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REPORT OF THE WORKING GROUP ON EXCEPTIONAL ALGAL BLOOMS

Hirtshals, Denmark, 17 - 19 March 1986

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REPORT OF THE WORKING GROUP ON EXCEPTIONAL ALGAL BLOOMS

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1. Opening of the Meeting

1.1 The Meeting was opened at 10.00hrs on 17 March 1986 and was hosted by Mr. K. Vagn Hansen, Danish Institute for Fisheries and Marine Research Nordsøcenter. Participants were welcomed by the Chairman of the Group.

1.2 Participation was as follows:

Mr. E. Dahl	Norway
Ms. J. Doyle (Chairman)	Ireland
Dr. L. Edler	Sweden
Dr. S. Fraga	Spain
Dr. R. Gowen	United Kingdom
Dr. M. Hageltorn	Sweden
Dr. K. Jones	United Kingdom
Dr. H. Kas	Denmark
Ms. M. Kat	Netherlands
Dr. P. Krogh	Denmark
Dr. O. Lindahl	Sweden
Dr. C. Marcaillou-le Bau	France
Ms. M.A. Sampayo	Portugal
Mr. K. Vagn Hansen	Denmark
Dr. A. White	Canada

1.3 Terms of Reference

The Chairman drew the attention of the Working Group to C. Res. 1985/2:33 which expanded the terms of reference for 1985. The following are the terms of reference:-

(i) to establish means of collecting and exchanging information on the incidence of problems due to exceptional blooms on mariculture operations, and on bivalve fisheries;

(ii) to consider means of improving the predictability of blooms events in time and space scales relevant to fish and shellfish farmers, including analysis of weather patterns in relation to bloom incidence;

(iii) to consider proposals for research on management techniques for overcoming the effects of exceptional blooms, and

(iv) to prepare advice for Member Governments on the principles of site selection in mariculture, and on monitoring, predicting and managing bloom events for fish and shellfish farmers and fishermen.

(v) to include consideration of the subject of various analytical methods (bioassays and chemical analyses) to assess the level of different toxins in bivalves and finfish fisheries, and to fulfill earlier instructions by commencing preparation of a Cooperative Research Report on "Management of Effects of Exceptional Algal Blooms on Marine Finfish and Shellfish Fisheries".

2. APPROVAL OF THE AGENDA

2.1 The Agenda was adopted as proposed; it is contained in Annex 1. Dr. Richard Gowen was appointed as Rapporteur.

3. REVIEW OF PROGRESS ON 1985 ACTION LIST

3.1 The Working Group reviewed progress on the action list proposed in the First Report (Doc. C.M. 1985/F:58 page 14).

3.2 The Chairman reported that Dr. Mommaerts had agreed to participate in future meetings of the Working Group, and to assist in the technical problems of long term archiving. He had prepared a report on exceptional phytoplankton blooms in 1984 which will be published shortly in Volume 41 of Annales Biologiques. Members of the Working Group were reminded to complete the forms sent out by Dr. Mommaerts for archiving of blooms events to ensure that the data base is updated annually. (The Report forms are contained in Annex III, page 20 Doc. C.M. 1985/F:58).

3.3 Progress on the compilation of the Directory of National Expertise was slow - only three member countries had replied in advance (Norway, Sweden and Portugal). It was agreed that the Chairman would contact scientific experts directly and a draft Directory would be prepared and circulated in the inter-sessional period with the objective of preparing a complete directory at the next meeting.

3.4 To ensure that bloom events are recorded, and that information on bloom events is disseminated rapidly to scientists the Working Group reaffirmed the need for National Co-ordinating Centres.

This should not preclude individual scientists from reporting blooms to Dr. Mommaerts nor from contacting other scientists.

The Working Group noted C. Res. 1985/4:22 (which requires Secretariat Initiative) as follows:-

Member countries will be requested, as a first step, to designate appropriate National Co-ordinating Centres to:-

a) facilitate information exchange on exceptional algal blooms in the North Atlantic Ocean and the Baltic Sea to expedite action and control by collecting and publishing, on an annual basis, detailed accounts of national activities and findings;

b) provide for a degree of international information exchange through the inclusion of summaries in the annual Reports on Activities of ICES Standing Committees (Mariculture, Shellfish, Biological Oceanography and Marine Environmental Quality Committees);

c) encourage research into the biology and life histories of bloom organisms which affect commercial species, in particular on:-

(i) culturing
(ii) identification of toxins
(iii) assessment of mode of toxic or pathogenic action

3.5 The Chairman reported that it was the opinion of members of the Biological Oceanography Committee with whom the matter was raised at the 1985 Statutory meeting of ICES that there was insufficient data on phytoplankton blooms to correlate bloom events with climatological change of weather patterns.

3.6 A report on site selection (to have been prepared by Dr. Gowen) was deferred pending further discussion on the applicability of a general site selection strategy.

3.7 A draft paper on a common approach to bloom sampling prepared by Dr. Tett was received by the Chairman, and copies circulated to the members for discussion.

