysochromulina polylepis</i>	Norway coastal waters/Skagerrak
<i>Fibrocapsa japonica</i>	Busum harbour, Germany
<i>Gymnodinium catenatum</i>	Mexican coasts
<i>Pyrodinium bahamense var compressum</i>	Mexican coasts
<i>Pyrodinium bahamense var compressum</i>	Manila Bay, Philippines
<i>Gymnodinium breve</i>	Mexican coasts
<i>Prorocentrum mexicanum</i>	Mexican coasts
<i>P. minimum</i>	Mexican coasts
<i>Pseudo-nitzschia australis</i>	Mexican coasts
<i>Nodularia spumigena</i>	Baltic Sea
<i>Anabaenopsis</i> sp.	Colombia (fresh water)
<i>Microcystis aeruginosa</i>	Colombia (fresh water)
<i>Anabaena cf. spiroides</i>	Colombia (fresh water)
<i>Alexandrium fundyense</i>	Eastern Canada-bay of Fundy
toxic event	India

The working group recognised that information from several important HAB species and geographic areas, where blooms are recurrent (e.g. in Australia, Japan, SE Asia, S. America, S. Africa) was either very scarce or not available, and therefore the material is not yet sufficient for a compilation of a synthesis. It was agreed that the survey will focus on the following genera: *Dinophysis*, *Alexandrium* group, *Gymnodinium*/*Gyrodinium* group, *Pyrodinium*, *Nodularia*, *Trichodesmium*, *Heterosigma*, *Chattonella*, *Chrysochromulina*, *Prymnesium*, *Pseudo-nitzschia*, *Prorocentrum*, *Noctiluca*. Patrick Gentien and Tom Osborn were asked to contact individual experts and national IOC representatives in different geographical areas directly and ask responses to the questionnaire. Furthermore, it was recognized that there was some inconsistency in the interpretations of questions and therefore the current structure of the questionnaire needs some updating.

**Term of Reference 3:** examine the population dynamics and assess the role of harmful benthic microalgae in benthic and pelagic food webs

This term of reference could not be addressed due to the lack of sufficient expertise in this field at the meeting. However, the working group recognises the extreme importance of this under estimated subject and recommends that this term of reference be examined at the next WG meeting.

**Term of Reference 4:** review strategies that could be used to control harmful algae, identify the systems where bloom control may be possible and highlight promising methods which require further research in order to reduce the extent and effects of HABs.

## Introduction

The ultimate goal of research and monitoring efforts on HABs and their impacts is to protect public health, fisheries resources, ecosystem structure and function, and coastal aesthetics. This requires a fundamental understanding of the many factors that regulate the dynamics of HABs, but by itself, that knowledge does not provide sufficient protection. Management and mitigation strategies are needed that reduce impacts by avoiding the blooms or minimising their effects (hereafter termed mitigation) or by directly affecting the bloom organisms (prevention or control). Example mitigation strategies include moving fish cages from the path of an HAB or altering the chemical composition of fish food to reduce their susceptibility to a bloom. Examples of control efforts would be reducing pollution inputs to a region in an effort to decrease the number or size of bloom events or direct application of chemicals or other materials that kill or disrupt HAB cells during blooms.

Given the large and expanding scale of the global HAB problem and the increasing use of coastal waters for food, commerce, and recreation, it seems logical that efforts would be undertaken to control the blooms or mitigate their impacts. In most countries, however, the HAB community has traditionally focused its efforts on fundamental research. Mitigation strategies such as monitoring and toxin detection are undertaken, but efforts to control blooms are not attempted to any significant extent, even though this is often the ultimate expectation of the general public and many agency officials (Anderson 1997).

The need for bloom mitigation strategies is most compelling in coastal aquaculture given that such facilities are already manipulating the local habitat for production purposes. It is thus not surprising that countries which 'farm' the sea heavily (e.g., Korea, China, Japan) have invested in bloom control research. The application of similar mitigation efforts to enhance the use of natural living marine resources (i.e. wild stocks) which are impacted by HABs or to improve coastal aesthetics is more problematic and controversial.

The WG discussed the present state of knowledge in HAB mitigation and control, recognising the need to maintain a focus on issues related to bloom *dynamics*. The section that follows highlights areas where fundamental research on bloom dynamics can potentially lead to mitigation and control strategies. There are clearly processes and mechanisms in HABs that are critical elements of bloom dynamics, and which are therefore logical areas to explore with respect to mitigation or control strategies. **However, the WG decided that their main focus should remain bloom dynamics, and that the compelling issues of HAB mitigation and control should be addressed in ways that do not detract from this primary goal.** This could be accomplished by organising a special theme session at the ICES annual meeting on mitigation and control, and/or by providing guidance and support for a special study group. The WG felt that mitigation and control issues should not be ignored by ICES and IOC, so a long term objective of the group could be to identify the critical points or processes in bloom development where mitigation might be effective. Once identified, the practical aspects of designing and evaluating mitigation could be relegated another group of scientists with expertise in such matters.

## Mitigation Strategies

It is possible that some effects of HAB's on natural, living marine resources can be restricted or avoided by specific mitigation strategies. Most of the negative impacts cause severe economic losses to aquaculture, natural fisheries, and tourist recreation activities. The minimisation of these economical losses is the goal of mitigation strategies. After many years of experience with HABs, it is clear that no single method will provide an effective solution to protect fisheries, aquaculture stocks, and natural environments.

Mitigation strategies for HABs were discussed previously by the WG on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries, and are presented in the ICES Co-operative Research Report "Management of the Effects of Harmful Algae on Mariculture and Marine Fisheries". This report indicated that, to counteract the effects of HABs, it is necessary to be able to predict the occurrence, or at least movement, of blooms. This requires a detailed

understanding of bloom dynamics. Early prediction can improve the chances of successful mitigation. Some examples of other mitigation strategies which require an understanding of HAB dynamics include:

- 1) Reduction in the introduction of HAB species to new areas during movement or transfers of marine species, especially shellfish stocks through the restrictions on the timing and geography of the transfers. Caution must be exercised in moving shellfish stocks until rational guidelines, based upon research on bloom initiation and organism biogeography, are developed. A similar recommendation applies to ballast water discharges.
- 2) Site selection for aquaculture farm operations should include an evaluation of the potential for chronic HAB occurrences. Such guidance requires a detailed understanding of bloom dynamics and distribution in a given area.
- 3) Aquaculture operations should be designed such that it is possible to reposition cultured stocks, both vertically and horizontally, when HAB's do occur. When the resources cannot be moved, early harvest can be an alternative solution if forecasts are given. These advisories require an understanding of the vertical and horizontal distribution of HABs, and of organism behaviour, physical transport, and other dynamic processes.

These are but a few of numerous possible mitigation strategies that have the potential to minimise fishery or aquaculture losses. More details are available in the *Cooperative Research Report* mentioned above. Since considerable time has elapsed since that report was written, the WG recommends that an effort be made to update that material, recognising that mitigation strategies to protect wild marine resources or to reduce negative aesthetic impacts caused by HAB's have not been considered to any extent.

### **Prevention/control of HABs**

Whereas mitigation efforts are designed to address the impacts of blooms, there is a second category of methodologies which attempt to alter the size, composition, or duration of the blooms. Control efforts of this type can be categorised as either "direct" or "indirect" depending upon whether the effort targets an existing bloom or strives to reduce future blooms, such as through alteration of pollution inputs.

#### Indirect Control.

*Nutrients/eutrophication.* HAB species, just like all plants, require certain major and minor nutrients for their nutrition. These can be supplied either naturally from marine and freshwater biogeochemical processes, or through human activities, such as pollution. A case has been made in several areas of the world that increases in pollution are linked to increases in the frequency and abundance of HABs (reviewed by Smayda 1989). It follows that a reduction in pollution can sometimes lead to a decrease in bloom frequency. A classic example of this occurred in the Seto Inland Sea of Japan, where pollution increased nutrient loadings and visible red tides more than tripled between 1970 and 1978. A law was passed to reduce industrial and domestic effluents, and several years later, red tide occurrences decreased to 50 % of peak levels, and that reduction has been sustained to this day (Honjo, 1994a,b).

Another prominent example is from the Long Island "green tides" of the 1950s. During that time, bays on the south shore of Long Island, New York, were subject to extremely dense blooms of algae that turned the water a vivid green colour. This not only altered the aesthetic quality of that region as a recreational area, but these blooms were also thought to be the principal cause of the failure of the local oyster industry. Research by Ryther and co-workers (reviewed in Ryther, 1989) correlated the green tides with the development of a duck farm industry located along the tributary streams and coves of these bays. The connection between the green tides and pollution from the duck farms was established through a series of surveys and laboratory experiments. The dense green tides which occurred in the 1950s diminished during the 1960s as the flushing characteristics of Moriches Bay were increased by opening a channel to the ocean and by the gradual demise of the duck farming businesses. Pollution control measures were also imposed on existing duck farms, and there have not been any recurrences of the green tide blooms.

These and other examples highlight the connection between human pollution and HAB incidence. It should be emphasised, however, that not all blooms show this linkage, and that many are supported by nutrients from natural sources, such as from deeper waters or regenerated production in the water column. Examples of HAB species for which linkages to pollution are probable include *Phaeocystis*, *Pfiesteria*, or *Microcystis*, whereas *Alexandrium*, *Gyrodinium*, and *Pseudo-nitzschia* are not often linked to polluted waters. Clearly, before control strategies based on reduction of nutrient inputs are implemented in an area, it is essential that the case be proven that human pollution is in fact responsible for the proliferation of a specific HAB species in a particular area. This requires considerable field and laboratory work, but it is necessary if the extent and political ramifications of nutrient regulations are to be effective.

It should also be recognised at the outset that this is a long-term approach that may take decades to reveal whether it was actually effective in reducing the local HAB problem.

*Bio-manipulation.* Man made optimisation of ecosystem structure to conserve/establish/re-establish the biological structure that may prevent HABs in an area could be termed bio-manipulation or bioremediation. One example might be the establishment of populations of benthic filter feeders to control the populations of HABs. In an analogous precedent, ten large farms of mussels will be established in polluted areas of Norway in an effort to reduce ambient nutrient concentrations through removal of phytoplankton. Another example might be artificial aeration to mix the water column, favouring species which thrive in well-mixed waters over those requiring stratification.

The design and evaluation of bio-manipulation strategies will depend on a fundamental understanding of associated processes, such as the grazing losses associated with benthic filter feeders, or the influence of water column mixing on different algal species. This again is a direct link to our focus on the dynamics of HABs.

*Modification of water circulation.* As exemplified in the description given above of the solution to the "green tide" problems on Long Island in the 1950's, alteration of circulation patterns can directly affect the incidence of HABs. In some semi-enclosed areas, HABs linked to either local eutrophication or restricted circulation can be minimised by changing the circulation of water masses to optimise flushing of nutrient rich water as well as the HAB species out of the area. This again requires understanding of linkages between hydrography, nutrient loadings, and bloom dynamics.

### Direct Control

*Biological Control.* A number of organisms interact with HAB microalgae, and these interactions can have both positive and negative impacts on bloom dynamics. Quantification of these processes is needed if we are to understand and model HAB bloom dynamics. The two functional relationships that are most closely associated with microalgal population dynamics are: 1) pathogens, and 2) predators.

Organisms classified here as pathogens include viruses, bacteria, and (protistan) parasites. It is well recognised that these members of the planktonic microbial community often have profound impacts upon HAB population dynamics, however, we have little specific or quantitative knowledge of these impacts. Aspects of interactions between HAB species and their pathogens include:

- 1) Selectivity -- is the target HAB species alone affected, and are effects consistent for all individuals within the target population?
- 2) Stability of the pathogen -- loss of pathogenic virility in culture is a common experience with microbial pathogens, particularly bacteria. In addition, "host switching" of viral pathogens complicates the question of specificity.
- 3) Density-dependence -- encounter rates between pathogen and host "particles" are dependent upon physical laws, as modified by motility behaviours. It appears, for example, that encounter rates between non-motile viral pathogens and single-celled hosts limit effectiveness of viral control of a bloom to exceptionally dense host concentrations. This likely would be the case for non-motile bacterial pathogens as well.
- 4) Physiological mechanisms -- host-pathogen interactions can be complicated by host defence mechanisms, life-history differences in host susceptibility, and differences in susceptibility caused by other physiological stresses. In addition, the mechanism and timing by which pathogens infect and kill the host and reproduce themselves may limit effectiveness of these potential control mechanisms, e.g., a parasite that kills the entire host population limits its own future as well.

Predators that consume HAB species include microzooplankton (most are protists), mesozooplankton (copepods, other pelagic crustaceans, and larvae of benthic invertebrates), and benthic filter-feeders (chiefly the bivalve molluscs). It is recognised that some of these phytoplankton consumers are affected negatively by certain HAB species. Indeed, it is the suppression of grazing pressure that often is responsible for the accumulation of HAB biomass that constitutes a "bloom". Nevertheless, predation and mortality of HAB species is obviously a critical element of bloom dynamics, but it also is an avenue to explore with respect to potential control strategies.

Much more information exists on interactions between grazers and HAB species than for pathogens. Zooplankton grazing rates have been investigated in both laboratory and field studies for a number of HAB species, but this knowledge needs to be expanded. Similarly, bivalve filtration rates and, in some cases, harmful effects in the presence of

HAB species have been reported. More specific information is needed on long-term effects of HAB species upon bivalve feeding behaviour. Research efforts to elucidate predator-prey dynamics should focus first on co-occurring HAB and consumer species. This information is needed both to elucidate aspects of HAB dynamics and to identify opportunities to exploit these predator-prey interactions to mitigate or control blooms.

Cautions and potential pit-falls that must be considered in evaluating the manipulation of planktonic and benthic grazers to control blooms include the following:

- 1) Consumers can provide an entry point for toxins into the marine food web, and acceleration of this trophic transfer may have negative consequences.
- 2) Consumers, especially benthic animals, may not completely digest or kill HAB cells, thereby concentrating rather than eliminating the target HAB population.
- 3) Phytoplankton consumers seldom are very selective, thus, enhancement of grazer populations may impact general trophic dynamics in unintended ways.

In general, the logistics of production and application of any biological agent may constrain the practicality of actually employing direct biological controls. Nevertheless, direct, active biological control opportunities should be explored as bloom dynamics studies elucidate community interactions during HAB events.

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**Term of Reference 5:** review, in a joint session with WGPE on 24 March 1998, the results of the Workshop on Development of *in situ* Growth Rate Measurements of Dinoflagellates held in Kristineberg, Sweden in 1996;

discussed and presented in the Joint Meeting Report

**Term of Reference 6:** review, in a joint session with WGPE on 24 March 1998, the status of taxonomic coding systems with a view to recommend the adoption of a single coding system for use in ICES;

A test of the international codification was set up in 1996 using the French monitoring database (QUADRIGE). The results were unfavourable: many taxa present in the database had no correspondence in the NCC coding system, and the NODC coding system was too complex and not satisfactory.

Taxonomic codes (changes in taxonomy, synonyms,) evolve and create numerous problems when maintaining a database. The problem is not the existence of a universal coding system, but resides in the agreement on the latin names, on the possible synonymes, and on the possible groups of taxa. Since the data maintenance may be performed in new databases, with non-significant and hidden codes, we strongly recommend to give up the idea of an universal coding system, and to focus on the establishment of a check-list of species; this check-list will be a list of latin names, and



should solve the problems of synonyms. The recent increase in computer power makes it possible to keep the entire name without the simplification associated with a coding scheme.

The ICES Working Group on Phytoplankton Ecology (WGPE) and the ICES/IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) recommend to set up a meeting of phytoplankton taxonomic experts for three days in Copenhagen (IOC taxonomic centre) in winter 1998-1999 to check a provisional species list compiled on the basis of the references given in the Annual Report of the WGPE in 1997, and with the additions made in 1998 during their meeting in Lisbon. The group of taxonomic experts should be composed of regional taxonomic experts covering the ICES area in full. Task of this ad-hoc group would be to check the taxonomic names used in current check-lists, to agree on new names, and to complete the distribution list of the species. Emphasis should also be given to toxic species or species to cause harm; these should be identified in the list.

**Term of Reference 7:** comment on proposals made by IOC's Intergovernmental Panel on Harmful Algal Blooms (IPHAB) concerning expanded work programmes on harmful algal bloom;

The Fourth Session of the IOC Intergovernmental Panel on Harmful Algal Blooms - IPHAB (Vigo, Spain, June 1998) recommended that a international science agenda on harmful algal blooms be prepared (IOC Document IOC/IPHAB-IV/3S). The idea has been adopted by the IOC Assembly, and the IOC has subsequently invited SCOR to co-sponsor the development of the HAB science agenda. SCOR has accepted the invitation and the planning is now in progress. The broad goal of developing the international science agenda is to generate the necessary research to ameliorate the effects of toxic/harmful microalgae. The first step in the process will be a workshop to formulate the science agenda. The workshop is planned for late 1998 and the participants will be invited by the IOC and SCOR (and other potential co-sponsors). In addition to the IOC and SCOR funding, support is expected from a number of national agencies and foundations.

