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REPORT OF THE WORKING GROUP ON PHYTOPLANKTON AND THE MANAGEMENT OF THEIR EFFECTS

Natural Environment Research Council
Dunstaffnage Marine Laboratory
Oban, Scotland

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*General Secretary
ICES
Palægade 2-4
DK-1261 Copenhagen K
DENMARK

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Report of the Working Group on Phytoplankton and the Management of Their Effects

Oban, Scotland, 3-7th April 1990

1. Opening of the Meeting

1.1 The meeting was opened by the chairman Dr R.J. Gowen at 0930 hours on the 3rd of April 1990. Professor J.B.L. Matthews, Director of the Dunstaffnage Marine Laboratory welcomed participants.

1.2 The agenda was adopted and is attached as Annex I.

1.3 A list of participants is given in Annex II.

1.4 Mr E.A. Black was appointed as rapporteur.

2. Review of the work undertaken by W.G. on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries.

2.1 Dr O. Lindahl, former chairman of the above WG, presented an overview of the history and work of this group. Dr Lindahl was asked to comment on the status of the proposed Co-operative Research Report on 'Management of the Effects of Harmful Algal Bloooms' which was prepared at the WG meeting in Nantes during April 1989. Dr Lindahl reported that the draft research report was presented to the 1989 Statutory ICES meeting. It was noted that the report was accepted for publication by both the Mariculture and Biological Oceanography Committee. This recommendation was endorsed by ICES Council (C Res. 1989/1:2). The final draft incorporating the suggested amendments had been delivered to ICES in December, 1989. Upon being informed that the report had not been forwarded for printing, the WG expressed concern about this apparent delay. The unfortunate delay in publishing this report has resulted in a delay in publishing the report of the *Chrysochromulina polylepis* Workshop which would have been a valuable aid to the work of this WG.

With respect to the proposed Co-operative Research Report on 'Management of the Effects of Harmful Algal Blooms', there have been rapid developments in some of the areas covered by the report. It was therefore decided to allocate time during the meeting to update sections of the report. The updated sections of the report were completed and given to the chairman of the former WG.

3. Review of the work undertaken by WG on Phytoplankton Ecology.

3.1 Unfortunately neither of the former chairmen were able to attend the meeting. Dr S. Bates, the last rapporteur of the WG on Phytoplankton Ecology, presented an overview of that group's work. A draft manuscript by Colijn *et al*. on a proposed incubator and method for measuring photosynthetic rate had beén reviewed, and the incubator was tested in

Hirtshals harbour. The recommended protocol was subsequently presented but is under continued revision. The importance of establishing a primary production ICES data bank was emphasized. A draft report of the Chrysochromulina polylepis bloom was reviewed by the former WG and was deemed to be a good case study. The research priorities identified by the WG on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries were considered, and it was agreed that research should focus on nutrient related hypotheses. A proposal for a symposium ón the Measurement of Primary Production was drafted. It was noted that there was an apparent delay in the publication of the report on the ICES primary production inter-calibration exercise.

4. A general discussion of the Terms of Reference.

4.1 The chairman informed the working group of Council Resolution C Res 1989/2:26 which established 8 terms of reference.

a) Report on the factors (chemical, physical, and biological) responsible for the initiation of exceptional blooms with special reference to the Baltic;

b) assess and improve management techniques to carry stocks through harmful events;

c) review, evaluate, and report on the toxicological information available on known and newly discovered algal toxins, and the methods for their detection and quantification;

d) document a standard method for primary production estimates based on ^{14}C fixation, including description of confidence limits that can be applied to the estimates.

e) prepare a review on the nutrient processes (i.e., the interaction between phytoplankton species and different nutrients;

f) exchange and analyze data derived from monitoring programmes to identify possible trends in the occurrence of harmful algae, and to improve monitoring programmes. This activity should include the evaluation of the establishment of a "Bloom" data base;

g) analyze the feasibility (in light of confidence to be placed on estimates) of the creation of a primary productioin data base and, if appropriate, specify characteristics of such a data base;

h) advise the Working Group on Marine Data Management on the implications of these data base needs so that it can develop the necessary handling procedure.