3.8 Little progress was made on cyst mapping. No new information on means of ameliorating the effects of blooms had emerged. The production of Bibliographies of recent publications relevant to the terms of reference was confined to a few member countries.

4. REVIEW OF NATIONAL REPORTS ON INCIDENCE AND EFFECTS OF BLOOMS IN 1985 AND RELATED NATIONAL RESEARCH FACILITIES

4.1 SPAIN

- Some DSP mouse bioassays were found to be positive in October after a change from a diatom dominated phytoplankton to dinoflagellate dominated phytoplankton. Dinophysis acuta could be implicated.

- A bloom of Gymnodinium catenatum mixed with Protogonyaulax affinis (a first record in Spain) occurred in November. Several days later Paralytic Shellfish Toxins were detected by mouse bioassay in blue mussels. In both instances harvesting was stopped. No fish kills were observed.

Research is concentrated on DSP toxicity the main species being Dinophysis spp (D.acuta D. acuminata D. fortii D. caudata Prorocentrum lima and other benthic dinoflagellates (Coolia spp. Scrippsiella spp.)).

For PSP Gymnodinium catenatum and Protogonyaulax spp are considered most important.

Of interest in potential fish kills are Gymnodinium breve and Gyrodinium aureolum.

4.2 FRANCE

A very detailed report on activities was presented by Mrs. C. Le Bau and is presented in summary herein.

The main areas of research concern studies of (i) the occurrence of toxic dinoflagellates and associated hydrological and meteorological parameters (ii) toxin detection utilising bioassay and improved chemical techniques with particular emphasis on the latter to quantify relevant toxins.

While no PSP outbreaks have occurred in France since 1976 the genus Protogonyaulax has been observed in coastal waters. In the case of DSP the main causative species may be Dinophysis acuminata. Studies in the Bay of Vilaine, an important shellfish production area, indicate that D.acuminata often occurs at low nutrient levels and when there is salinity stratification. Highest levels are observed in surface or shallow waters.

Blooms of Gyrodinium aureolum were reported to have inhibited the growth of scallop larvae in 1985. Cultures of G.aureolum will be used to establish if this species was responsible for shellfish damage.

Other species under study include D.acuta Prorocentrum minimum Gyrodinium spirale and Gonyaulax tamarensis.

A comprehensive monitoring programme is undertaken to provide an early warning system. Sampling intensity is increased when a toxic species is detected. Bioassays are conducted and when positive results are obtained. administrative steps are taken to ban harvesting and marketing of shellfish.

4.3 DENMARK

Blooms of G.aureolum Prorocentrum minimum and Eutreptiella were recorded. PSP and DSP were not detected. Other species of economic importance include Dinophysis spp. Distephanus speculum G.tamarensis and Prymnesium parvum.

4.4 CANADA

A small bloom of Gonyaulax excavata occu red during the summer months in the Bay of Fundy. Moderate levels of paralytic shellfish toxins were detected during this period. Marginal levels of the toxins persisted in soft-shell clams throughout the non bloom period. G.triacantha red water was reported in the Bay of Fundy, but was not associated with toxicity.

The first incidence of a G.excavata bloom and shellfish toxicity occurred along the south coast of Nova Scotia. Toxic Gonyaulax blooms and shellfish toxicity in Quebec and in British Columbia were consistent with the general patterns in those regions.

The main toxic dinoflagellate species of concern are Gonyaulax excavata G.tamarensis G.catenella G.acatenella and Gyrodinium aureolum.

4.5 IRELAND

A bloom of Gonyaulax tamarensis occurred during the early summer in a bay on the south coast. Low levels of PSP were detected for the first time in mussels and the fishery was closed for one month. No DSP outbreaks occurred. Gyrodinium aureolum was observed at levels of up to 0.5×10^6 cells L^{-1} in coastal and offshore waters.

There was a major kill at a salmon farm on the west coast during a bloom of Olisthodiscus luteus.

A phytoplankton monitoring programme was conducted from March to October on major shellfish growing areas and at salmon farm sites. The main species of economic importance are Dinophysis acuminata D.acuta (DSP) Gonyaulax tamarensis (PSP) and Gyrodinium aureolum Olisthodiscus luteus and Flagellate "X" (fish kills).

4.6 SWEDEN

Blooms of Heterocapsa triquetra, Ceratium spp. Dinophysis acuta D.norvegica, Gonyaulax polyedra and Prorocentrum minimum occurred in Swedish waters. It was reported that several hundred people suffered from DSP. The causative species is unknown, but Dinophysis spp. is suspected. Mussels were found to be toxic throughout the year.

Other species of interest to Swedish research workers are Prorocentrum micans and Gyrodinium aureolum.

An important programme of research into alternative methods of toxin detection had commenced. The methods include Gas chromatogrphy, HPLC, Isotachophoresis "in vitro" cell tests and immunological techniques.

4.7 NORWAY

Blooms of G.aureolum caused fish deaths in September - one farm losing 30% of its rainbow trout stock. Toxin (okadaic acid) was detected in mussels and a number of people suffered poisoning. The causative species was suspected to be Dinophysis acuta.