Some years ago the IPHAB formulated and adopted the IOC Harmful Algal Bloom Programme Plan. The Plan provides the framework for a number of the international and regional activities on HAB which have emerged during the last 7 years. The development of a science agenda is to be seen as a step further in the implementation of the HAB Programme Plan.

The national and regional basis for the development includes important initiatives such as the work of the ICES-IOC WGHABD, the US ECOHAB programme, and the development of a priority plan for HAB research in the European Union.

One approach in the development of the science agenda could be to look for problem specific solutions. An approach that is also the background for the ICES-IOC questionnaire on HAB scenarios.

It is envisaged that the science plan could consist of species specific and oceanographic environment specific cases where lab experiment, field work and modelling are integrated in the description of the various cases. In other words the objective is species and case specific modelling.

The strategy proposed is comparable to the one applied in the development of international research programmes such as JGOFS, WOCE and GLOBEC. The next step after the development and recognition of the science agenda will be the development of an implementation plan composed of both national, regional, potentially international projects.

The WGHABD welcomed the plans for the development of an international science agenda and recognised the importance of it to achieve national and regional funding for research projects. The WGHABD recommends that ICES supports and take active part in the IOC-SCOR initiative to develop an international science agenda on HAB.

**Term of Reference 8:** consider the future work programme in relation to the remit of the Oceanographic Committee and the development of the ICES five-year plan, including cooperation with other groups.

The WGHABD welcomes the development of a 5-year plan which will allow to keep continuity and to benefit from other working groups' expertise. Since the work programme will span on 5 years, the WG defined its remits in generic and broad terms of reference.

**Overall Goal:** To develop an understanding of the population dynamics controlling the development of Harmful Algal Events

**Terms of Reference:**

1. Develop a synthesis of the occurrences, similarities, and differences for HA species in the Global Ocean
2. Identify critical needs for information and facilitate activities to fill the identified gaps in our knowledge.
3. Contribute to the establishment of a study group on mitigation and management of Harmful Algal Events
4. Time series analysis for status and trends of harmful events at different geographical scales
5. Develop links to other working groups
6. Support effectively the development of an international programme

**Justifications:**

§1. This ToR is already justified in the Terms of Reference for 1999. However, it is felt that one year will not probably be sufficient to establish a phenomenological grouping of different events. This action is seen a basis for a theory of HABs.

§2. Defining the critical gaps in knowledge will be possible on the basis of ToR §1 and will help increasing knowledge in areas leading to answers useable by the society.

§3. Mitigation and management of HABs, when possible imply a broader range of expertise than simply identifying the critical control processes of a population: for instance, engineering, ecological studies, etc.

WGHABD could contribute to such a study group but could not address the various topics involved.

§4. As stated in Vol. 41 of Ecological Series, NATO ASI (Anderson *et al.*, Eds), scientific community is still arguing about the apparent proliferation of HABs. It appears that statements of a global increase are not backed up by appropriate time series analyses, but they may induce high indirect costs such as induced by drastic reductions in nutrient loadings.

§5. It is realised by the WGHABD that development of effective links with other groups will be required in order to achieve the goals. In particular, it will require strong links with shelf seas oceanography, statistics group, phytoplankton and zooplankton ecology.

## **5 FORUM**

The suggestion that the group should take the opportunity to present new results and concepts related to the dynamics of harmful algal blooms was well received. Ten contributions were presented.

### **Overview of the August 1996 red tide event in the St. Lawrence: effects of a storm surge**

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Between 19 and 21 July 1996, more than 225 mm of rain fell over the Saguenay River area in the province of Québec. This unusual weather resulted in the flooding of several towns along the Saguenay River. In the St. Lawrence estuary, the heavy rain caused a drastic decrease in surface water salinity accompanied by a bloom of the toxic dinoflagellate *Alexandrium tamarense* on 29 July. In mid August, red tide concentrations of  $3 \times 10^6$  cells l<sup>-1</sup> of *A. tamarense* were measured in a patch located along the north shore of the Gaspé Peninsula. In the same area, mortalities of sand lance (*Ammodytes hexapterus*) and herring gulls (*Larus argentatus*) were reported. Domestic cats who had eaten dead fish on the beach also exhibited symptoms characteristic of paralytic shellfish poisoning (PSP). Results from HPLC analyses revealed concentrations as high as 360 µg STX eq/100 g in the dead sand lances. Levels of PSP toxins reached 84 and 36 µg STX eq/100 g in the intestines and brains, respectively, of the dead herring gulls. Concerns for the potential transfer of the toxins from the sand lance to commercial fish

prompted the Department of Fisheries and Oceans to advise the population not to eat the livers of fish, e.g. cod, caught in this area of the St. Lawrence. This episode made a strong case for the previously proposed relationship between freshwater runoff and *Alexandrium* blooms, but also highlighted our poor understanding of the dynamics of PSP accumulation and depuration in finfish.

### Uncertainty Analysis For The Estimation Of Growth Rates

T. Osborn

Starting from the formula for exponential growth:

$$N(t) = N_0 e^{\mu t}, \quad (1)$$

an error analysis can be performed on estimates for  $\mu$ , which are derived from measurements of  $N(t)$  and  $N_0$ .

The analysis consists of first taking the natural logarithm,

$$\ln(N(t)) = \ln(N_0) + \ln(e^{\mu t}), \quad (2)$$

$$\ln(N(t)) - \ln(N_0) = \mu \cdot t \quad (3)$$

followed by a differential.

$$\frac{dN(t)}{N(t)} - \frac{dN_0}{N_0} = \mu \cdot dt + t \cdot d\mu \quad (4)$$

Divide by  $\mu \cdot t$ ,

$$\frac{\left( \frac{dN(t)}{N(t)} - \frac{dN_0}{N_0} \right)}{\mu \cdot t} = \frac{dt}{t} + \frac{d\mu}{\mu} \quad (5)$$

and use equation (3),

$$\frac{\left( \frac{dN(t)}{N(t)} - \frac{dN_0}{N_0} \right)}{\ln N(t) - \ln N_0} = \frac{dt}{t} + \frac{d\mu}{\mu} \quad (6)$$

and rearrange the terms.

$$\frac{d\mu}{\mu} = \frac{\left( \frac{dN(t)}{N(t)} - \frac{dN_0}{N_0} \right)}{\ln N(t) - \ln N_0} - \frac{dt}{t} \quad (7)$$

Assuming the errors in the different terms are independent:

$$\left| \frac{d\mu}{\mu} \right|^2 = \left| \frac{dt}{t} \right|^2 + \frac{\left| \frac{dN(t)}{N(t)} \right|^2 + \left| \frac{dN_0}{N_0} \right|^2}{[\ln N(t) - \ln N_0]^2} \quad (8)$$

In the example reported by Legrand et. al. on the Kristineberg Workshop 9-15 September using cell counts of *Alexandrium fundyense* grown in culture

$$\left| \frac{dN(t)}{N(t)} \right| = \frac{368}{2256}$$

and

$$\left| \frac{dN_0}{N_0} \right| = \frac{80}{1573}$$

with the denominator evaluated as

$$\ln N(t) - \ln N_0 = \ln \frac{N(t)}{N_0} = \ln \frac{2256}{1573} = 0.361.$$

Neglecting the effect of the uncertainty in the time, the uncertainty in the growth rate is essentially 2.8 times the uncertainty in the population estimates.

$$\left| \frac{d\mu}{\mu} \right| = 0.47$$

If the experiment is run over 5 doubling periods then  $N(t)/N_0 = 32$  and  $\ln(N(t)/N_0) = 3.5$ . This serves to reduce the fractional error in the number sampling whereas short growth intervals accentuates the effect.

The effect of the uncertainty in the time is difficult to assess in a straightforward manner. First, it takes the plankton a while to recover from being put into the flask. Second, some phytoplankton separate at specific times of the day but the length of their cycle for reproduction can be several days. Third, the experiment may not be consistent with the daily cycle of the plankton, for example, this experiment went over 36 hours that included 2 light periods and only one dark period. Does that mean it was a 1.5 day or a 2 day experiment? The contribution of uncertainties of this sort can be as great or greater than the uncertainties associated with the counts.

#### **Report on the Study Group on Ballast Water and Sediments**

Jane Groos (IOC)

The ICES/IOC/IMO Study Group on Ballast Water and Sediments meet in The Hague, The Netherlands on 23 - 24 March 1998. The Study Group had almost 50 participants and was chaired by James Carlton, USA. The group is generally concerned about the introduction of non-indigenous organisms carried by ballast water and sediments and by hull fouling. Presentations were made on research and management tools used to avoid the transfer and introductions of unwanted organisms including harmful algae. A presentation of research on survival of harmful algae and cysts of

harmful algae were made by Dr. Chris Bolch, Australia. The problems are sought solved through various mechanisms. Monitoring systems to measure survival of species carried by ballast water and sediments are being intercalibrated through an EU Concerted Action Plan. Treatments systems like heating of the ballast water, filtering ballast water before it enters the ballast tanks and deballast/reballast at open oceans are being tested and risks analyses are being made on individual ships. The IMO working group on ballast water MEPC has drafted guidelines for the control and management of ships ballast water to minimise the transfer of harmful aquatic organisms and pathogens. IMO Guidelines are expected to be implemented in year 2000.

### Overview of "ECOHAB: Trophic effects of two dinoflagellates."

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<sup>3</sup>Department of Marine Sciences, University of Connecticut, Groton, CT; and <sup>4</sup>LAAMP, School of Veterinary Medicine, University of Pennsylvania, Marine Biological Laboratory, Woods Hole, MA (Additional funding from Connecticut Sea Grant has permitted us to extend experiments funded by the US ECOHAB Program).

Most HAB dinoflagellates grow relatively slowly; therefore, accumulation of their biomass (a bloom) is likely attributable, to some extent, to reduced grazing. Among the grazing organisms that normally limit phytoplankton biomass accumulation are pelagic consumers, such as protozoans, copepods, and larvae of benthic invertebrates, as well as benthic filter-feeders – chiefly the bivalve mollusks. Knowledge of direct, harmful effects of an algal species upon consumers would explain the mechanism by which a bloom of that alga can occur, and provide predictive capability of the types of ecosystems, dominated by benthic or pelagic consumers, that are most susceptible to blooms of that alga.

We are investigating systematically, under controlled laboratory conditions, effects of three cultured HAB dinoflagellates, *Prorocentrum minimum*, *Gyrodinium aureolum*, and *Gymnodinium breve*, upon a suite of representative consumer organisms, including three protozoans, two copepods, and a larval and post-set bivalve. Effects of these dinoflagellates, both alone and in various combinations with "good food" algae, upon feeding, behaviour, population dynamics, and histological condition of individual organisms will be documented. This work will benefit from a team approach utilizing, in all experiments, identical algal cultures produced in the unique Milford Microalgal Mass Culture Facility. Results will provide information critical to interpretation of field studies of HAB dynamics and food-web effects.

The objective of this project is to document, under controlled laboratory conditions, effects of the three selected HAB dinoflagellates upon a taxonomically-diverse list of algal consumers: larval and post-set bay scallops, *Argopecten irradians*; copepods, *Acartia tonsa* and *Temora longicornis*; and micro-zooplankters, the tintinnid *Favella ehrenbergii*, an oligotrich ciliate (*Strombidinopsis* or *Strombidium*) and a heterotrophic dinoflagellate (*Protoperidinium* sp.). We will evaluate both feeding response and histological condition, especially of digestive organs, of animals fed unialgal and mixed algal diets that include the two dinoflagellates. In addition, strains of the two dinoflagellate species listed by the Provasoli-Guillard Center for the Culture of Marine Phytoplankton (CCMP) as being toxic and non-toxic may be compared if inimical effects are found with the "toxic" strains. Algal strains used will be analysed for two specific types of dinoflagellate toxins to assess the potential role of these toxins in effects upon the consumer organisms.

### The Long Island Brown Tide

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Prepared for 1998 Meeting of the ICES/IOC Working Group on Harmful Algal Bloom Dynamics

The "Long Island brown tide," caused by blooming of the chrysophyte *Aureococcus anophagefferens*, is an example of a harmful algal bloom (HAB) that disrupts trophic function of a coastal ecosystem but does not produce human toxins. The brown tide has remained limited geographically to a region encompassing Narragansett Bay, the Peconic estuary

system, and Barnegat Bay (Fig. 1), and high populations of the causative species, first described formally in 1987, have been measured sporadically only since 1985. Accordingly, this bloom scenario provides an excellent opportunity to summarize the process by which the scientific and natural-resource management communities respond to a new HAB. The following Table was prepared to stimulate discussion on the development and evolution of an HAB scenario, in terms of both ecological and societal dynamics.

Year	Summary	Consequences	Research Reported	Hypotheses	Funding	Management Response
1985	First noticeable bloom, ca. $10^7$ cells per ml in Narragansett Bay, Peconic Bay, possibly Barnegat Bay	Loss of Peconic scallop fishery valued at \$2 million; blue-mussel mortalities in Narragansett Bay	None	The diatom, <i>Minutocellus</i> or an unknown chrysophyte is responsible	None	Document loss of scallop landings
1986	Bloom less intense than 1985, but still $10^6$ cpm, and confined to portions of the Peconic estuary	Native bay scallop commercially extinct in Peconic system; eelgrass beds damaged	"Emergency Conference" convened by SUNY Stony Brook and URI; <i>A. anophagefferens</i> in culture w/bacteria	Climate, nutrients (organic P, Se), interference with grazing, hydrography	New York State and Port Authority support Conference; research based on funding for general ecological studies	Emergency Conference, yielding first Research and Monitoring Plan (attached)
1987	Bloom intensity moderate	Bay scallop re-seeding started	Cosper et al. Descriptive article	As above	Some from various sources to SUNY; "Green Seal" group funds re-seeding	False security; problem going away?
1988	Bloom very light and confined to Long Island bays; survey published later shows presence of <i>A. anophagefferens</i> from central NJ to ME	Scallop re-seeding continued	Species description published by Sieburth et Hargraves; "Novel Phytoplankton Blooms" meeting (publ. 1989); immunoassay! Nelson & Siddall show toxic effects on larval scallops in lab; Tracey et al show effects on mussels	1-Food value NOT reason for trophic effects 2-Benthic spore? 3-"Open niche" of Smayda; not predictable 4-Mixotrophy 5-Grazer "trophic cascade" 6-Pesticides killed grazers 7-No allelopathy 8-Poor clearance by bivalves 9-Toxic ectocrine? 10-Hydrographic residence time 11-Slobodkin "paradox null condition"	\$820K earmarked from Suffolk County, NY State, US EPA, and NOAA Sea Grant	BTCAMP instituted by Suffolk County (NY) Health Dept.; objectives to research brown tide AND conventional water quality problems
1989	Bloom essentially gone	Scallop opulations rebuild	Publication of "Novel Phytoplankton Blooms" volume	As above		
1990	Bloom essentially gone	Scallop recruitment	None			

Year	Summary	Consequences	Research Reported	Hypotheses	Funding	Management Response
1991	Short, intense bloom in Peconic Bay	Poor scallop recruitment	Gainey and Shumway show dopamine-mimetic effects on bivalve gill cilia			
1992	Small blooms confined to south-shore LI bays	Scallop recruitment good		Micronutrients, esp. Fe and Se implicated by lab studies		BTCAMP Summary document issued; conclusion that N&P eutrophication not responsible
1993	Bloom essentially gone	Scallop harvest rebounds	Anderson et al. survey of NE coast; "National Plan" mentions brown tide	Conditions specific to Peconic system more conducive to blooms		
1994	Bloom essentially gone	Scallop harvest returns to pre-bloom level	Milligan & Cosper describe virus that lyses brown tide	Bloom collapse is caused by viral infection	NOAA funds ECOHAB meetings	ECOHAB Workshop and 1st draft
1995	Moderate, but widespread blooms	Scallop population set-back	Proceedings of the Brown Tide Summit	"holistic" hypothesis of Cosper: dry winter, then spring rain adds pulse of nutrients; bloom perpetuated by low flushing rates, micronutrient requirements, mixotrophic growth, and photoadaptive characteristics; trophic cascade developed by Lonsdale	NOAA funds Brown Tide Summit; pledges \$3 million over two years for grant program BTRI	ECOHAB document issued, brown tide section lists research priorities; Brown Tide Summit convened; BTRI Steering Committee instituted
1996	Moderate, widespread blooms on Long Island; intense in parts of Barnegat Bay	Scallop populations greatly reduced; clam hatcherys have poor growth	Gobler & Cosper Fe stimulation evidence	Nutrient, hydrographic, physiological, and trophic projects funded by BTRI, i.e., no hypothesis rejected	BTRI RFP	Funding allocated according to Summit and Steering Committee recommendations
1997	Bloom essentially gone from Long Island, return to Barnegat Bay	Clam hatchery problems again	Milligan & Cosper show A. anophagefferens grows better in fluctuating light	Brookhaven hypothesis -- organic N necessary for bloom	ECOHAB RFP	BTRI holds public forum; BTRI projects fully funded, but bloom does not appear!