4.2 The chairman advised members of the concern expressed by Council at the last statutory meeting regarding the need to reduce the number of Working Groups. The Chairman also informed members of an initiative by the Mariculture Committee to limit the lifespan of working groups to an initial 5 years and, except where there was a request by Council or ACMP for annual advice, working groups should meet in alternate years. In view of the initiative by the Mariculture Committee the Chairman asked members of the WG to consider if there were any areas where developments were so rapid as to require an annual meeting and presentation of advice to ICES.

4.3 It was agreed that, with the exception of terms of reference f and h (which would be discussed in plenary session) the most effective means of discussing the terms of reference would be to divide the WG into four sub-groups:

1. Dr M.J. Perry chaired a sub-group to discuss factors responsible for the initiation of exceptional algal blooms which included the role of nutrients (terms of reference a and e).

2. Mr E. Black chaired a sub-group to assess and improve management techniques to carry stocks through harmful events (term of reference b).

3. Dr A. Cembella chaired a sub-group to review, evaluate and report toxicological information on algal toxins and methods for their analysis (term of reference c).

4. Dr L. Edler chaired a sub-group which discussed the documentation of a standard method for primary production and the feasibility of a primary production data base (terms of reference d and g).

A list of participants in each sub-group is given in Annex III.

5. Detailed discussions of the Terms of Reference

5.1 Factors responsible for the initiation of harmful events and the identification of trends in harmful events.

a. It was considered that a clarification of the phrase exceptional bloom was required. The term bloom denotes a high concentration of algal cells, but it is known that certain toxic species can have an effect at concentrations in the order of 100 cells litre^{-1}. The term "harmful algal event" was considered more appropriate since it does not imply a cell concentration and also denotes a deleterious effect on target population(s).

b. Ms Kononen outlined some studies which have been undertaken in the Baltic:

The toxicity of the blue-green algal blooms in the Baltic Sea has been shown by several studies since the 1970s (Sivonen et al. 1989a,b and references cited therein). The results of Sivonen (1989) prove that the toxicity of the bloom is mainly caused by Nodularia spumigena. According to the traditional concept the initiation of the blue-green algal blooms in the Baltic Sea is mainly due to the ability of the bloom-forming species (N. spumigena, Aphanizomenon flox-aquae) to overcome nitrogen nutrient limitation by nitrogen fixation. Owing to the high temperature optima of the species the bloom usually takes place in July-August, when the water is warmest, around 17°C (Horstmann 1976). However, there is evidence that N^2 fixation might not be as important in the N-nutrition of those species as previously expected (Leppänan et al. 1988; Sahlsten and Sorenssen 1989). Moreover occasional blooms of A. flos-aquae in cold (< 10°C) waters during late autumn have been observed in the Gulf of Finland (Niemi 1989). At the present time the hydrographic factors responsible for bloom formation is poorly understood.

Following the presentation by Ms Kononen the sub-group agreed that with the present composition of the Working Group it was not possible to produce a detailed review of the factors causing blooms in the Baltic.

c. The initiation of harmful events is a result of complex interactions among physical, chemical and biological factors. There are a number of review papers (see for example Holligan 1987 and Smayda 1990) which discuss the mechanisms for the initiation of harmful events. These events include changes in abundance of harmful species and/or changes in the toxicity of the specific population. It was agreed that at the present time to again review all of the potential factors which may be responsible for harmful events would not extend our understanding of inter-relationships.

The most effective way to improve our understanding of the causal relationships amongst environmental factors and the occurrence of harmful events is to focus on long-term process-orientated ecosystem studies and detailed studies of harmful events. With respect to studying harmful events, it should be recognized that there is a limitation to this approach. That is, the specific factor(s) responsible for initiation of the event may occur long before (weeks, months, or in some cases, even years) the observation of the event. It was noted that several programmes designed specifically to determine the processes responsible for the initiation of harmful events are now in operation (e.g. the EEC project on "Phaeocystis blooms in nutrient enriched coastal zones") and it was agreed that the Chairman of the WG would liaise with the directors of these programmes, and advise members of the details and progress of these programmes.

d. With respect to the role of nutrients, the sub-group agreed that an insight into the role of nutrients in causing harmful events might be gained by reviewing and evaluating existing reports and data. In this context the term nutrient is taken to include both macro- (for example Nitrogen and Phosphorus) and micro-nutrients (for example, Iron and Vitamins).