It was suggested that Hitra Disease (Cold Water Vibriosis) might be associated with the spring bloom of phytoplankton.

Research programmes at a number of Institutions in Norway were reported involving inter alia nutrient studies, monitoring for toxic dinoflagellates at fish farms and mussel plants, and taxonomic revision on species within the PSP producing complex. The results of offshore monitoring for toxic

dinoflagellates in the Skagerrak and along the Norwegian coast are applied to bloom forecasting.

The species consisted to be of economic importance are Dinophysis acuminata, D.acuta D.norvegica, Gonyaulax Protogonyaulax belonging to the excavata/tamarensis complex, also Gyrodinium aureolum Prorocentrum minimum and Distephanus speculum (Flagellate "X"?).

4.8 PORTUGAL

No PSP, DSP or fish mortalities associated with algal blooms were recorded.

The species of economic importance are: Dinophysis complex, Gonyaulax tamarensis complex, Gymnodinium catenatum and G.galatheanum Prorocentrum minimum and Gyrodinium aureolum

4.9 THE NETHERLANDS

No DSP or PSP outbreaks were reported. Priority is assigned to Dinophysis acuminata and Prorocentrum minimum.

4.10 UNITED KINGDOM

No DSP, PSP or fish mortalities associated with algal blooms were reported during the year. The main species of concern in Scotland are Gyrodinium aureolum and Flagellate "X", Dinophysis acuta, D.acuminata, D.norvegica and G.tamarensis.

4.11 Conclusions Drawn from 1985 Incidents

In the discussion which followed the Working Group expressed concern about the persistence of toxicity in a number of countries and the implications that such persistence had for monitoring and harvesting.

The species believed to be responsible for DSP intoxication appeared to vary from country to country. D.acuta had been

implicated in DSP in Norway and Spain. D.acuminata was implicated in mussel toxicity in France, Holland and Ireland. The position in Sweden was obscure.

The question of the relationship between cell numbers and toxicity was discussed. In some instances low cell numbers (200 - 1000 cells L^{-1}) were reported to cause toxicity and in other instances the relationship between the numbers of Dinophysis and toxicity is obscure. This might be due to a number of factors

- patchy distribution of phytoplankton
- delays or inadequacies in sampling strategy
- variation in toxicity within the species and the possibilities of toxic and non toxic strains

It was concluded that more detailed study of phytoplankton distributions should be conducted.

5. COLLECTION AND EXCHANGE OF INFORMATION

5.1 Other International Bodies

5.1.1. In addition to the previously identified need for National Co-Ordinating Centres and the preparation of a Directory of National Expertise in the ICES area (see 3.2 - 3.4 above) - the Working Group took note of the activities of other related International activities.

5.1.2. Dr. Vagn Hansen reported on a meeting of the Intergovernmental Oceanographic Commission (IOC) of UNESCO held in Paris 6-12 March 1986. A proposal for an international mechanism to co-ordinate the preparation and distribution of standard reference materials for use in marine pollution research and monitoring in marine chemistry had been considered. A group of Experts on Standard Reference Materials for Marine Pollution and Chemistry had been created with comprehensive terms of reference to provide inter alia advice on the needs for and availability of standard reference materials and to co-ordinate efforts to

develop and distribute such materials.

5.1.3. Dr. Vagn Hansen also reported on the IOC/UNESCO Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Shelf Seas and Gulfs. At present PSP, DSP and Ciguatera fish poisoning are virtually unknown in the Central Indian Ocean. However PSP is spreading through the East Indies and Protogonyaulax has caused recent fatalities in Thailand. The IOC has established a Study Group to develop taxonomic expertise and to inform public health authorities in the region.

5.1.4. Dr. Palle Krogh briefed the Working Group on the activities of the World Health Organisation (WHO), the International Union of Pure Applied Chemistry (IUPAC) and the EEC in connection with the identification and assay of algal toxins which are a threat to human health.

5.1.5. Reporting of Bloom events: In order to harmonise data reporting for the archive, Dr. Tett prepared a draft report on bloom sampling which was adopted by the Working Group (Annex II). It was agreed that excerpts of the Working Groups common sampling protocol should be disseminated to authorities and individuals involved in the collection of sampling during blooms.

5.2 PREDICTABILITY OF BLOOM EVENTS

5.2.1. Arising from the previous meeting, Dr. Tett was to have prepared a draft report on predicting bloom events, but submitted that there was insufficient data for statistical analyses of any predictive models. He recommended that there was a need to collect good time series of data from selected sites where there is known to be a good chance of blooms (see letter Annex II).

The Chairman will seek advice from the Hydrography Committee and the ICES Statistician on a long term sampling programme.

5.2.2. The selection of sites for research and priorities for collaborative research will be discussed at the next meeting.

5.2.3. The W.G. distinguished between monitoring for detecting bloom events and the need for research to develop models for predicting bloom events.