Among the important lessons to be learned from this history are:

- 1) A sustained funding/research effort is difficult to manage for a sporadic HAB event
- 2) An inclusive, consensus-building strategic-planning process for a HAB is more successful when generating a full list of hypotheses than when attempting to prioritize research needs
- 3) A combination of autecological and systems-ecological information is necessary for generation of a holistic "bloom scenario"
- 4) Research implementation plans for sporadic HAB's should include contingency plans for preserving resources in non-bloom years
- 5) Mitigation strategies (in this case, re-planting of scallops) are likely to fail without knowledge-based risk analysis

Most noteworthy is the slow pace of progress in understanding the brown tide phenomenon, despite early attempts to organise research effort by both government agencies and university departments. Also important is the observation that stake-holders (scallop fishermen) providing political pressure was more effective in generating dedicated research funds than were research scientists submitting brown-tide proposals through standard RFP channels; this suggests that interaction between stake-holders and research scientists could facilitate progress on understanding HAB's.

#### **OCEANOGRAPHIC CONTROL OF BLOOMS OF *GYRODINIUM AUREOLUM* AND *DINOPHYSIS* SPP. IN THE COASTAL WATERS OF SW IRELAND.**

Terry McMahon, Marine Institute, Fisheries Research Centre, Abbotstown, Dublin 15, Ireland.

Physical, chemical and biological measurements were made in the shelf waters off southwestern Ireland between 1992 and 1995. A haline front, separating coastal and oceanic waters, was recorded in the area. The front had a horizontal scale of movement of approximately 30 km, which was comparable to its distance from the coastline. Current measurements showed a residual northwestward flow of 8 cm/s inshore of the front and a southwestward flow of 3.5 cm/s offshore of the front. During periods of extended winds from the southwest quadrant the front approached close to the shore and the flow of the coastal current was restricted. Winds blowing from the east resulted in the movement of the front further offshore allowing a strong (20 cm/s) clockwise coastal flow to develop.

Under prevailing southwesterly winds, the water in the northwestern Celtic Sea tended to become isolated and as a result the dissolved oxygen concentration in the subthermocline waters were reduced to approximately 65 % saturation. In this area of weak circulation, large populations of dinoflagellates, associated with the pycnocline, were recorded during late summer. Very large populations of *Gyrodinium aureolum* ( up to  $4 \times 10^6$  cells/litre) and *Dinophysis* spp. (up to  $125 \times 10^3$  cells/litre) were recorded. These communities were advected towards and into the bays of southwest Ireland when the coastal current inshore of the front operated as a result of changes in wind direction from prevailing southwesterlies to easterlies. The advected populations *Gyrodinium aureolum* resulted in discoloured waters or "red tides" while the advected populations of *Dinophysis* spp. resulted in the accumulation of DSP toxins (Okadaic acid and DTX-2) in farmed mussels.

#### **OCEANOGRAPHIC CONTROL OF *DINOPHYSIS* IN SOUTHERN BRITTANY WATERS (FRANCE)**

Patrick Gentien

*Dinophysis* is recurrent in summer along this 300 km long coast line. Very little was known about its distribution. Three important features of its distribution have been presented.

- 1) *Dinophysis* can be found alive and swimming actively at 80-100 m depth (0 % incident light) in a very localised area. Water movements simulated with a 3-D hydrodynamical model and under the real meteorological conditions demonstrated a drift of this water mass to the coast.
- 2) At least, at the initiation of the toxic event, *Dinophysis* was present at 20 m depth at the southern edge of the Loire river, in a layer of ca. 50 cm. The population was confined in a lens of water less than 10 nautical miles in diameter

for about a fortnight. Simulations under real meteorological conditions demonstrated the presence of a small scale eddy lasting at that same position during the same time scale.

- 3) Dissolved organic matter in the layer containing *Dinophysis* was more concentrated and presented characteristics of organic matter produced by decomposing phytoplankton.

It would therefore, seem that live *Dinophysis* being present in the dark, this species do not necessarily rely on inorganic nutrient assimilation and light. Temporary small-scale eddies are essential to the build-up of the population in that dispersion of cells is probably limited in such a structure. This population then may be distributed to the shore line. It is interesting to compare these elements to the scenario leading to the establishment of *Solea solea* in the coastal nurseries. This report shows clearly the need for species-specific models.

## A NEW POLYETHER TOXIN FROM *FIBROCAPSA JAPONICA*

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Communication to the ICES WGHABD in Lisbon 24-27 March 1998 by F. Colijn, Germany

*Fibrocapsa japonica* produces ichthyotoxins that have been identified as brevetoxins. These toxins activate sodium channels. They have a low toxicity which is in the range of a few µg/mouse.

Recently the alga has invaded the North Sea. A toxin secreted by this organism killed fishes in a breeding tank. Since the toxin could also be harmful to North Sea fishes and mammals, we isolated the alga and cultured it. The toxin produced under in vitro conditions was purified by HPLC and crystallised. The toxicity of the product (20 ng/mouse) was much higher than that of brevetoxin. The toxin was named "fibrocapsin".

Fibrocapsin was characterised by IR- and mass-spectrometry. The IR-spectrum of fibrocapsin shows very strong vibration bands at wavelengths of 3548 and 3404 cm<sup>-1</sup> that originate from hydroxy groups or, respectively, from its hydrogen bond. At wavelengths of 1685 and 1620 cm<sup>-1</sup> signals appear that are indicative of a lactone ring and a,b-unsaturated groups. The bands of a symmetrical ether are visible at wavelengths of 1140 and 1114 cm<sup>-1</sup>, and its in-plane vibrations are present at 669 and 602 cm<sup>-1</sup> reflecting the presence of an aromatic ether. The mass-spectrum shows two peaks, one at 782 u and one at 803 u, indicating that two isoforms, fibrocapsin A and B, exist. Fibrocapsin and brevetoxin possess the same polycyclic basic pattern. However, the IR-spectrum of the latter indicates that the hydroxy groups have been exchanged for methyl groups. Moreover, the aromatic ether seen in the IR- spectrum is absent in brevetoxin. Thus, fibrocapsin is more lipophilic than brevetoxin. Although the molecular structure closely resembles that of brevetoxin, fibrocapsin toxicity is 100-500fold higher. Assuming that both toxins affect sodium channels the increased toxicity may have originated from the lipophilic character of fibrocapsin. Preliminary experiments on isolated nerves have shown that the toxin blocks neural conductivity at concentrations as low as 0,01 ng/ml, which is in the range in which tetrodotoxin blocks sodium channels. Mice after subcutaneous injections of the toxin develop tonic-clonic seizures, indicating that the toxin is capable of passing through the blood-brain barrier.

The alga is not endemic in European waters. Its highly potent toxin could therefore pose a threat to the previously unexposed North Sea fauna and also to humans.

## FIBROCAPSIN FOUND FOR THE FIRST TIME IN SEALS FROM GERMANY

Information from the Research- and Technology Centre Westcoast (FTZ), Busum, Germany, based on observations by Marion Rademaker (TRIPOS), Urban Tillmann (FTZ), Marcus Reckermann (FTZ) and Ursula Siebert (FTZ)

*Fibrocapsa japonica* (Chrysophyte, Raphidophyceae) was observed in low densities in part of the German Wadden Sea (Schleswig-Holstein) adjacent to a seal rehabilitation centre 10 km away from our institute. At the same period two adult and three newborn seals (all kept in captivity) died in the rehabilitation centre of gastroenteritis or bronchopneumonia. Detailed further investigations revealed only bacteria typical for secondary infections, but no signs for other etiology could be detected.

In the rehabilitation centre water samples were collected positively showing the presence of *Fibrocapsa* cells. Further studies were performed including analysis of toxicity levels in serum and organs obtained from the died seals. Also analyses were conducted on the presence of toxins in cultures of *Fibrocapsa*. All studies showed the presence of toxins provisionally called Fibrocapsin in the algal cultures as well as in the blood and organ samples from the seals. Whether Fibrocapsin played a causative role in the death cases of the five animals in the rehabilitation centre remains unclear. Further studies are needed to solve whether toxin intoxication can occur through the food (chain) or through direct skin contact (aerosols?) with Fibrocapsin-contaminated water.

A more detailed analysis of the *Fibrocapsa* distribution has been performed (Note to Harmful Algal News) showing maximal densities of up to hundreds of cells/l in the study period (summer 1997).

In 1998 we plan to study the temporal and spatial occurrence and distribution of *Fibrocapsa* in more detail. The species can easily be identified by flow-cytometry; both identification can take place through current dot-plot analysis as well as through sorting and a subsequent check by light microscopy, which has been performed. Cultures to study toxin production are available. Attempts are made to upscale the production of toxins for further tests and analysis in cooperation with the Institute of Toxicology, Medical School of Hannover (see above).

## **6 PROPOSED TERMS OF REFERENCE FOR THE 1999 WGHABD**

The WGHABD should meet in Iena (Dr. Berndt Lucas; Germany) from the 16th to 20th March 1999 to:

- 1) collate and assess national reports, update the mapping of HABs and evaluate the development of the harmful algae event database (HAEDAT)
- 2) prepare a review document on the population scenarios for the different harmful algae species;
- 3) examine the population dynamics and assess the role of harmful benthic microalgae in benthic and pelagic food web
- 4) identify and summarize existing knowledge on sources of founding populations for HABs such as over-wintering of vegetative cells, cyst germination, hydrographic transfer, transfer through biological or human activities
- 5) examine with the help of invited experts and if possible some members of the WGSSO, the recent developments and the inherent assumptions in physical coastal modelling.
- 6) report and discuss on new findings.

### **Justification for ToR §1**

Besides their collation, the assessment of national reports should take into account the possible use of data (numbers) from algal monitoring for management purposes from different countries.

The table produced in the IOC report on monitoring should be updated because much experiences have been gained the last few years. The review could reveal if the action limits in different member countries are scientific sound in the light of to days knowledge of toxicity and growth dynamics of toxic algae, and it could be a good way of demonstrating for the outside society how data from algal monitoring may be used for practical management of seafood toxicity due to algae.

### **Justification for ToR §2.**

The objective is to produce descriptions of the population life histories for each specific region and species of interest in their oceanographic context. This information will be used as the basis of communication between physical oceanographers and the physiological ecologists for modelling work. While physicists are trained to simplify problems by neglecting details in order to make models that explain the features of the system, biologists must examine and identify the details that separate species. A joint description of the basic systems will form a common base for discussion and modelling.

These case descriptions will include details of algal life histories, physical processes, and interactions with other organisms. These scenarios should identify the salient features of the population history to enable modelling of bloom

initiation, the effects of growth, grazing, behaviour, advection as well as environmental fluctuations on seasonal cycles as well as random events. To be compiled by P. Gentien and T. Osborn during the intersessional period from contributions of identified experts.

#### **Justification for ToR § 3.**

Benthic harmful microalgae are an important source of phycotoxins transferred through benthic and pelagic food webs. The WGHABD has not previously addressed this problem, since studies on HAB dynamics usually focus on events and processes in the pelagic domain, where stratification can contribute to bloom aggregation. Biomass and growth rate estimates for toxigenic benthic species (e.g. *Prorocentrum* spp., responsible for some D.S.P. outbreaks) are often considered difficult to ascertain because growth is spatially heterogeneous (in « patches »). Nevertheless, the fact that these populations are relatively stationary may yield advantages to studying growth rates, nutrient dynamics, susceptibility to grazing, allelopathic interactions and microscale processes. Thus, whilst benthic harmful microalgae warrant special attention, the results may prove highly relevant for interpreting similar mechanisms for pelagic blooms.

#### **Justification for ToR §4.**

The first imperative for development of any population is the presence of "founding" individuals. For HAB's, the most common sources of founders appears to be:

- 1) over-wintering of vegetative cells
- 2) cyst germination, or transfer of pelagic stages to the pelagic environment
- 3) hydrographic transfer of water containing pelagic populations through such processes as on-shore currents
- 4) transfer of founder cells through biological or human activities, e.g. transfer of shellfish stocks

This ToR will summarize available knowledge and may lead to recommendations concerning human activities. Dr. Gary Wickfors has accepted to coordinate the intersessional work on this subject with a number of identified contributors.

#### **Justification for ToR §5.**

Recent developments and the status of physical models for coastal circulation will be reviewed to understand the inherent accuracy, resolution, assumptions and parameterizations, etc. This understanding and interaction is necessary to appropriately incorporate the details of the population dynamics (bloom initiation, growth, and mortality...) to provide meaningful calculations of the population development.

#### **Justification for ToR §6.**

The working group annual meeting is seen by the members as a unique opportunity to exchange ideas and discuss their new results. It was, of course, done previously but given the willingness of members to share their new findings and the time required in this rapidly evolving topic, it was felt necessary to formalise this as a term of reference.

### **7. RECOMMENDATIONS**

The WGHABD recommends that:

- a) given the need for further coordination in research on this topic and the recent international developments, the group be continued under the new Oceanography Committee.
- b) during the 1999 ASC, a theme session be held on management and mitigation for harmful algae is proposed for the 1999 annual science conference. It should be co-chaired by Hans Dahlin, Lars Edler and Henrik Enevoldsen (IOC).
- c) concerning ICES-IOC HAEDAT:
  - the *ad hoc* working group work inter-sessionally as specified in the tentative time table of developing steps. This group will prepare a report on the HAEDAT for presentation at the next meeting of the WGHABD in 1999.
  - the use of the HAEDAT should be encouraged.

**Justification for the recommendation for an ICES ASC Theme Session on the Management and Mitigation of Harmful Algae:**

The WGHABD has since its start in 1991 addressed several aspects of management and mitigation of harmful algae. At this years meeting the general discussion on the issue illustrated the diversity of topics and scientific and technical disciplines involved. The WGHABD wishes the management and mitigation issue to be addressed more thoroughly and to highlight the development and improvement of management and mitigation strategies. With the anticipated rapid growth of this subject it is beyond the scope of the WG to address the issue adequately and still deal with the fundamental work necessary on HAB population dynamics.

To attract the required expertise, and for ICES to focus on the management and mitigation issue, it is proposed to include a Theme Session on management and mitigation of harmful algae at the 1999 ICES Annual Science Conference in Stockholm.