Three potential effects of nutrients were identified:

1) Changes in Algal Biomass

There are some well established relationships between the level of nutrients and total phytoplankton biomass. The level of biomass associated with a given nutrient input will depend on physical oceanographic processes, meteorological forcing and the interaction among different trophic levels. These relationships have been clearly pointed out, for example from studies in the Black Sea, Seto Inland Sea, Kattegat and Adriatic Sea and have been reviewed by Smayda (1990). Since there is already a considerable body of evidence covering this subject it was decided that this topic would be given a low priority in the proposed assessment of the role of nutrients in the occurrence of harmful events.

2) Species Composition and Succession

The changes in the Silicon to Nitrogen to Phosphorus ratios recorded in some regions (see Smayda 1990 and references cited therein) have been accompanied by increased frequency of blooms of non-siliceous species. These trends indicate that nutrient ratios can influence both species composition and succession. A specific example comes from a study of more than 20 years near Helgoland. A decrease in the silicon to phosphorus has resulted in a 10-fold decrease in diatom: flagellate biomass and a pronounced increase in flagellate biomass (Berg and Radach 1985).

3) Changes in Toxicity

During the Chrysochromulina bloom in the Skagerrak in 1988 it was suggested that a low P:N ratio in the water mass caused the toxicity of the algae (Dahl et al. 1989). A considerable increase in the toxicity of this species was identified when phosphorus deficient water later demonstrated in laboratory experiments (Edwardsen et al. 1990). A toxic bloom of Prymnesium parvum in a Norwegian fjord system in 1989 occurred in low phosphorus waters (Kaartvedt et al. 1990). The toxicity of this species has previously been demonstrated to be strongly promoted by phosphorous deficiency (see Shilo 1982).

It was agreed that a review of available literature and data on the relationships betwen nutrient ratios and (1) species succession/ composition and (2) the toxicity of individual species should be undertaken by each member of the WG using information from their own country. The reviews should be presented at the next WG meeting for discussion and evaluation. It was further agreed that reviews should include non-harmful species and should not be restricted to anthropogenic inputs.

e. Identification of Trends

In relation to analyzing data from monitoring programmes to identify possible trends in the occurrence of harmful events, the working group distinguished between the identification of causal relationships and the elucidation of trends. The working group felt strongly that at the present time there were too few studies which could provide adequate data to identify precise causal relationships. However, many member states have monitoring programmes for the occurrence of harmful species and/or the occurrence of shellfish toxicity and finfish mortality. It was agreed that:

1) data from these programmes should be analyzed for trends in the frequency of occurrence, spread, severity and persistence of harmful events;

2) members of the working group would undertake preliminary analysis of the data during the intersessional period;

3) the data together with the results of trend analysis would be discussed and evaluated at the next meeting. The suggested format for reporting the data is given in Annex IV.

It is anticipated that analyses of these data may provide information on:

1. Trends in geographical patterns and frequency of occurrence. One approach in pattern analysis is the identification of functional groups of species. Such functional groups should not be a priori limited to taxonomic criteria but should also take into account functional cell biological responses, such as ability to form cysts, inhibit the growth of other species, reaction to heavy rainfall, salinity and nutrient ratios, response to recirculation patterns etc.

2. Problems arising from inaccurate identification of species.

3. The efficacy of expanding the analysis to include additional environmental data.

4. Methods for refining and improving monitoring programmes.

5. The identification of the type of data to be incorporated in, and the format of, a bloom database.

5.2 Evaluation of the establishment of a bloom database

The WG agreed that it would be more profitable to evaluate the purpose, type of data and format of a database on harmful events before giving any advice on the need for a database to the WG on Marine Data Management. It is anticipated that the analysis of the data for trends in the occurrence of harmful events would aid in determining the type of data which would be most useful to include in a database. It was noted that Dr Mommaerts had collated information on harmful events and questions regarding the fate of the records were raised. In connection with this it was decided that the chairman of the WG would contact ICES to establish the current state of the records and also contact the chairman of the WG on Marine Data Management to discuss the availability of resources within ICES for the establishment and maintenance of a database on harmful events.