5.2.4. The Working Group also distinguished between small scale physical processes. Small scale physical processes were defined as being in the order of 100 sq. km. and large scale processes in the order of 1000 sq. km.

It was agreed that small scale physical processes (such as the concentration of a bloom by wind) have a local effect on a bloom event. Large scale physical processes (such as transport mechanisms) which could transport a bloom from offshore regions of bloom development such as fronts to mariculture, shellfish growing areas could result in the widespread occurrence of a bloom.

It was agreed that the development of models which predict the short term occurrence of bloom events, in time and space, should be given priority. In this respect it was noted that in some member states studies of small scale processes relating to bloom events were under way, and it is hoped that this will lead to empirical models to predict bloom events. However, the Working Group identified a need for fundamental research into large scale interactions between inshore and offshore physical processes and for this to be related to bloom events.

The Working Group agreed that comprehensive archiving of bloom events would lead to a better understanding of long term trends in the occurrence of exceptional blooms.

5.2.5. Sampling Strategy: The Working Group distinguished two separate sampling strategies: (i) monitoring for detection of toxic species and (ii) Reporting of bloom events (as described in Annex II).

It was agreed that monitoring for detection of toxic phytoplankton may reduce the time required for the extensive use of bio-assays, and provide a useful warning of a bloom event so that counter measures can be implemented. The feasability of direct testing of phytoplankton for toxicity was discussed and Dr. Krogh agreed to produce a draft report on this possibility for the next meeting.

It was agreed that inadequacies in sampling strategy could lead to confusion in determining the causative species and the cell densities required for toxicity and/or mortalities. The WG discussed sampling techniques and agreed that depth integrated samples would help to overcome some of these problems. It was recommended that where possible the sampling apparatus described by Odd Lindahl (Annex III) should be tested with a view to assessing and standardizing sample collection. The use of this method will be discussed at the next meeting.

It was not possible to prepare a general sampling strategy. It was recognised that familiarity with an area is required to set up a good monitoring programme since the frequency of sampling and the siteing of sampling stations will be determined by local conditions.

5.3 PROPOSALS FOR RESEARCH AND ADVICE ON MANAGEMENT TECHNIQUES

5.3.1. Conscious of the request by ICES to commence preparation of a Co-operative Research Report on "Management of Effects of Exceptional Blooms on Marine Finfish and Shellfish Fisheries" (C.Res. 1985/2:33), members reviewed the position and concluded that there had been no significant advances since the first meeting. While the options presented in section 5.3 of the 1985 report are still those considered likely to yield results for fin fish, the absence of any major bloom events associated with fish kills precluded on-site trials in 1985.

In discussions the potential use of deeper cages, deep water and more exposed sites and floating tanks were presented as additional options.

5.3.2. In the case of raft culture of mussels it was reported that research was commencing in Norway with the aim of assessing the strategy of avoiding blooms by lowering mussels to greater depths during a bloom event. Progress on this work will be presented to the next meeting.

5.3.3. It appears that in many countries low accord is given to research in this area. This may be due to the low frequency of bloom events in areas under culture in the case of fin fish and the perceived cost of management techniques proposed. Using case studies it is hoped that the W.G. might attempt to assess the economics of management techniques. In the short term and in the absence of experimental data the Working Group cannot fulfil this term of reference.

5.4 ADVICE ON PRINCIPLES OF SITE SELECTION

5.4.1. It was agreed that it was not possible to develop guidelines for site selection which would be generally applicable to all member states. However, to assist member states, which have developing fin fish industries, in site selection it was agreed that

Dr. Gowen would compile a report on criteria presently used for site selection to be discussed at the next meeting.

5.4.2. It was noted that waste from fish and shellfish farms might bring about changes in water quality which could influence phytoplankton growth and species composition. It was reported that work on these effects is commencing in some member states, and the Chairman will seek advice from the ad hoc Study Group on the Environmental Impacts of Mariculture.

5.5 ALTERNATIVE TOXICITY TESTING PROCEDURES

5.5.1. The Working Group was aware of the antipathy in some countries relating to the use of live animals for bio-assay of toxins and discussed the use of alternative methods. It was noted that several chemical methods of analysis for PSP have been developed during the last decade, with various degrees of comparability with the mouse assay. Recently a HPLC method of analysis (Sullivans procedure) has been described, with promising results in terms of sensitivity and detection of the individual PSP components. A collaborative study of this method is being undertaken by AOAC in the USA, a study that might be joined by the IUPAC Working Group on aquatic biotixins. If the results of this study are acceptable this method may well substitute for the mouse assay as an official method for PSP in many countries.

5.5.2. The Working Group were informed that work has commenced in Sweden, the Netherlands, Spain and France on alternative methods for DSP detection. The methods under test include Gas Chromatography,HPLC, Isotachophoresis "in vitro" celltests and immunological techniques. However there is at present no substitute for bioassays.

It was agreed that there should be standardisation of bioassay methods for DSP. It was decided as a first step that Dr. Hageltorn would draft a report on the bio-assay methods used by member states. The aim being to provide the basis for intercalibration of methods and a manual of standard methods.