## ANNEX I

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**ANNEX II**  
**NATIONAL REPORTS**

## CANADA

### HARMFUL ALGAL EVENTS IN CANADA - 1996

#### BAY OF FUNDY

##### Domoic Acid

1. **Location:** Bay of Fundy
2. **Date of Occurrence:** June, Late August - mid September, 1997.
3. **Effects:** Domoic acid was not detected in shellfish.
4. **Management Decision:** No shellfish areas were closed to harvesting.
5. **Causative Species:** *Pseudo-nitzschia pseudodelicatissima*. Cells were observed throughout the year with highest concentrations observed during June and August. Highest concentrations observed during 1996 were 151,776 cells/litre on August 20 at an offshore sampling location at the Wolves.
6. **Environment:** Temperature range: 8 - 12° C, Salinity - 32 ppt, Water Column - mixed inshore; stratified offshore
7. **Advected Population or in situ Growth:** In situ as well as advected.
8. **Previous occurrences:** Although *P. pseudodelicatissima* has been observed annually in the Bay of Fundy, the only years that shellfish harvesting areas were closed to harvesting were during 1988 and 1995.
9. **Additional Comments:**
10. **Individual to contact:**  
Jennifer Martin  
Department of Fisheries & Oceans  
Biological Station  
St. Andrews, New Brunswick  
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(506) 529-8854  
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jlmartin@sta.dfo.ca (e-mail)

## HARMFUL ALGAL EVENTS IN CANADA - 1997

### BAY OF FUNDY

#### Domoic Acid

1. **Location:** Bay of Fundy
2. **Date of Occurrence:** June, Late August - mid September, 1997.
3. **Effects:** Domoic acid was not detected in shellfish.
4. **Management Decision:** No shellfish areas were closed to harvesting.
5. **Causative Species:** *Pseudo-nitzschia pseudodelicatissima*. Cells were observed throughout the year with highest concentrations observed during June and August. Highest concentrations observed during 1997 were 1440 cells/litre on August 26 at an offshore sampling location at the Wolves.
6. **Environment:** Temperature range: 8 - 12<sup>0</sup> C, Salinity - 32 ppt, Water Column - mixed
7. **Advected Population or in situ Growth:** In situ as well as advected.
8. **Previous occurrences:** Although *P. pseudodelicatissima* has been observed annually in the Bay of Fundy, the only years that shellfish harvesting areas were closed to harvesting were during 1988 and 1995.
9. **Additional Comments:**
10. **Individual to contact:**  
Jennifer Martin  
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## HARMFUL ALGAL EVENTS IN CANADA - 1997

### BAY OF FUNDY

#### Domoic Acid

1. **Location:** Bay of Fundy
2. **Date of Occurrence:** June, Late August - mid September, 1997.
3. **Effects:** Domoic acid was not detected in shellfish.
4. **Management Decision:** No shellfish areas were closed to harvesting.
5. **Causative Species:** *Pseudo-nitzschia pseudodelicatissima*. Cells were observed throughout the year with highest concentrations observed during June and August. Highest concentrations observed during 1997 were 1440 cells/litre on August 26 at an offshore sampling location at the Wolves.
6. **Environment:** Temperature range: 8 - 12<sup>o</sup> C, Salinity - 32 ppt, Water Column - mixed
7. **Advected Population or in situ Growth:** In situ as well as advected.
8. **Previous occurrences:** Although *P. pseudodelicatissima* has been observed annually in the Bay of Fundy, the only years that shellfish harvesting areas were closed to harvesting were during 1988 and 1995.
9. **Additional Comments:**

**Individual to contact:**

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## HARMFUL ALGAL EVENTS IN CANADA - 1997

### BAY OF FUNDY

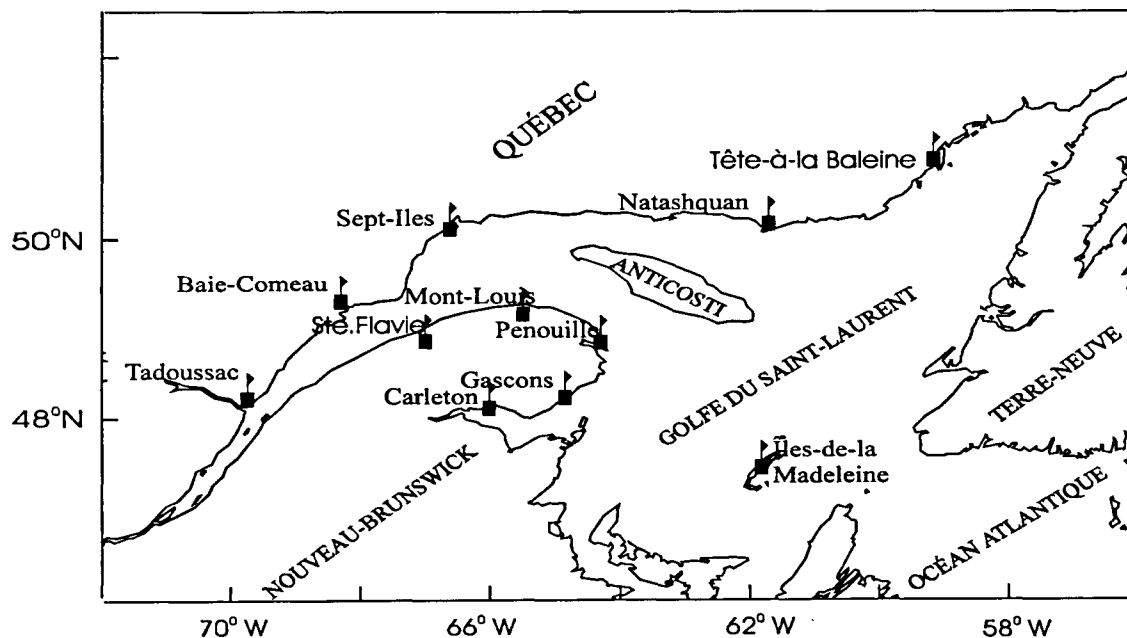
#### Paralytic Shellfish Poisoning

1. **Location:** Bay of Fundy
2. **Date of Occurrence:** A lower number than normal of shellfish harvesting areas were closed to harvesting for a short period of time between late May - mid August.
3. **Effects:** The highest levels of paralytic shellfish poisoning toxins were measured at Lepreau Basin on July 9, 1997 (920 µg/100g in *Mytilus edulis*).
4. **Management Decision:** Shellfish harvesting areas in the southwestern Bay of Fundy were closed to harvesting due to levels of psp toxins exceeding the regulatory limit of 80 µg/100g. The Bay of Fundy is closed year round to the harvesting of blue mussels.
5. **Causative Species:** *Alexandrium fundyense*. Cells were observed from mid May to late August with highest concentrations observed during 1997 (8,200 cells/litre) on June 24 at an inshore sampling location, Deadmans Harbour.
6. **Environment:** Temperature range: 8 - 12° C, Salinity - 32 ppt, Water Column - mixed inshore; stratified offshore. Summer weather conditions resulted in extended periods with little precipitation or wind.
7. **Advected Population or in situ Growth:** Advected.
8. **Previous occurrences:** Shellfish harvesting areas are closed to harvesting annually (generally during summer months) in the Bay of Fundy due to unsafe levels of psp toxins in shellfish tissues.
9. **Additional Comments:**
10. **Individual to contact:**  
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# HARMFUL ALGAL EVENTS IN CANADA - 1996-1997

## St. LAWRENCE

- Location:** Harmful algae are monitored on a weekly basis at 11 stations in the Gulf of St. Lawrence since 1989 (Figure 1).



- Date of Occurrence:** Eight potentially harmful species have been found at the eleven coastal stations. Location and date of maximum occurrence in 1996 and 1997 are presented in Table 1.

Species	Stations	Dates	Maximum abundances (cells l <sup>-1</sup> )
		1996	
<i>Alexandrium tamarense</i>	Ste. Flavie	17/08	142976
<i>Alexandrium ostenfeldii</i>	Sept-Iles	29/07	380
<i>Dinophysis acuminata</i>	Mont-Louis	13/08	2480
<i>Dinophysis norvegica</i>	Carleton	8/07	2480
<i>Prorocentrum lima</i>	Îles-de-la-Madeleine	9/09	120
<i>Prorocentrum minimum</i>	Sept-Iles	14/07	5440
<i>Pseudo-nitzschia delicatissima</i>	Baie-Comeau	14/09	917833
<i>Pseudo-nitzschia seriata</i>	Ste. Flavie	24/09	9200

Species	Stations	Dates	Maximum abundances (cells l <sup>-1</sup> )
		<b>1997</b>	
<i>Alexandrium tamarense</i>	Sept-Iles	19/07	8480
<i>Alexandrium ostenfeldii</i>	Penouille	2/07	180
<i>Dinophysis acuminata</i>	Gascons	22/06	1480
<i>Dinophysis norvegica</i>	Carleton	15/09	1560
<i>Prorocentrum lima</i>	Tête-à-la-Baleine	15/06	40
<i>Prorocentrum minimum</i>	Penouilles	22/07	2320
<i>Pseudo-nitzschia delicatissima</i>	Baie-Comeau	28/09	549330
<i>Pseudo-nitzschia seriata</i>	Sept-Iles	10/08	43780

- Effects:** Paralytic shellfish toxins concentration have exceeded 80 µg STX equi./100 g (as determined by the mouse bioassay technique) at several stations in 1996 (see below) and 1997. In 1996, three persons became seriously ill and were hospitalised after eating toxic clams during the red-tide event. In 1997, two persons became ill after eating toxic clams near Havre-St-Pierre, an area usually toxin-free.
- Management decision:** Shellfish areas with paralytic shellfish toxins concentration exceeding 80 µg STX equi./100 g (as determined by the mouse bioassay technique) were closed to harvesting during variable periods of time during summer months of 1996 and 1997. During the 1996 red-tide, concerns for the potential transfer of the toxins from the sand lance to commercial fish prompted the Department of Fisheries and Oceans to advise the population not to eat the livers of fish, e.g. cod, caught in this area of the St. Lawrence.
- Causative species:** *Alexandrium tamarense* and *Alexandrium ostenfeldii*.
- Environment:** The year 1996 was atypical. Between 19 and 21 July 1996, more than 225 mm of rain fell over the Saguenay River area in the Province of Québec. This unusual weather resulted in the flooding of several towns along the Saguenay River. In the St. Lawrence estuary, the heavy rain caused a drastic decrease in surface water salinity accompanied by a bloom of the toxic dinoflagellate *Alexandrium tamarense* on 29 July.
- Advection population or in situ growth:** in situ growth.
- Previous occurrences:** PSP toxicity has been measured by the mouse bioassay technique on a regular basis since 1961 in the St. Lawrence. Algae are monitored at the coastal stations only since 1989.
- Individuals to contact:**

Phytoplankton  
Maurice Levasseur/Esther Bonneau

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850 Route de la Mer, C.P. 1000  
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Shellfish toxicity  
Gilbert Sauvé

Agence Canadienne d'Inspection des Aliments  
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## SPAIN

### Harmful Algal Blooms in Galicia in 1997

1. Location: Rías of Vigo, Arousa, Pontevedra and Ares.
2. Date of occurrence: On May in Ría of Ares; On October in Rías of Vigo, Pontevedra and Arousa.
3. Effects: DSP mussel toxicity.
4. Management decision: Harvesting was closed in the culture areas affected.
5. Causative species: On May, in Ría of Ares: *Dinophysis acuminata* with a maximum cell concentration of 1280 cells/l. On October, in the Rías of Vigo, Pontevedra and Arousa: a mixture of *D. acuminata*, *D. acuta* and *D. caudata* with a maximum cell concentration of 1300 cells/l, 880 cells/l and 560 cells/l respectively.
6. Environment: variable conditions.
7. Advected population or *in situ* growth: The Ría of Ares population was *in situ* growth while the Ría of Vigo, Pontevedra and Arousa populations were probably advected.
8. Previous occurrences: The DSP episodes caused by *D. acuminata* are a recurrent phenomenon with more or less incidence depending on the year.
9. Additional comments:
10. Individual to contact:

Maneiro; Y. Pazos; A. Moroño  
Condicions Oceanográficas e Fitoplancton  
Centro para o Control da Calidade do Medio Mariño  
Peirao de Vilaxoán. D. P. 36600  
Vilagarcía de Arousa. Pontevedra. España  
Tél: 34 86 51 23 20  
34 86 51 23 22  
fax: 34 86 51 23 00

## SPAIN

### Harmful Algal Bloom in Galicia in 1997

1. Location: Rías of Vigo, Pontevedra, Muros and Ares.
2. Date of occurrence: On April in the Rías of Vigo, Pontevedra, Muros and Ares; On October in the Rías of Vigo and Pontevedra.
3. Effects: ASP bivalve (mussels and scallops) toxicity.
4. Management decision: Harvesting was closed in culture areas when domoic acid concentration was more than 20 ppm.
5. Causative species: *Pseudonitzschia spp* with a maximum cell concentration of 500,000 cells/l.
6. Environment: variable conditions.
7. Advected population or *in situ* growth: The population that appeared on April was *in situ* growth while the October population was probably advected.
8. Previous occurrences:
9. Additional comments: Since March 97 an autonomous legislation exists that regulates the levels of this phytotoxin in Galician shellfish.
10. Individual to contact:

Maneiro; Y. Pazos; A. Morono  
Condicions Oceanográficas e Fitoplancto  
Centro para o Control da Calidade do Medio Mariño  
Peirao de Vilaxoán. D. P. 36600  
Vilagarcía de Arousa. Pontevedra. España  
Tél: 34 86 51 23 20  
34 86 51 23 22  
Fax: 34 86 51 23 00

## SPAIN

### Harmful Algal Blooms in Andalucía in 1997

1. Location: Huelva coast (Gulf of Cadiz, Atlantic)
2. Date of occurrence: From March to July
3. Effects: Toxification of shellfish (detected by mouse bioassay for DSP)
4. Management decision: Closure shellfisheries. The water monitoring program was definitely increased (up to date) from monthly to weekly for the whole region.
5. Causative species: *Dinophysis acuminata* Claparede et Lachmann
6. Environment: During this period the dominant wind direction was SW-S
7. Advected population or in situ growth: Unknown. Probably the bloom formation started at rivers mouths areas: Guadiana River (western section of the Gulf), Odiel and Guadalquivir Rivers (eastern section of the Gulf).
8. Previous occurrences: Unknown
9. Additional comments: Maximum level detected of this species was 5.900 cells/Litre.
10. Individual to contact:

Luz Mamán  
D.A.P. – CICEM Aguas del Pino  
P.O. Box 104  
21071 Huelva  
Spain  
Phone: +34 59 504218 (from April 4<sup>th</sup> the areal code changes from 59 to 959)  
Fax: +34 59 504218 (as above)

## SPAIN

### Harmful Algal Blooms in Andalucía in 1997

1. Location: Western section of Guadalquivir River mouth (Gulf o Cadiz, Atlantic).
2. Date of occurrence: At the end of October.
3. Effects: Absence of toxicity in shellfish (by mouse bioassay for PSP)
4. Management decision: The water monitoring and PSP analysis programs were increased.
5. Causative species: *Gymnodinium catenatum* Graham
6. Environment: The bloom could be associated with a rain and south wind period.
7. Advected population or *in situ* growth: Probably *in situ* growth. The bloom was detected during a short period (few days) and it didn't progress toward other areas.
8. Previous occurrences: At the end of November of 1994 at the same area.
9. Additional comments: Maxim level detected of this species was 4.600 cells/Litre.
10. Individual to contact:

Luz Mamán  
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21071 Huelva  
Spain  
Phone: +34 59 504218 (from April 4<sup>th</sup> the areal code changes from 59 to 959)  
Fax: +34 59 504218 (as above)

## SPAIN

### Harmful Algal Blooms in Balearic Islands in 1997

1. Location: Palma Harbour (Mallorca Island)
2. Date of occurrence: March 1997
3. Effects: water coloration abnormally reddish brown
4. Management decision: the local government forbade the fishing in the harbour.
5. Causative species: *Alexandrium minutum* Halim
6. Environment
7. Advected population or *in situ* growth: *in situ* growth.
8. Previous occurrences: previous two years on April – May period.
9. Additional comments:
10. Individual to contact:

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07071 Palma  
Spain  
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Fax: 34 71 17 31 84

## SPAIN

### Harmful Algal Blooms in Balearic Islands in 1997

1. Location: Peguera Beach (South of Mallorca Island)
2. Date of occurrence: July 1997
3. Effects: water greenish brown coloration near the coast
4. Management decision: none
5. Causative species: *Alexandrium tailori* Balech
6. Environment
7. Advectioned population or *in situ* growth: *in situ* growth.
8. Previous occurrences: previous two years on the summer period, and probably since 1985
9. Additional comments:
10. Individual to contact:

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07071 Palma  
Spain  
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## SPAIN

### Harmful Algal Blooms in Catalonia in 1997

1. Location: Arenys de Mar Harbour (Catalonia)
2. Date of occurrence: March 1997
3. Effects: PSP toxicity in mussels
4. Management decision: Temporal and spacial monitoring inside and outside the harbour. Cells weren't detected outside.
5. Causative species: *Alexandrium minutum*
6. Environment: Salinity 29.9-33.8 psu, temperature 15-17 °C
7. Advected population or *in situ* growth: *In situ* growth
8. Previous occurrences: Arenys de Mar Harbour in May 1996; Vilanova Harbour in January-February 1996
9. Additional comments:
10. Individual to contact:

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Institut de Ciències del Mar  
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## SPAIN

### Hamful Algal Blooms in Catalonia in 1997

1. Location: Barcelona Harbour (Catalonia)
2. Date of occurrence: July-September 1997
3. Effects:
4. Mangement decision: Temporal and spacial monitoring inside and ouside the harbour. Cells weren't detected outside.
5. Causative species: *Alexandrium cf. catenella*
6. Environment: Salinity 37.1-37.5 psu, temperature 24-28 °C
7. Advected population or *in situ* growth: *In situ* growth
8. Previous occurrences: Barcelona Harbour in August-September 1996
9. Additional comments: An additional bloom was detected in September in Vilanova Harbour, but concentrations were less than  $2 \times 10^4$  cells/L.
10. Individual to contact:

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Institut de Ciències del Mar  
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08039 Barcelona  
e-mail: magda@icm.csic.es  
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## SPAIN