The Chairman informed the WG of the establishment of an IOC group of experts on algal blooms which is chaired by Dr D. Anderson. One of the recommendations of the IOC Group was for the formation of a global bloom data base which would be divided on a regional basis. For the reasons discussed above it was agreed that at the present time the WG was not in a position to advise the IOC Group on the format and type of data needed for a bloom data base. It was agreed that there should be close liaison between the Chairman of the WG and the Chairman of the IOC Group of Experts on the needs of a data base and issues relevant to both groups.

It was noted that one of the activities of the former WG on Harmful Algae and their Effects on Mariculture and Marine Algae was the collation and discussion of national reports on harmful events. These reports were considered to be a valuable means of rapidly exchanging information between members of the WG. It was agreed that the preparation of national reports on an annual basis should be continued at least until the need for a database on harmful events was clarified. Those national reports submitted by members of the WG are appended in Annex V.

5.3 To assess and improve management techniques to carry stocks through harmful events

a. It was felt that reference should be made to the fact that the WG is interested in practical (cost-effective) techniques for managing the effects of algal blooms.

b. Harmful algal events which are temporally and spatially predictable are rare. When they do occur, such as in the Faroes (E Gaard, pers. comm.) their predictability is the result of compilation of repeated experiences. As a consequence of the unpredictable nature of harmful events, the group felt that much of the development of knowledge on the management of stocks during harmful algal events would occur as a result of opportunistic studies. It was therefore decided that the most effective method for development of knowledge in this area would be the compilation of case studies to help determine practical and effective mitigation techniques. The following case histories were reported.

Finfish

(i) An outbreak of the toxic species Prymnesium parvum in Hylsfjorden and Sandsfjorden in SW Norway. This area has 34 salmon farms. The algae were first detected on 28/7/89 at the head of the fjord at 50,000 cells l^{-1}. In a situation of high fresh water input, leading to salinities of less than $25^{o}/oo$ and high N, low P concentrations, the algae multiplied. Eleven farms were eventually affected and 750 tonnes of fish lost.

A system of monitoring of both physiochemical factors and algal biomass was initiated. The hydrography of the area is well known. It was thus possible to predict the probable spread of the bloom and advise the farms on the appropriate action. Some farms were 'trapped' at the head of inlets, and did not waste resources by moving cages. Other farms were put on standby, ready to tow cages as necessary. As the toxic effect was not apparently correlated with algal cell concentration an additional safeguard was made. Well-boats containing fish patrolled affected areas. As a bioassay to identify toxic water masses the fish were observed for mortalities.

Prymnesium parvum grows in low salinity water. To inhibit algal growth and dilute the concentration of algae, plastic skirts were placed around the cages and deep water was pumped up into them (Tilseth, S., pers. comm.).

(ii) Alexandrium excavatum has occurred annually since 1984 in the Faroe Islands where it has been responsible for mass mortalities of farmed salmon. As a result of past experience the times and areas where this alga will bloom can now be anticipated. When blooms are anticipated on a farm site, fish cages have been towed to alternative locations. During a recent bloom algal concentrations reached 2.1 million cells/litre in the bloom area while cell concentrations at the alternative site were only 60,000 cells/litre (Gaard, E., pers. comm.).

Summary: These cases illustrate the importance of monitoring during bloom situations as well as a variety of avoidance measures. The potential usefulness of bioassay techniques in this type of situation is also demonstrated.

Shellfish

A number of case studies designed to reduce the time in which contaminated mussels took to detoxify were examined.