5.6 BASIC UNDERSTANDING OF TOXIC ALGAE AND THE ACTION OF TOXINS

5.6.1. Arising from the 1985 report the Working Group affirmed its view that priority should be given
- to the culture of toxic algae
- studies on the mode of action of toxins
- studies on toxin production including the chemistry, the toxicology and analysis of toxins.

In addition it was suggested that the Directory of Experts should include details of Institutes with facilities for culturing and maintaining algal cultures. The development of reference strains is vitally important for comparative studies.

5.6.2. To further an understanding of the effects of exceptional blooms on farmed organisms and to assist in the development of management techniques to prevent losses it was considered that more detailed reporting of events was necessary. As a first step it was agreed that the Chairman should seek and compile case studies (from 1985 to the present) of blooms and associated losses which will be discussed at the next meeting.

5.6.3. The Working Group recommended that where possible work on effects of exceptional algal blooms on marine organisms should be encouraged. In the event of a toxic bloom and detection of toxicity in shellfish or mortalities of farmed fish, samples of other marine organisms in the vicinity of the bloom should be preserved for histopathological analyses.

5.6.4. Recognising the importance of laboratory experiments in assessing the mode of action of algal toxins the following areas of research should be encouraged and expanded where possible

- assessment of the behavioural response of fish exposed to G.aureolum and definition of lethal threshold of cell counts (Denmark)
- studies on the toxic effects of G.aureolum on fish (Scotland)
- Growth experiments in various light and temperature regimes
- Ecological studies of dinoflagellates in large plastic bags
- Bioassays using toxic dinoflagellates on various fish in laboratory (Norway)
- Laboratory studies on the effects of G.aureolum on shellfish larvae and spat (France)

5.6.5. Regarding the toxicity of Gonyaulax tamarensis the following research projects in progress in Denmark were noted:

(a) Measurements of toxicity including toxin profile of various clones of G.tamarensis, isolated from the Faroe Islands in connection with the PSP outbreak in 1984 as well as the type strain of G.tamarensis isolated at Plymouth and declared to be non-toxic.

(b) Experimental reproduction of lesions in fish (gill lesions in particular) induced by exposure to cultures of G.tamarensis as a further step in the elucidation of the fish mortalities associated with the G.tamarensis bloom in the Faroe Islands in 1984.

6. OTHER MATTERS

6.1 Cyst mapping

Dr. White drew attention to the work on cyst mapping in Canada and the USA and hypothesised that only those cysts in the upper layers of the sediment surface normally get an opportunity to germinate and seed on a regular basis. However sporadic seeding may also occur if major storms expose and release cysts from the lower layers. The study and quantification of cysts is complex. It is not clear what role advected cysts play in bloom development. Further study is required on possible long term changes in cyst concentrations and it is also necessary to establish the importance of cyst reservoirs for the possible colonisation by dinoflagellates of neighbouring areas under favourable hydrographic and climatic conditions.

6.2 Dr. Hageltorn advised the Working Group on the Swedish Regulations for imports of shellfish from other countries with respect to DSP. He also reported on chronic effects of DSP on humans.

7. ACTION LIST FOR MEMBERS OF THE WORKING GROUP

It was agreed that the following tasks be undertaken by members of the Working Group:-

1) The Chairman will write to individual scientific experts with a view to compiling a draft Directory of experts and seek the inclusion of details of cell culture facilities and retention of reference strains

2) The Chairman will write to the General Secretary of ICES concerning the nomination of National Co-ordinating centres.

3) National reports on bloom events to be sent to the Chairman for dissemination to members of the Working Group for discussion at the next meeting.

4) Dr. Hageltorn to draft a report on bio-assay methods for PSP to be circulated in advance of the next meeting of the Working Group.

5) Results on the use of Odd Lindahls sampling method to be discussed at the next meeting.

6) E. Dahl to report on work aimed at assessing attempts to avoid toxic blooms by lowering mussels to a greater depth.

7) The Chairman will consult the Pathology working group and the Biological Effects working group to obtain information on ways of preserving material for histopathological analyses.

8) The Chairman will seek and compile case studies of bloom events with the aim of extending an understanding of the effects of bloom organisms on farmed organisms

9) Dr. Gowen will draft a report on the criteria presently used for site selection of fin fish farms for the avoidance of toxic blooms.

10) Dr. Krogh to draft a report on testing phytoplankton for toxicity, to be circulated prior to the next meeting.

11) The Chairman to seek information from the Ad-hoc Study Group on the Environmental Impacts of Mariculture concerning the effects of fish farm and Shellfish waste on phytoplankton.

12) All members of the Working Group are to prepare reports on national monitoring programmes where they exist to be circulated in advance and discussed at the next meeting.