### Harmful Algal Blooms in Catalonia in 1997

1. Location: Garraf Harbour (Catalonia)
2. Date of occurrence: August-October 1997
3. Effects:
4. Mangement decision: Temporal and spacial monitoring inside and ouside the harbour. Cells weren't detected outside.
5. Causative species: *Ostreopsis* sp.
6. Environment: Salinity 37.5-37.8 psu, temperature 22-27 °C
7. Advected population *or in situ* growth: Resuspension from benthos
8. Previous occurrences:
9. Additional comments: An additional and puntual bloom was detected in October in Blanes Harbour.
10. Individual to contact:

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08039 Barcelona  
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## SPAIN

### Harmful Algal Blooms in Catalonia in 1997

1. Location: Alfacs bay (Ebro Delta, Catalonia)
2. Date of occurrence: winter season
3. Effects: mortality of wild fauna
4. Mangement decision: Monitoring the dinoflagellate concentration before pumping of water to ponds.
5. Causative species: *Gyrodinium corsicum* Paulmier
6. Environment: Salinity 35-37 psu, temperature 11-17 °C
7. Advected population or *in situ* growth: *In situ* growth
8. Previous occurrences: previous 3 years on the same dates
9. Additional comments: This species was associated to fish mortalities in culture ponds in 1994 on the same dates and also in the present month (march 1998). Mortalities of wild fish and mussels have been noticed this year.
10. Individual to contact:

Maximino Delgado  
Institut de Ciències del Mar  
Pg. Joan de Borbó, s/n  
Barcelona  
Tel.: 34 3 2216450/ 2216416

## **National Report: Germany, North Sea**

### **Harmful Algal Bloom Report**

1. **Locations:** off Büsum, Schleswig-Holstein
2. **Date of Occurrence:** 21.- 31 July 1997
3. **Effects:** none, but cultures have been shown to produce toxins
4. **Management Decisions:** none
5. **Causative Species:** Raphidiophyte *Fibrocapsa japonica*
6. **Environment:** coastal waters with high tidal current velocities
7. **Advected Population or In Situ Growth:** probably in situ growth
8. **Previous Occurrences:** first record in German waters 1992, since 1994 regularly with increasing cell numbers
9. **Additional Comments:**
- 10.
11. **Individual to Contact:**

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## **National Report: Germany, Baltic Sea**

### **Harmful Algal Bloom Report**

1. **Locations:** Eastern Gothland Basin, Baltic Sea; Bloom maximum at 56°N and 17°E
2. **Date of Occurrence:** 3. August 1997, maximum density noticed at 1 August
3. **Effects:** Enrichment of cyanobacteria aggregates at the surface; at higher wind velocities distributed into the water;  
High concentrations of Nodularin
4. **Management Decisions:** none
5. **Causative Species:** *Nodularia spumigena*; *Aphanizomenon* sp.
6. **Environment:** At maximum densities: wind  $< 1 \text{ m s}^{-1}$   
POC:  $758 \text{ mM dm}^{-3}$ ; PON:  $1.16 \text{ mM dm}^{-3}$ ; Chl.  $a$ :  $419 \text{ } \mu\text{g dm}^{-3}$
7. **Advected Population or In Situ Growth:** no information
8. **Previous Occurrences:** Similar blooms occur more or less each summer in the Baltic;  
In August 1997, cyanobacteria blooms were also reported from Arkona Sea and Mecklenburg Bay, Western Baltic Sea
9. **Additional Comments:**
10. **Individual to Contact:**

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Seestr. 15; D- 18119 Warnemünde, Germany  
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## **National Report: Germany, North Sea**

### **Harmful Algal Bloom Report**

- 1. Locations:** Coast of Lower Saxonia (Niedersachsen) between the island Spiekeroog and the Weser River
- 2. Date of Occurrence:** August to November 1997; maximum: September 2 1000 cells dm<sup>-3</sup>
- 3. Effects:** DSP in blue mussels
- 4. Management Decisions:** None, since no mussel fishery was applied
- 5. Causative Species:** Potential toxic Dinophysis (*D. acuminata*, *D. cf acuminata*, *D. norvegica*)
- 6. Environment:** Coastal waters
- 7. Advected Population or In Situ Growth:** advected population
- 8. Previous Occurrences:** In low numbers (< 1 000 cells dm<sup>-3</sup>) nearly every year  
Higher numbers (> 1000 cells dm<sup>-3</sup>) September 1994 with maximum 4 200 cells dm<sup>-3</sup>
- 9. Additional Comments:**
- 10. Individual to Contact:**

**Dr. Michael Hanslik,  
NLÖ-Forschungsstelle Küste; An der Mühle 5; D - 26548 Norderney,  
Germany  
Tel.: + 49 4932 916 162; FAX: + 49 4932 1394**

## **National Report: Germany, North Sea**

### **Harmful Algal Bloom Report**

- 1. Locations: off North Frisian Islands**
- 2. Date of Occurrence: 15 July to 06 August 1997**
- 3. Effects: none**
- 4. Management Decisions: none**
- 5. Causative Species: Diatom *Rhizosolenia imbricata***
- 6. Environment: coastal waters**
- 7. Advected Population or In Situ Growth: probably both, first advected than in situ growth**
- 8. Previous Occurrences: common in many years in high cell numbers in late summer**
- 9. Additional Comments: spiny *Rhizosolenia* species - blooms have been associated with avoidance by herring in the literature**
- 10. Individual to Contact:**

**Jeannette Göbel**  
**Landesamt für Natur und Umwelt; Hamburger Chaussee 25; D-24220**  
**Flintbeck FRG**  
**Tel.: + 49 4347 704 444; FAX: + 49 4347 704 402**  
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## **National Report: Germany, North Sea**

### **Harmful Algal Bloom Report**

1. **Locations:** North Frisian Coast, west off Eiderstedt
2. **Date of Occurrence:** 16. June 1997
3. **Effects:** brownish discoloration, foam formation
4. **Management Decisions:** none
5. **Causative Species:** Prymnesiophyceae: *Phaeocystis globosa*
6. **Environment:** Wadden Sea
7. **Advised Population or In Situ Growth:** probably both
8. **Previous Occurrences:** almost annually occurrence in early summer
9. **Additional Comments:**
10. **Individual to Contact:**

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## **National Report: Germany, North Sea**

### **Harmful Algal Bloom Report**

1. **Locations:** North Frisian coast off Sylt
2. **Date of Occurrence:** 18. July 25. August 1998
3. **Effects:** Brown water discoloration; Secchi depth: 0.5 m; strong smell;
4. **Management Decisions:** none
5. **Causative Species:** Diatom Fam. Cymatosiraceae: *Minutocellus pseudopolymorphus* Hasle, von Stosch & Syvertsen
6. **Environment:** surfzone, only about 20 m broad parallel to the sandy beach, about 15 km long
7. **up to  $2 \times 10^7$  cells  $\text{dm}^{-3}$ ; up to 20  $\mu\text{mg}$  Chl.  $\text{dm}^{-3}$ ;**
8. **Advected Population or In Situ Growth:** in situ growth
9. **Previous Occurrences:** first record of surfzone diatom blooms on German coasts
10. **Additional Comments:** chemical analysis by HPLC revealed no PSP, DSP or ASP toxins (Prof. Luckas, Jena)
11. **Individual to Contact:**

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Wattenmeerstation Sylt; Hafenstr. 43; D - List/Sylt; Germany  
Tel.: + 49 4651 956 135; FAX: + 49 4651 956 200



## **National Report: Germany, Baltic Sea**

### **Harmful Algal Bloom Report**

1. **Locations:** Flensburg Fjord
2. **Date of Occurrence:** End of June 1997
3. **Effects:** Water discoloration
4. **Management Decisions:** none
5. **Causative Species:** Dinoflagellate: *Heterocapsa triquetra*
6. **Environment:** eutrophic inner Fjord waters
7. **Advected Population or In Situ Growth:** in Situ growth
8. **Previous Occurrences:** almost annually phenomena during summer time
9. **Additional Comments:** has caused in earlier years fish mortality due to oxygen super saturation
10. **Individual to Contact:**

Jeannette Göbel  
Landesamt für Natur und Umwelt; Hamburger Chaussee 25; D-24220  
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## **National Report: Germany, Baltic Sea**

### **Harmful Algal Bloom Report**

- 1. Locations: Along the East Coast of Schleswig-Holstein**
- 2. Date of Occurrence: Beginning of August to beginning of September 1997**
- 3. Effects: water discoloration, about 20 µg Chl.  $a$  dm<sup>-3</sup>;**
- 4. Management Decisions: none**
- 5. Causative Species: Dinoflagellate: *Prorocentrum minimum* and diatom *Rhizosolenia fragilissima***
- 6. Environment: coastal waters**
- 7. Advected Population or In Situ Growth: In Situ Growth**
- 8. Previous Occurrences: nearly each year blooms of *Prorocentrum minimum***
- 9. Additional Comments:**
- 10. Individual to Contact:**

**Jeannette Göbel  
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## **National Report: Germany, Baltic Sea**

### **Harmful Algal Bloom Report**

1. **Locations:** Lübeck and Mecklenburger Bight
2. **Date of Occurrence:** 17. - 20. August 1997
3. **Effects:** Water discoloration; max. 30 µg Chl. a dm<sup>-3</sup>;
4. **Management Decisions:** Information of the public by the Ministry of Environment of Schleswig-Holstein
5. **Causative Species:** Cyanobacteria: Nodularia spumigena, Anabaena sp., Aphanizomenon sp.
6. **Environment:**
7. **Advected Population or In Situ Growth:** Advected from Danish waters
8. **Previous Occurrences:** yes
9. **Additional Comments:**
10. **Individual to Contact:**

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## ANNEX III

### ANALYSIS OF PREVIOUS NATIONAL REPORTS

Jorge Diogène, IOC-IEO Science and Communication Centre on Harmful Algae

#### Introduction:

At the previous meeting of the WGHABD in La Roche Canillac, France, 1997, the proposal for the development of a computer data-base on harmful algal occurrences worldwide was submitted (Annex V). It is stressed that the development of this project is open to everybody.

Herein are presented 1) the advancement of the project, 2) the needs for its continuation and 3) the future steps to take.

#### 1) Advancements of the project:

##### Report analysis:

A set of 169 national reports corresponding to 1994-96 has been analyzed in order to evaluate the type of information provided. Table 1 indicates the absolute and relative amount of reports that include information on a given subject. Major conclusions are as follows:

- Approximately 23 % of national reports consist of more than one event.
- Location of the event is often vague (43 %) and coordinates are rarely present (13 %)
- The date of occurrence or duration is often vague (67 %).
- The causative species is determined in 74 % of the reports and quantified in 51 %.
- There is very little information regarding pigments or cysts.
- Data regarding toxins include transvectors, toxin levels, harmful effects and management decisions.
- Data regarding weather, current or wind direction and velocity are very few.
- Except for water temperature (40 %) and salinity (37 %), there is very little information regarding oceanographic conditions.

TABLE 1

HAB NATIONAL REPORTS 94-96		
	n	%
NUMBER OF REPORTS	169	
DETAILED LOCATION	101	59,8
APPROXIMATIVE LOCATION	68	40,2
COORDINATES	22	13,0
DESCRIPTION OF LOCATION/BOTTOM	3	1,8
MAP	22	13,0
APPROXIMATIVE DATE (MONTH)	113	66,9
ACCURATE DATE (INITIAL/FINAL)	55	32,5
CAUSATIVE SPECIES	125	74,0
SUSPECTED SPECIES	11	6,5
CAUSATIVE GENUS	32	18,9
UNKNOWN SPECIES	3	1,8
CELL CONCENTRATION (Cells/L)	87	51,5
CELL ABUNDANCE (QUALITATIVE)	4	2,4
ADVECTED/IN SITU	52	30,8
PIGMENTS	5	3,0
CYSTS	2	1,2
VECTOR OF TOXINS	45	26,6
UNEXPLAINED TOXICITY	3	1,8
TOXIN LEVELS (QUANTITATIVE)	40	23,7
TOXIN LEVELS (QUALITATIVE)	24	14,2
EFFECTS (HUMAN / ECOSYSTEM)	65	38,5
MANAGEMENT DECISION	93	55,0
WEATHER (QUALITATIVE)	12	7,1
WIND DIRECTION	1	0,6
WIND VELOCITY	0	0,0
CURRENT DIRECTION	5	3,0
CURRENT VELOCITY	0	0,0
STRATIFICATION WATER COLUMN	13	7,7
LOCATION OF BLOOM IN THE WATER COLUMN	5	3,0
TURBIDITY/SECCHI DISK	5	3,0
TEMPERATURE WATER (DETAILED: MIN-MAX/AVG)	67	39,6
TEMPERATURE WATER (QUALITATIVE)	5	3,0
SALINITY (DETAILED: MIN-MAX/AVG)	62	36,7
SALINITY (QUALITATIVE)	4	2,4
OXYGEN CONTENT (DETAILED)	10	5,9
ANOXIA	3	1,8
pH	0	0,0

NUTRIENTS	3	1,8
METHODOLOGIES	1	0,6
REPORTS THAT INCLUDE SEVERAL EVENTS:	39	23,1
UNCOMPLETE REPORT	1	0,6

### Introduction of 1996 HAB National Reports in a computer Data-Base (Access):

National Reports on HAB corresponding to 1996 (n = 39) have been introduced in a data-base using the software Access. This data base allows organization of data in tables with flexible possibilities in relation to formularies for the input of data, search tools, reports and links with other softwares.

Examples of a formulary and a report are presented. The fields corresponding to the present National Report formulary have been included. In addition, we have introduced, as examples, new fields in order to facilitate further data analysis. Such a new version would/could:

Improve the organization of data.

Extend the outcome of these reports: data analysis, statistics, long-term studies,

Extend the spreading of information.

Stimulate «reporters» to input more information.

Allow introduction of weblinks in order to:

- link databases and particular data associated to the reported event (oceanographical data, toxicological data, bibliography, methodologies,...).
- facilitate communication through e-mail.
- link reports among them.

#### 2) Needs for its continuation

The present format of National Reports allows the search of events according to different criteria (country, year, causative species,...). However, there are several restrictions in order to treat data and to conduct searches in different fields. These impairments can be solved by an improvement of the National Report format: new organization of the data and a more precise compartmentation of the information. This would allow the development of the computer Data Base on HAB and facilitate its integration in the internet WWW.

Therefore, several issues should be discussed at the present meeting and resolutions taken:

- Is a new format for the National Report needed? If needed, this new format should be defined (Type of data, compartmentation, links,...).
- Should the introduction of HAB reports in the data base be possible all year around? By whom? The set-up of the «HABDAT» database would allow to accelerate and simplify the input of data.
- The expected outputs of the project could be defined in detail (Statistics, graphs, maps,...)
- Should this project be extended to non-ICES countries? In which way?
- Other...

#### 3) Future steps:

Once the previous needs are fulfilled:

- The information from previous HAB National Reports would be introduced into the «HABDAT» data base.
- The information of the data base will be introduced into WWW servers (ICES, IOC,...)

- Search tools and data analysis will be developed
- The project will be proposed to non-ICES countries.



## NATIONAL REPORTS

1994-96 (n = 169)

- LOCATION
- DATE
- MICROALGAE
- HARMFUL EFFECTS
- WEATHER/CURRENTS
- WATER CHARACTERISTICS
- ADDITIONAL DATA
- 

«HABDAT»

## DEVELOPMENT STEPS

- PROPOSAL TO THE WGHABD (La Roche Canillac, 1997)
- CONDUCT AN ANALYSIS OF REPORTS (1994-96)
- TRANSFER DATA FOR 1996 INTO A COMPUTER DATA-BASE (ACCESS)
- UPDATE TO THE WGHABD (Lisbon, 1998)
- 

AT THE WGHABD meeting (Lisbon, 1988):

- DETERMINE THE FUTURE FORMAT OF THE NATIONAL REPORT
  - DETERMINE THE FUTURE MECHANISM TO INPUT DATA (RAPID UPDATE)
- FUTURE STEPS
- INPUT PREVIOUS NATIONAL REPORTS
  - INTRODUCE THE DATA INTO WWW SERVERS (ICES, IOC,...)
  - DEVELOP SEARCH TOOLS AND DATA ANALYSIS
  - EXTEND THE PROJECT TO NON-ICES COUNTRIES
  - OTHER...

## CONCLUSIONS FROM THE ANALYSIS OF REPORTS - 1994-96 (n = 169)

The present format of National Reports allows search of events according to different criteria (country, year, causative species,...)

However, in order to develop a computer Data Base on HAB, there are several restrictions which are consequences of some of these conclusions:

The present format does not allow easy integration of data for further analysis.

Approximatively 23 % of national reports consist of more than one event.

Location of the event is often vague (43 %) and coordinates are rarely present (13 %)

The date of occurrence or duration is often vague (67 %).

The causative species is determined in 74 % of the reports and quantified in 51 %.

There is very little information regarding pigments or cysts.

Data regarding toxins include transvectors, toxin levels, harmful effects and management decisions.

Data regarding weather, current or wind direction and velocity are very few.

Except for water temperature (40 %) and salinity (37 %), there is very little information regarding oceanographic conditions.

## ANNEX IV

### NEW EVENT REPORT FORMAT

#### PREMISES:

- One report (One form) will be associated to ONE event.
- Every event will be associated to a PRECISE DAY and a PRECISE COORDINATE.
- It will be possible to include other types of information that are not specified herein as ADDITIONAL DATA.
- In addition to numerical data and text, those people reporting the event that use internet are invited to complement their report with attached files (Graphs, maps, pictures, tables,...) and weblinks.

EVENT NUMBER	ex: US-1996-003 (Country-year-number) Designated by the national focal point.
	Has this event occurred before in this area?
DURATION OF THE EVENT	
LOCATION	
COUNTRY	
REGION	
AREA CODE	Designated in a national basis.
COORDINATES	One point corresponding to the maximum cell concentration. If cell concentration is not available, use maximum toxicity or another one.
DETAILED LOCATION	Name of bay, city,...
APPROXIMATIVE EXTENT OF THE EVENT	km <sup>2</sup> ; mile <sup>2</sup>
GRAPHICAL SUPPORT	
DATE	
DATE	One point corresponding to the maximum cell concentration. If cell concentration is not available, use maximum toxicity or another one.
INITIAL DATE	First observation
FINAL DATE	
ADDITIONAL INFORMATION	
MICROALGAE	
CAUSATIVE SPECIES	
SPECIES/GENUS	
TAXONOMICAL CLASS	
CELL CONCENTRATION	Cells/L
COMMENTS	
ADDITIONAL SPECIES	

SPECIES/GENUS	
TAXONOMICAL CLASS	
CELL CONCENTRATION	Cells/L
COMMENTS	
<b>OTHER BIOLOGICAL INFORMATION</b>	
PIGMENTS	Type/Concentration
CYSTS	Presence/Quantification/Distribution

<b>HARMFUL EFFECTS</b>	
TOXICITY	YES/NO
HUMANS	
OTHER TERRESTRIAL	
BIRDS	
AQUATIC MAMMALS	
FISH	
SHELLFISH	
BENTHIC LIFE	
PLANCTONIC LIFE	
EXTENT OF EFFECT	Biological (Not economical)
SYNDROM	ASP, DSP, NSP, PSP,....
UNEXPLAINED TOXICITY?	
<b>ASSAY INFORMATION</b>	
SPECIES CONTAINING THE TOXIN	
TOXIN	
CONCENTRATION	
ASSAY TYPE	
TISSUE	

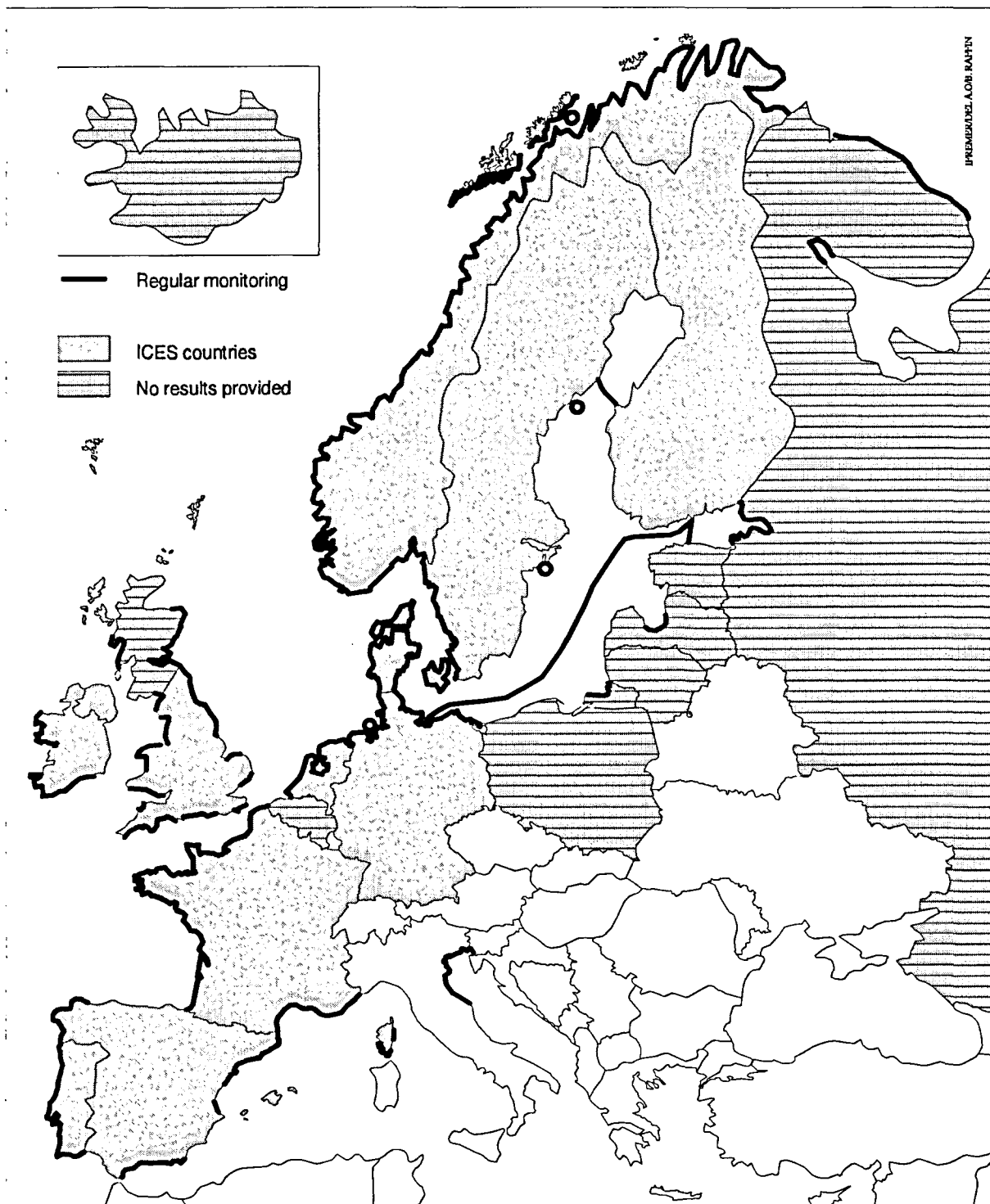
<b>ENVIRONMENTAL CONDITIONS</b>	
WEATHER	Particular weather conditions previous or during the event.
WIND DIRECTION	
WIND VELOCITY	
CURRENT DIRECTION	
CURRENT VELOCITY	
ADVECTED/IN SITU	
LOCATION OF THE BLOOM IN THE WATER COLUMN	
PARTICULAR OCEANOGRAPHIC CONDITIONS	
TEMPERATURE	Maximum/Minimum/Temperature
SALINITY	Maximum/Minimum/Salinity
OXYGEN CONCENTRATION	
pH	
NUTRIENTS	(Nutrient/Concentration)
TURBIDITY	Secchi disk-T.U.

<b>COMPLEMENTARY INFORMATION</b>	
MANAGEMENT DECISION	
PREVIOUS OCCURRENCES	
ECONOMIC LOSSES	
ADDITIONAL DATA	
BIOLOGICAL MATERIAL AVAILABLE	
EVENT ASSOCIATED BIBLIOGRAPHY	
INDIVIDUAL TO CONTACT	