8. RECOMMENDATIONS

1. Noting with concern the increasing persistence of DSP toxicity in some countries and the serious impact of this phenomenon on mariculture operations the Working Group recommends that priority be given to work in the following areas:

   - the identification of causative species
   - the determination of minimum cell numbers which induce toxicity
   - the precise toxicological effects
   - the possible long term effects on consumers
   - the need to intercalibrate bioassay and chemical analytical techniques to ensure comparability of results

2. To maximise our understanding of the toxic effects of Dinophysis species the Working group recommends support for opportunistic research when bloom of these species occur.

3. Noting also that persistent PSP toxicity has been reported when no blooms are present the Working Group recommends that causes of persistence be investigated.

4. Recognising the importance of laboratory experiments in determining the mode of action of algal toxins strongly recommends continuing support of the

research projects related to this topic in the National Programmes in progress in Denmark, Sweden, Norway and France.

5. Noting that at the 1985 meeting the Working Group recognised and encouraged the theoretical and experimental investigations of the relationship between phytoplankton ecology and chemical and physical features of the marine environment, it now recommends that multidisciplinary programmes of research be instituted by member countries in economically relevant areas into processes leading to the development and transport of blooms of toxic species.

   In this context the Working Group identified both the need for studies on biological, physical and chemical interactions influencing toxic bloom development at shelf sea fronts and other off-shore areas; also the need for identification of physical processes leading to the transport of blooms between frontal areas and coastal mariculture sites and the relationship between oceanic and coastal phenomena. The Working Group recognises the need for liaison with other ICES committees in this area, specifically the Biological Oceanography Committee and Hydrography Committee.

6. The Working Group recommends that it should meet for 3 days, 2-4 February 1987, at Hirtshals, Denmark to continue its work in accordance with the terms of reference.

ANNEX I

ICES WORKING GROUP MEETING ON EXCEPTIONAL ALGAL BLOOMS

Danish Institute for Fisheries and Marine Research
The North Sea Centre
Hirtshals
Denmark

17-19 March 1986

AGENDA

Monday, March 17

1. 10.00 hours: Opening of the meeting
2. Adoption of the Agenda
3. Appointment of Rapporteur
4. (i) Progress Report on 1985 Action list
   (ii) Review of National Reports on incidence and effects of blooms in 1985 and related National Research activities
5. Terms of Reference (summarised):

   (a) Means of collection and exchange of information on problems due to exceptional blooms - National Co-ordination Centres
   (b) Predictability of bloom events
   (c) Proposals for Research on Management Techniques
   (d) Advice on principles of site selection
   (e) Alternative toxicity testing procedures

6. Any other matters.
7. Adoption of the Report.

ANNEX II

University College of North Wales,
Department of Marine Biology,
Marine Science Laboratories,
Menae Bridge,
Gwynedd LL59 5EH.

Ms. J. Doyle,
Department of Fisheries,
Fisheries Research Centre, Abbotstown,
Castleknock, Co. Dublin,
Ireland

10th March 1986

Dear Jacqueline,

ICES Working Group on Exceptional Algal Blooms

Herewith a detailed draft proposal on bloom sampling. I have sent a copy to Ken Jones so that he will be able to speak to it if you wish. If the draft proves generally acceptable I am willing to prepare a revised version. What then?

One point not mentioned in the draft or its appended notes is that I have been in touch with Dr. Meirion Jones of the UK MIAS database at Bidston. He serves on an ICES data-processing group and will be able to comment on the deposition of bloom data with the ICES Hydrographic Service as well as with MIAS in the UK. I have therefore sent him a copy of the draft.

Having thought more about the topic of numerical modelling I found I don't yet have enough to say on its application to short-term bloom prediction to justify writing a paper, so beg permission to postpone the task for a year. As we discussed on the telephone. it looks as if the search for empirical models for more general bloom prediction is hampered in respect of European waters by a a shortage of good time series for statistical analysis. In addition to improved reporting of blooms in Annales Biologiques it seems to me desirable to press for the establishment or continuation of long-term programmes of regular (i.e. at least weekly) sampling of phytoplankton and physical and chemical conditions at a few well-chosen European sites where there is known to be a good chance of blooms. Such time-series would also help us define 'exceptional blooms' quantitatively. and would provide data from periods preceeding blooms which could be used to validate short-term theoretical models.

Hope the meeting goes well.

Best wishes

PAUL TETT

BLOOM SAMPLING : PROPOSALS FOR A COMMON APPROACH

1. The ICES Working Group on Exceptional Algal Blooms discussed, at its 1985 meeting (a), the need for a standard procedure for sampling exceptional blooms and for reporting them to Annales Biologiques. This paper contains draft proposals for such a procedure.

2. The report of the 1984 ICES Special Meeting on Exceptional Marine Blooms defines (b) such blooms as those 'noticeable, particularly to the general public, directly or indirectly through their effects such as visible discolouration of the water, foam production, fish or invertebrate mortality or toxicity to humans.'

3. Algal blooms become visible when algal pigments absorb, and algal cells scatter, a substantial proportion of submarine light. In addition, organic substances leaked into the sea in sufficient quantities can cause foaming or other obvious change in sea surface properties. Blooms that are visible in this way are thus of high biomass, and because of self-shading (c), are likely to occur only near the sea surface. In any case it is only here that they will be noticed without special sampling equipment.