**ANNEX V**

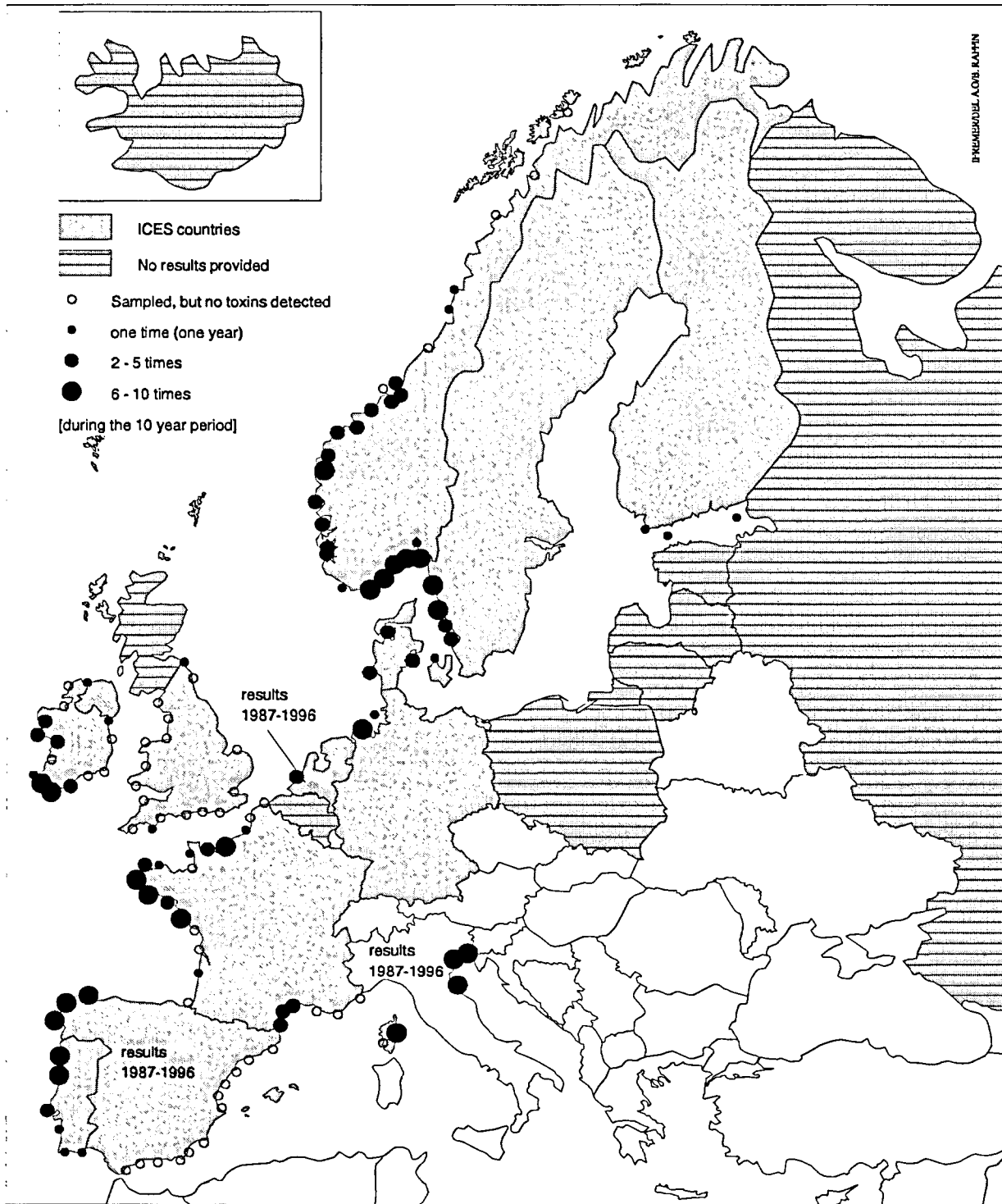
**DECADAL MAPS  
OF PHYTOPLANKTON TOXINS  
IN THE ICES AREA**

**Period  
1988-1997**



# Presence of DSP toxins

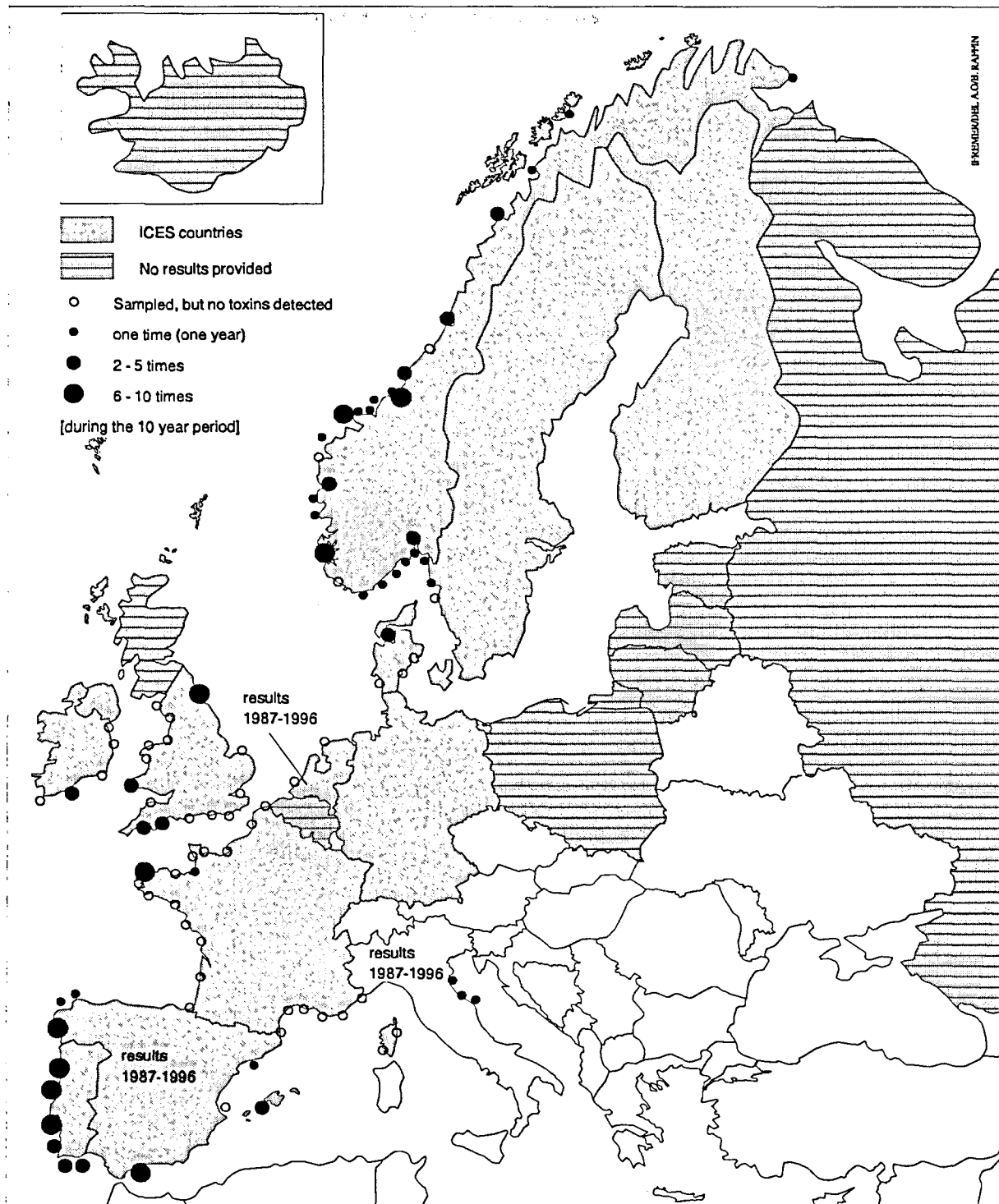
1988 - 1997





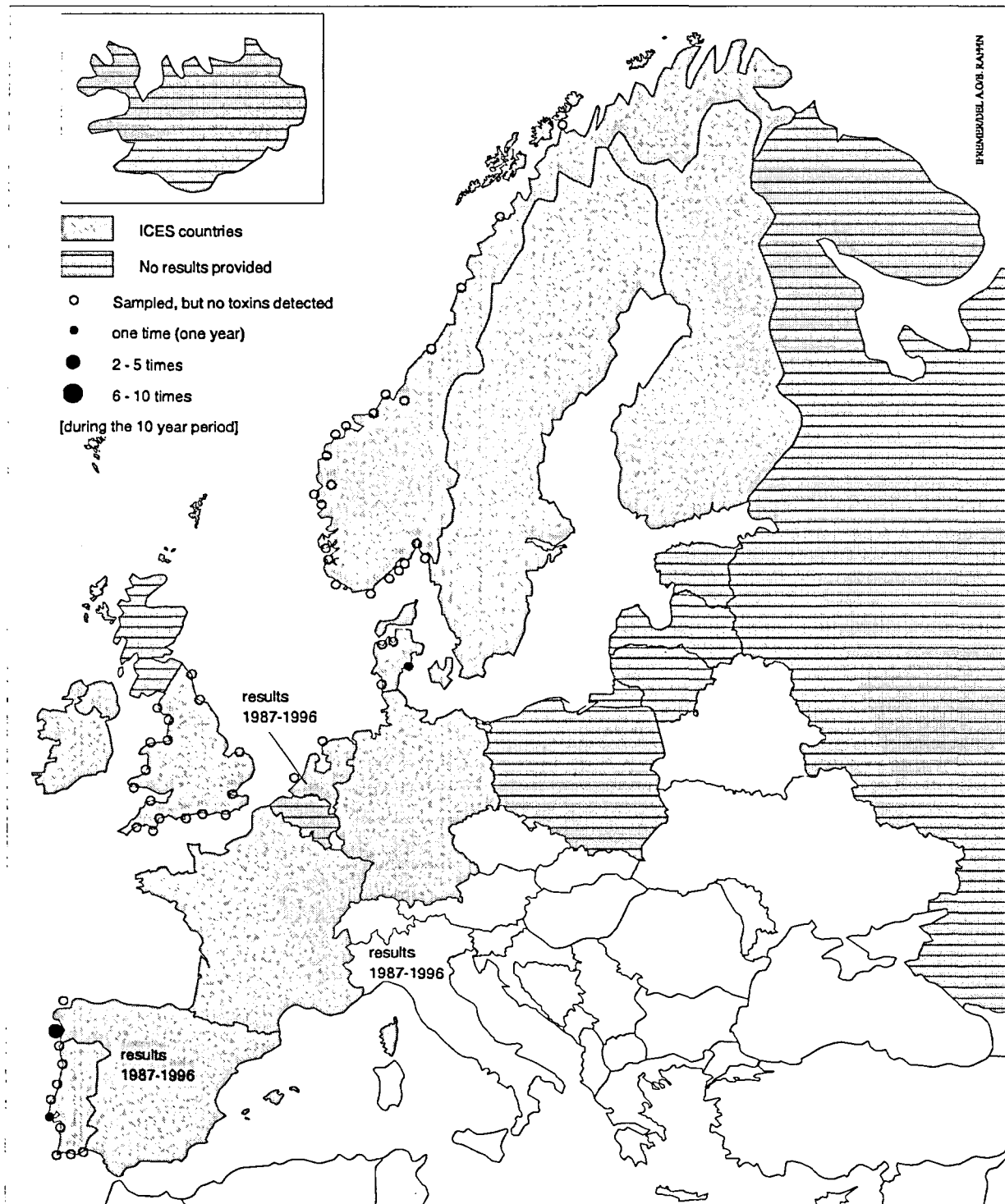
# Presence of PSP toxins

1988 - 1997



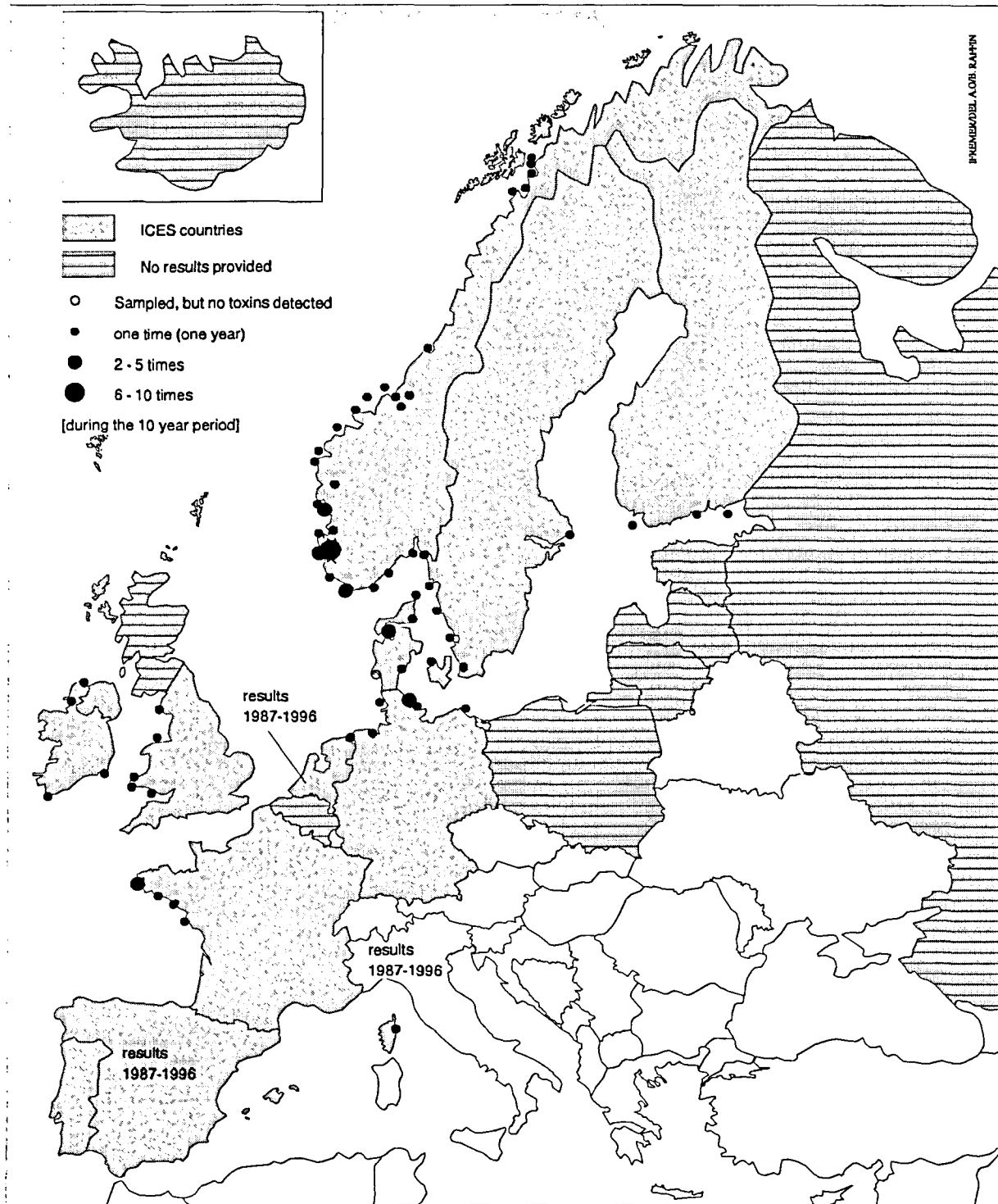
# Presence of ASP toxins

1988 - 1997

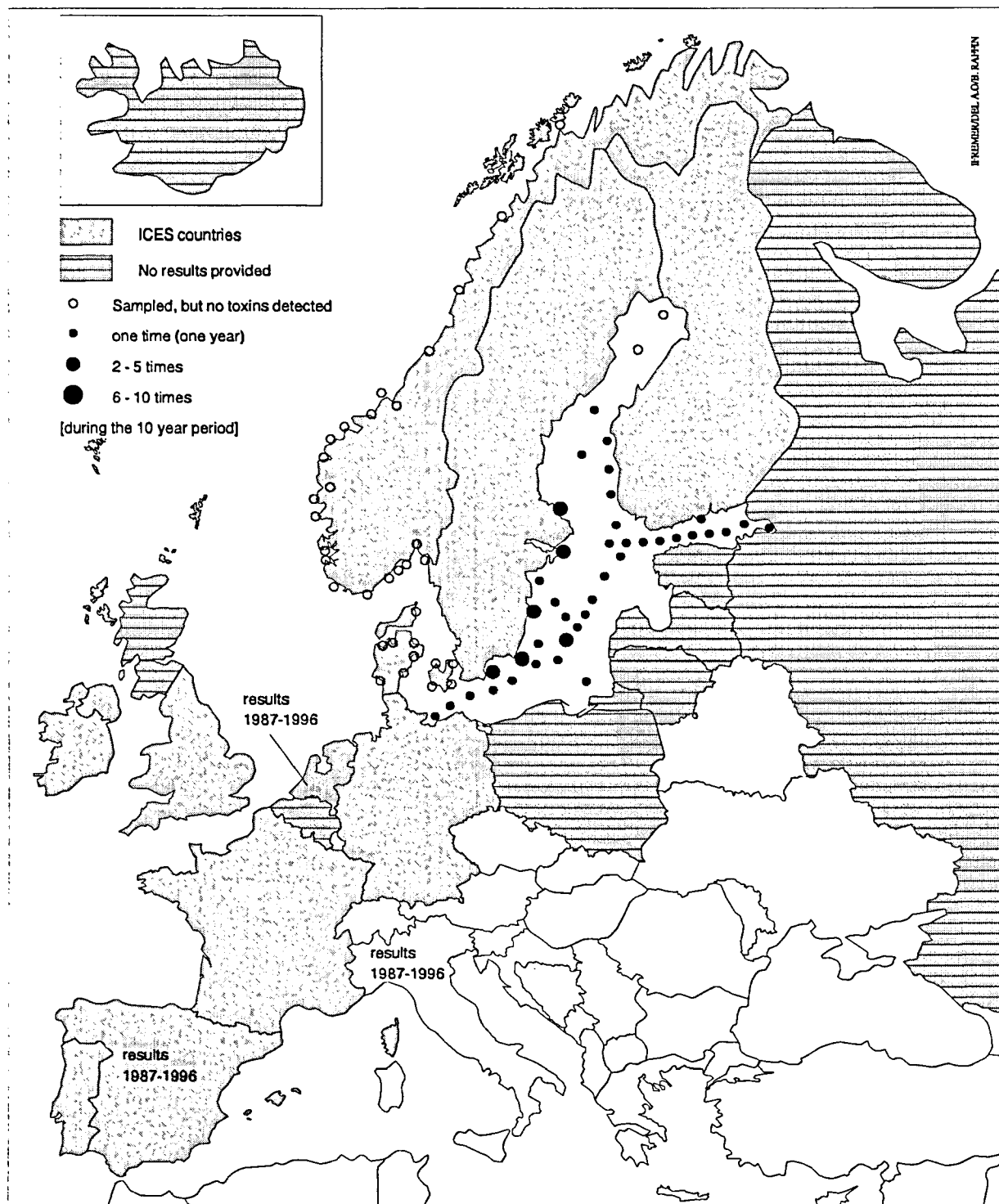


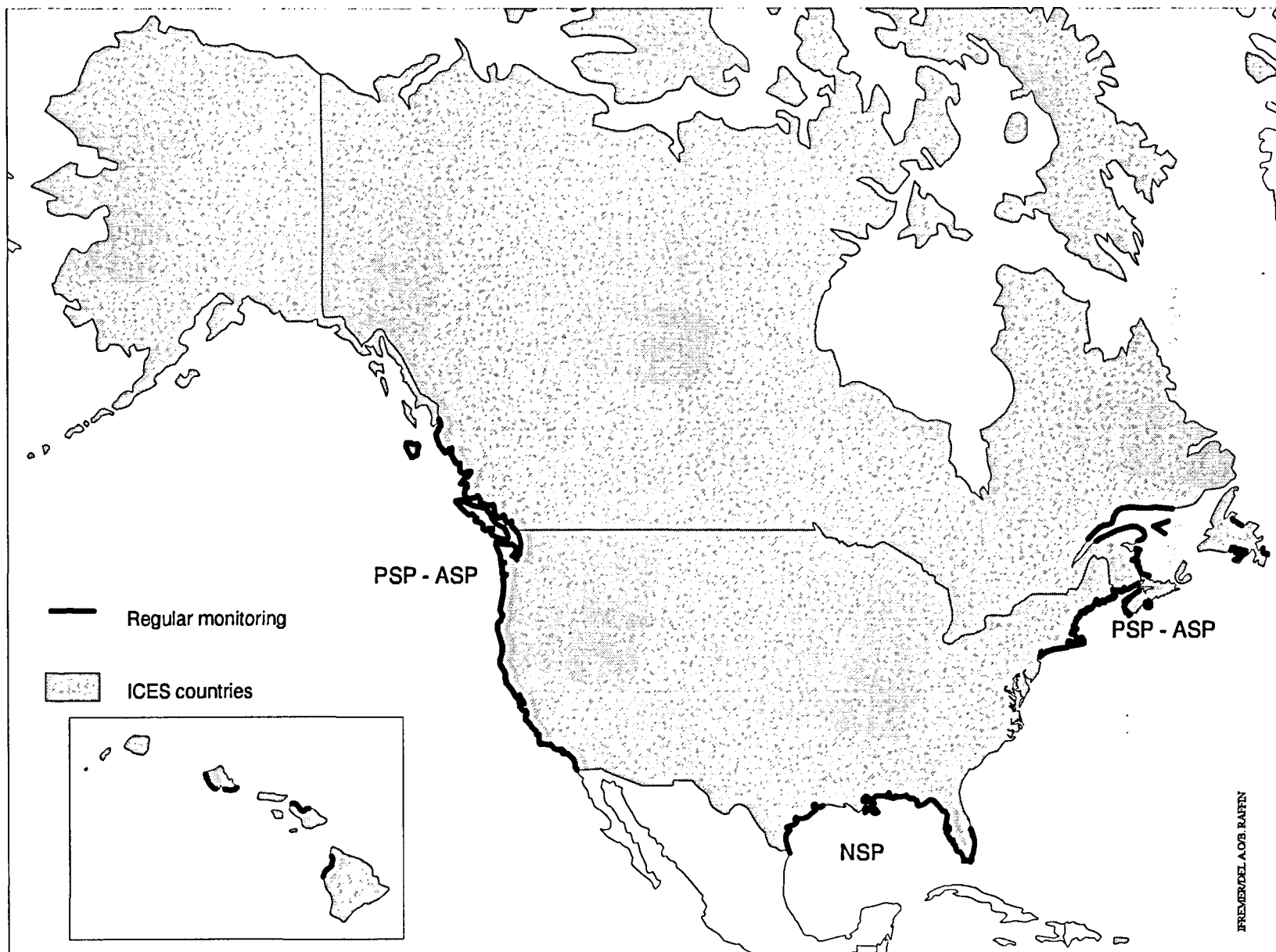