4. In some cases shellfish may become toxic at relatively low algal biomasses, which may not otherwise be noticeable. The concentration of such toxic populations near the sea surface cannot be presumed. Nevertheless, most shellfish harvests come from the littoral or immediate sublittoral; fish cages or mussel ropes do not usually extend more than 5 metres below the sea surface (x); and the harmful effects of low-biomass toxic populations, as well as of visible blooms, are thus likely to be confined to within 5 metres of the sea surface.

5. It is thus proposed that summary reports of exceptional blooms should refer to this part of the water column. They should give arithmetic 'mean cell numbers per litre in the surface 5 metres' of the species thought to dominate biomass and of any other species of potential toxicity. Where possible these data should be supported by estimates of arithmetic mean chlorophyll a concentration (free of pheopigments) between 0 and 5 metres.

6. If standard equipment is unavailable it may be necessary to resort to unorthodox methods of sampling blooms. An integrated 0-5 m sample may be taken with a length of tubing such as that used for garden hose (d). The contents of the tube are run into a small bucket, and sampling repeated as necessary to obtain a sufficient volume, which should be well mixed before subsampling.

7. It is desirable, if facilities are avilable, to examine and photograph living material, and to fix (e) a subsample with glutaraldehyde for later electron microscopy. In any case at least one subsample of 30 to 100 ml should be fixed (f) with acidic Lugol's iodine and a separate subsample with neutralized dilute formaldehyde (f). When preservatives are not immediately available the sample can be held for a few hours in a refrigerator, a vacuum flask, or a cool dark place.

8. A further subsample (g) should be filtered onto a glass fibre filter (Whatman GF/C or equivalent), which should be either immediately immersed in 90% acetone, or immediately frozen for later extraction, for eventual estimation (g) of photosynthetic pigments.

9. Because of possible relationships between visible blooms and density layering, an attempt should be made (h) to measure and report the density structure of the water column. In particular it is desirable to report $\Delta\sigma_T$ between 0 and 5 metres.

10. Where a well equipped laboratory is at hand for sampling and analysis, it is desirable to make detailed profiles from sea surface to sea bed at a minimum of one station within the area affected by the bloom and one control station immediately outside this area. Variables measured should include density (calculated from measurements of temperature and salinity), transparency (calculated from measurements of downwelling irradiance, or from observations with a Secchi disc), dissolved mineral nutrients (especially ammonium and nitrate, but also reactive phosphate and silicate if it is though that the latter might be limiting), dissolved and particulate organic carbon and nitrogen, photosynthetic pigments, and numerical abundance of the species dominating biomass and of any other potentially toxic species. The 5 metres closest to the surface should be sampled intensively, and means calculated and reported as proposed in paragraph 5. The full data, in the form of tables against depth, should be communicated to one or more recognized data bases (i) and the deposition(s) noted in the report to Annales Biologiques.

11. Visible blooms are sometimes suitable for the measurement of ratios or rates (j) that may provide information of general value on the physiology of the dominant alga as well as on the local dynamics of the bloom. Where such measurements have been made on a well-characterized bloom, there is a good case for publishing the resulting information as a note.

Notes and references

(a) Report of the Working Group on Exceptional Algal Blooms, Dublin, Ireland, 23-25 April 1985. ICES CM 1985/F:58, paragraphs 5.1.7 to 5.1.10.

(b) Report of the Special Meeting on the Causes, Dynamics and Effects of Exceptional Marine Blooms and Related Events, Copenhagen, Denmark, 4-5 October 1984. ICES CM 1984/E:42, paragraph 2.3.

(c) At a biomass of 100 mg chlorophyll a/cubic metre and a typical *in vivo* chlorophyll absorption cross section of 0.012 square metres/milligram, irradiance is 1% of that at the sea surface at about 3 metres depth. Blooms of this magnitude are thus likely to be confined to a thin layer near the surface. Initial stages of bloom growth may however take place at a subsurface thermocline (see P.M.Holligan (1979) in Taylor & Seliger, eds., Proceedings of the Second International Conference on Toxic Dinoflagellate Blooms, pp 249-256), and the original innoculum may have been most abundant near the sea, perhaps as the result of the hatching of cysts or other benthic resting stages.

(d) The tube (of 10 to 20 mm internal diameter) should be slightly longer than 5 m and should initially be open at both ends. A weight is attached to one end, which is then lowered on a string until the tubing is vertical in the water, the other end being held just above the sea surface. The top end of the tube is then closed, and the lower end raised with the string until it can be lifted from the sea at the same time as the top end.

(e) Details to be inserted.

(f) Acidic Lugol's iodine is a good general purpose fixative; neutralized formalin preserves coccolithophorids and other calcified algae whose carbonaceous parts may be dissolved by acid. Details of these preservatives, and their use, are given in A.Sournia, ed. (1978) Phytoplankton Manual, UNESCO, Paris.