# Animal and plant mortalities

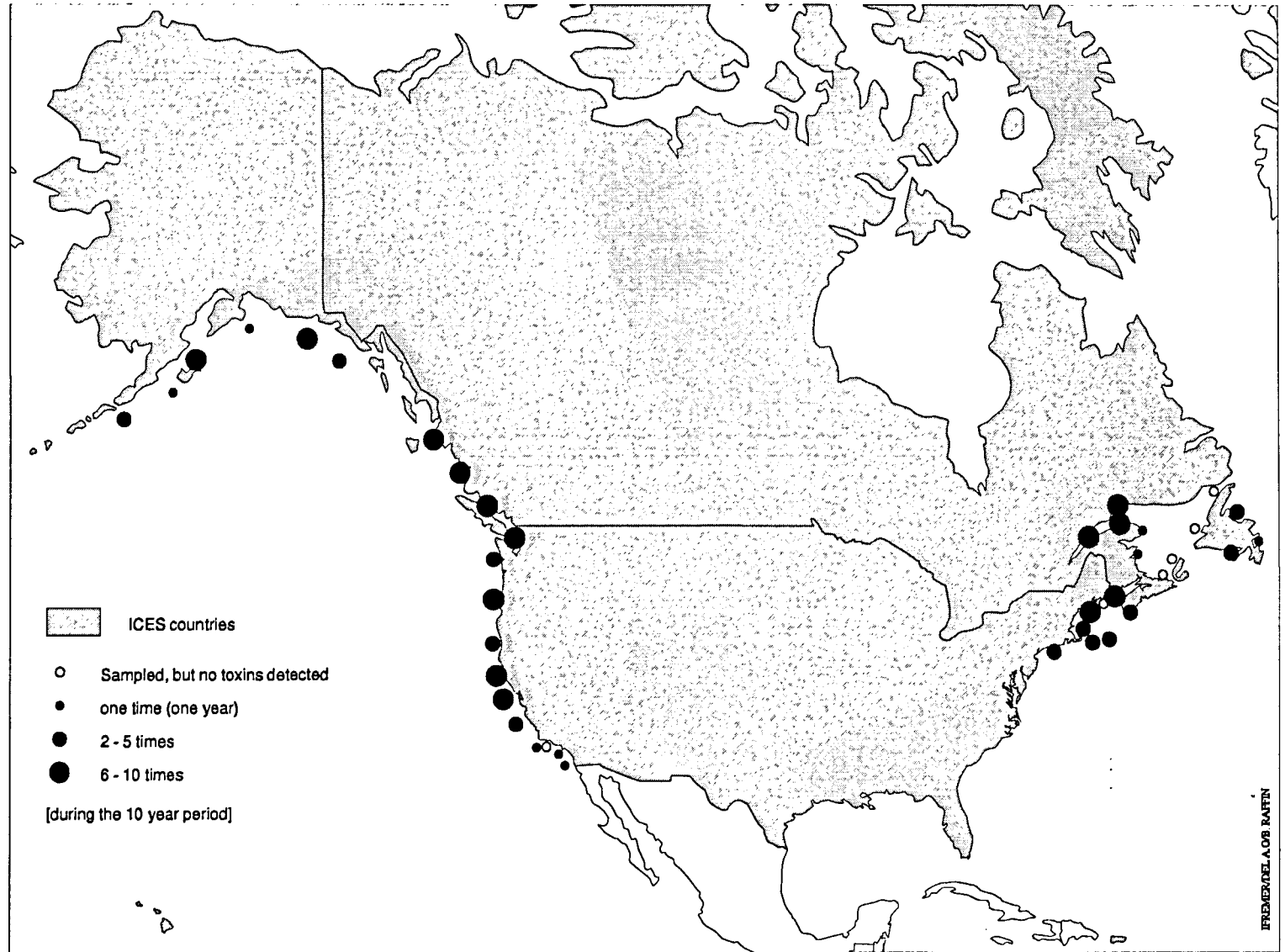
1988 - 1997



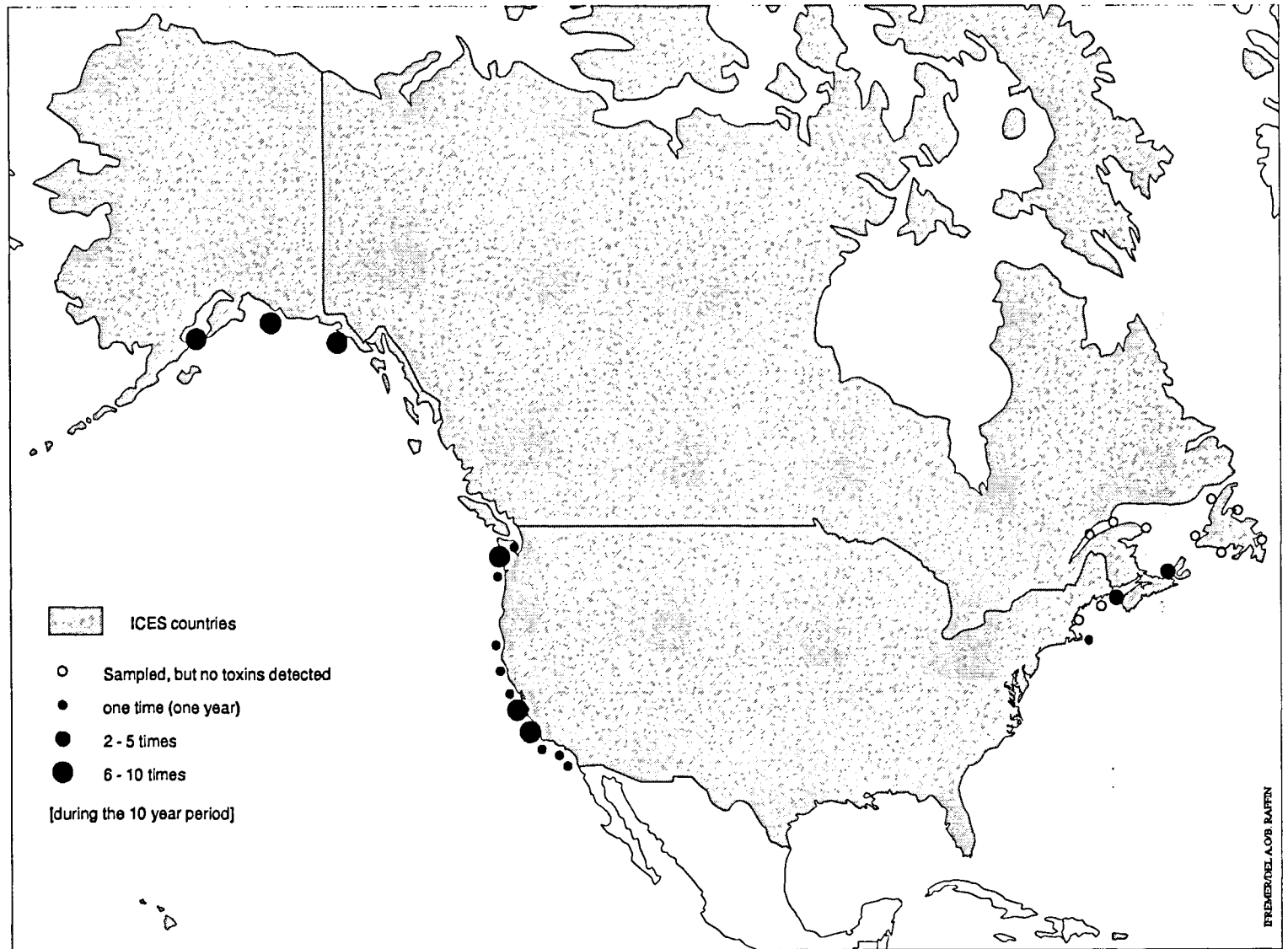
Other toxic effects  
cyanobacteria  
1988 - 1997



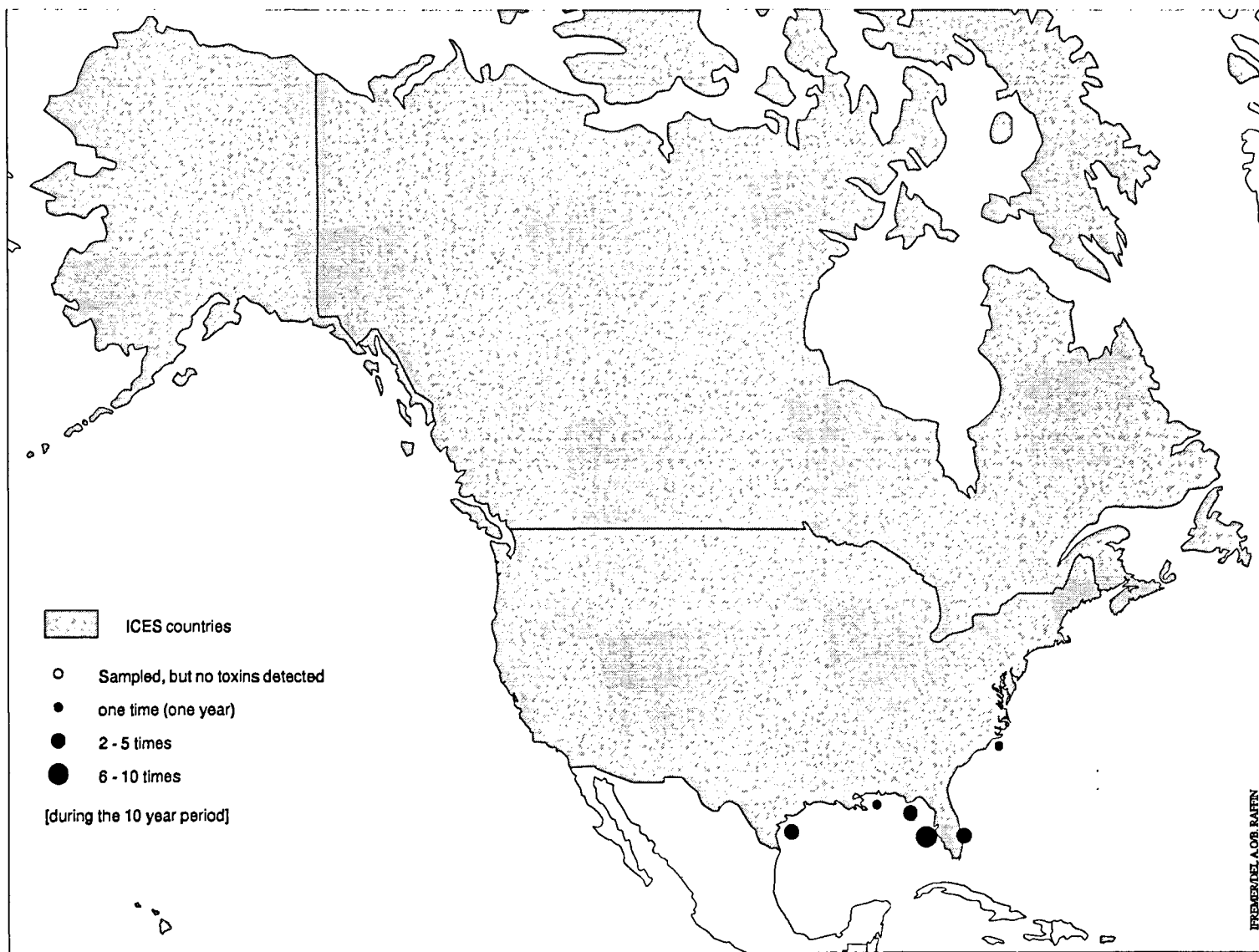




Presence of PSP toxins  
1988 - 1997

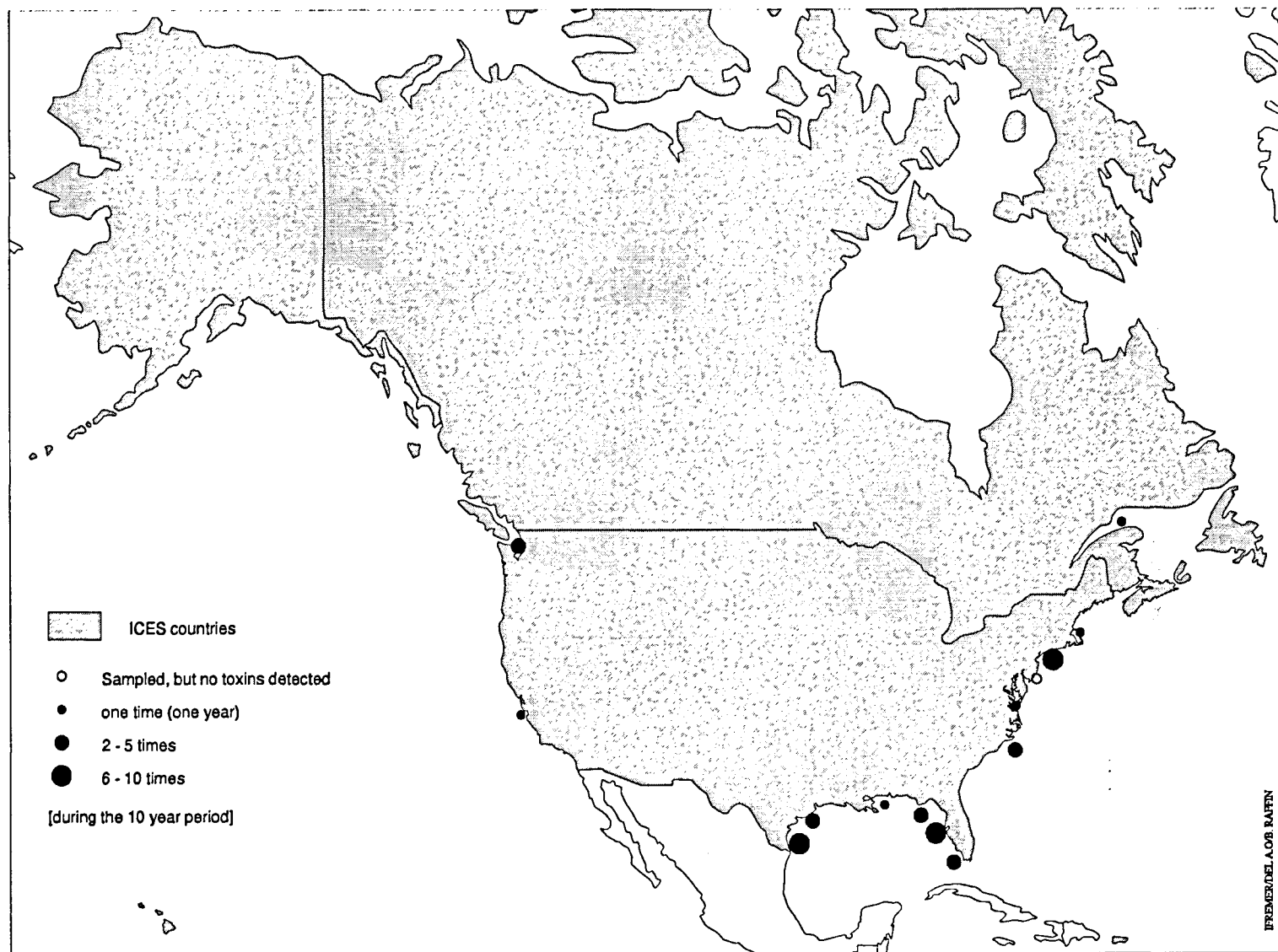


Presence of ASP toxins  
1988 - 1997

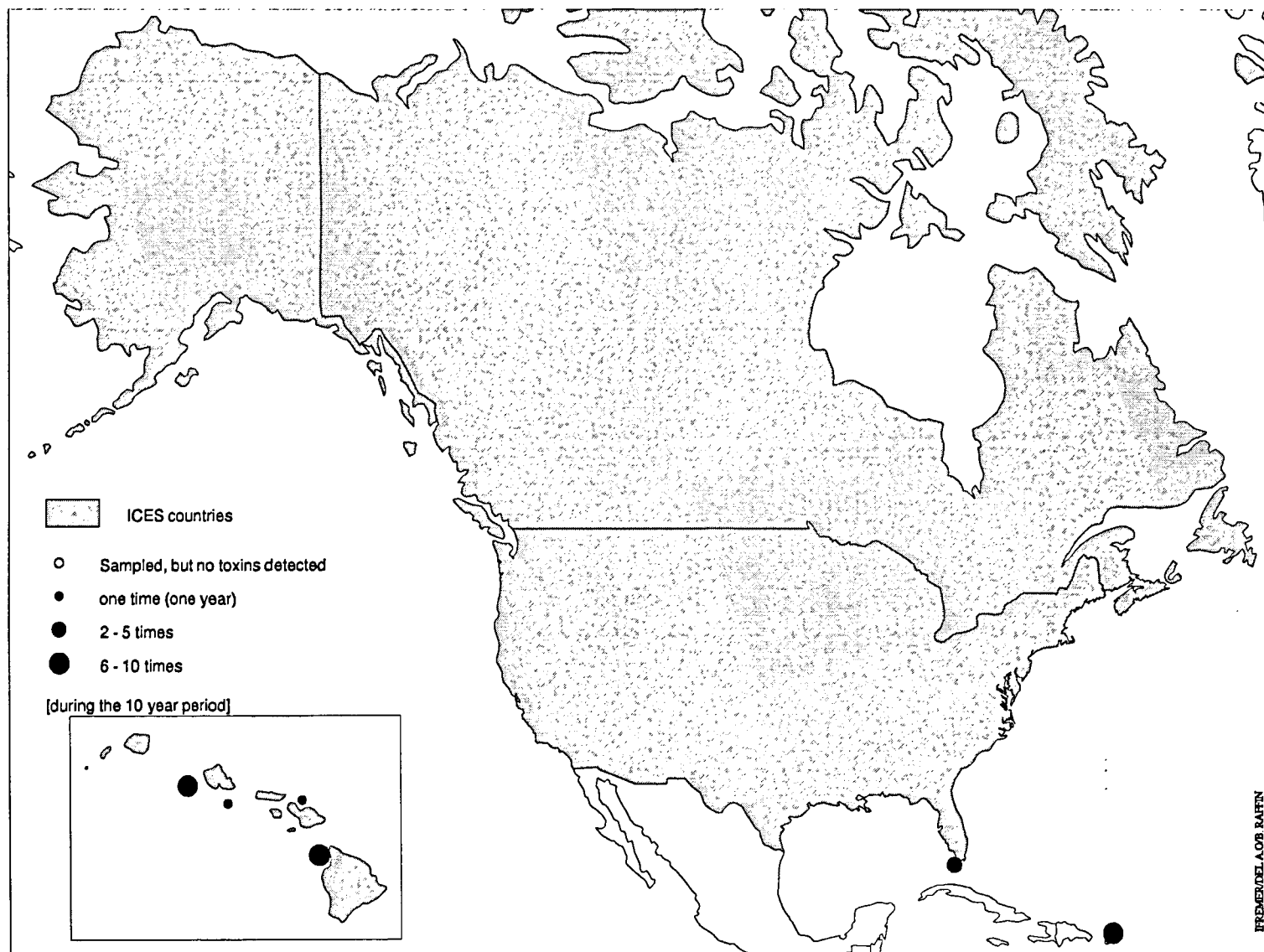


Presence of NSP toxins  
1988 - 1997





Animal and plant mortalities  
1988 - 1997



Ciguatera Fish Poisoning  
1988 - 1997