(g) Either spectrophotometric, fluorometric or HPLC/fluorometric methods may be used. Details of methods in the first two cases are given by (amongst others) T.R.Parsons, Y.Maita & C.M.Lalli, A Manual of Chemical and Biological Methods for Seawater Analysis, Pergamon, Oxford, 1984; the acidification step, which distinguishes chlorophyll from pheopigment, should always be included. HPLC analysis can be carried out only by suitable equipped and experienced laboratories, but the method may provide a fuller characterization of the bloom in terms of its photosynthetic pigments. If a fluorometric method is to be used, filter 50 ml of water containing a visible bloom, or 200 ml if their is no visible discolouration; for later spectrophotometry filter 500 to 1000 ml of subsample.

(h) In the absence of specialized equipment, samples of surface water can be taken with a bucket and samples of water from 5 metres with a weighted glass bottle with a stopper to which a string has been secured. The bottle, with stopper in place, is lowered on a separate string; the stopper is pulled from the bottle by a tug on its own string; and the filled bottle is returned to the surface. Significant density layering is often associated with temperature gradients of 0.1 to 1.0 degree/metre, and so useful measurements of temperature can be made by inserting ordinary thermometers into the sampling bucket or bottle immediately after sampling. Subsamples of about 250 ml should be kept in rinsed, air-tight bottles for later determination of salinity. Density can be calculated from such temperatures and salinities estimates, as well as from more precise estimates with reversing thermometers or conductivity/temperature probes. P.Tett (in Biological Surveys of Estuaries and Coastal Waters, J.Baker, R.Mitchell & W.J.Wolff, eds., Cambridge University Press, 1986) discusses physical measurements in relation to sampling plankton.

(i) An approach should be made by the Working Group to the ICES secretariat concerning archiving of such data by the Hydrographic Service. Additionally, or as an alternative, data could be communicated to one or more national oceanographic data bases. In the case of the UK the Marine Information and Advisory Service, IOS, Bidston Observatory, Birkenhead, Merseyside, would be appropriate.

(j) Most measurements of carbon:chlorophyll or elemental ratios of natural marine phytoplankton are corrupted by non-algal

particulate material whose concentration often exceeds that of the phytoplankton. In some blooms the biomass of the dominant species far outweighs that of other organisms and non-living organic material. The ratios can thus be measured substantially free of error in these cases. Dark bottle measurements of changes in oxygen concentration during incubations of 2-3 hours allow estimates of the maximum respiration rate of the bloom algae. This respiration will be mainly free of meso- and microzooplankton components, but may be augmented by bacteria associated with the bloom. Oxygen or carbon-14 estimates of photosynthetic rates as a function of illumination, or in bottles incubated just below the surface of the sea may also be useful. Again, bloom conditions allow short incubations, and this and the absence of zooplankton avoids some difficulties with the interpretation of photosynthetic data from natural microplankton communities enclosed in bottles.

(x) Further information needed, especially on depth to which mussels are cultivated when suspended from rafts etc.

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ANNEX III

A DIVIDABLE HOSE FOR PHYTOPLANKTON SAMPLING.

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INTRODUCTION.

In many phytoplankton monitoring programmes the inhomogeneous vertical distribution of the cells, specially dinoflagellates, is a problem when qualitative as well as quantitative samples are needed. Adequate sampling of stratified populations can be performed by taking a large number of water-bottle samples. However, that is a time consuming process and normally not possible in a monitoring programme.

One way to overcome this difficulty is sampling with a hose. However, by this metod no information about the vertical distribution of the phytoplankton will be available, unless the hose is dividable so that the water-column in the hose may be split into sub-samples, each representing a depth-interval (fig. 1).

The above described sampling technic has been found to give good information of the vertical distribution of phytoplankton communities on the Swedish west coast. In that case the hose was divided into four 5 m parts, but the division may of course be made differently, adapted to local conditions.

TECHNICAL DESCRIPTION.

Hose: a rubber hose is recommended since a plastic will get stif when it is cold. A hose with an inner diameter of 12 mm (1/2 inch) has been used, but a wider hose can also be used presupposed that tube connectors and stop-cocks in that dimension are available. Note that the top part of the hose must reach up to the deck of the re-search vessel.

Connectors: quick-connectors for gardening was used for easy and fast connecting of the parts of the hose. A string together with a snap-hook is recommended at each connection as an extra security.

Stopcocks: laboratory stopcocks of polypropylene which are opened and closed by a quarter turn revulotion was found to be suitable.

HANDLING THE HOSE.

When sampling, the hose must be lowered slowly, a speed of about 20 m per minute has been used. It is important that all stopcocks are open and that the hose is not folded anywhere. When the whole length has been lowered the top stopcock is closed and the hose is pulled up gently. The stopcocks are closed as they appear. The parts of the hose are disconnected and each part is emptied by opening the stopcock. The stopcock-end is kept higher than the other end which is kept in a vessel, where the sample can be mixed so that a representative subsample from the actual depth interval can be taken.

FIG. 1: DIVIDABLE HOSE FOR PHYTOPLANKTON SAMPLING