(i) In Sweden, Haamer et al. (1990) examined the effects of transplantation and re-immersion of mussels for detoxification from okadiac acid (OA). By transporting mussels with levels of toxin between 60-130 µm OA per 100 gm tissue to an uncontaminated area, they found average toxin levels decreased in 10 days at a rate of approximately 12 µm OA/day/100 gm.

(ii) A study conducted by Marcaillou-Le Baut et al. (1990) of DSP detoxification kinetics in the field and the laboratory showed that in the field it took less time to detoxify mussels than under laboratory conditions (30 days as compared to 42 days). Further, in the case of the laboratory mussels, the levels of toxins present were still above the limit for marketing. It was speculated that inadequate diet was responsible for slower detoxification and concluded that toxin breakdown was related to metabolic rate.

(iii) In Norway, Bohle et al. (1989) attempted to avoid continued exposure to toxic Dinophysis spp. by lowering mussels to a depth of 30 m at a temperature of 7°C. They found that mussels at this depth remained toxic for longer and had lower meat content than those retained at the surface. This was probably due to poor availability of food and low metabolic rate which was the probable cause of slow detoxification.

(iv) Preliminary results from a similar study in Eastern Canada (Martin, 1990, pers. comm.) on the detoxification rate of mussels containing paralytic shellfish toxins concluded that mussels detoxified slightly more rapidly at the surface than those maintained on bottom, or those raised and lowered through the water column to avoid Alexandrium fundyense cells. Furthermore growth rates and flesh content decreased in both those maintained on or lowered to the bottom whereas those returned to the surface layers and those maintained there had higher flesh weights.

(v) A further study in Canada (Desbiens et al. 1990) examined the PSP toxicity of wild and cultured blue mussels induced by Alexandrium excavatum in Gaspe Bay. Results indicate that the entire water column provides a favourable environment for the accumulation of toxins by mussels in coastal semi-open waters such as the Bay of Gaspe. The immersion of mussel-growing structures in order to avoid summer increases in toxicity is not only inefficient but can also bring about toxicity levels that increase with water depth at some point during the critical period.

Summary:

1) The distribution of both DSP and PSP toxicity throughout the water column does not allow a grower to avoid intoxification simply by modifying the depth of holding structures.

2) Rates of detoxification are not uniformly decreased by modifying holding depth of structures but growth rates are adversely affected.

3) The resources required to move large quantities of marketable mussels to 'clean' areas is expensive. The cost-effectiveness relative to the length of closure would have to be determined.

4) Monitoring and toxin detection programmes with closure of affected areas remain the most effective strategies to avoid human illness due to shellfish toxins.

5.4 Detection and quantification of Phycotoxins

a. The rapid development of analytical protocols makes it imperative that ICES this WG remain apprised of these new techniques through reporting by the analytical method sub-goup at frequent intervals. The ICES WG should also be aware of its responsibilities to provide guidance and recommendations in the application of these methods during the intersessional periods.

b. Considered term of reference c - "review, evaluate, and report on the toxicological information available on known and newly discovered algal toxins, and the methods for their detection and quantification".

It was agreed that the word "toxicological" was inappropriate in this context, as it implies the evaluation of clinical and epidemiological studies on the acute and chronic effects of these toxins. Reporting on the human health implications of intoxication goes beyond the perceived mandate and expertise of this ICES WG. Furthermore, such evaluations are presently being carried out by WHO and various national health organisations in many countries. The WG also expressed a preference for the substitution of the term "phycotoxins" for "algal toxins" in the proposed term of reference. This unambiguous term is now in common international usage among researchers and it appears in the published proceedings of symposia (e.g. Bates and Worms, 1989). A revised version of this term of reference is proposed in the list of WG recommendations.

c. Subsequent to the submission of the cooperative research report of the WG on Harmful Effects of Exceptional Algal Blooms on Mariculture and Marine Fisheries, problems have been identified in ICES member countries in the persistent application of existing methods (Stabell and Cembella, 1990). In some cases, these difficulties are inherent to the method itself, and thus can only be rectified by improving or replacing the technique. In other cases, although the method may be fundamentally sound, its implementation may be hindered by the lack of technical training and the availability of reliable reference standards for calibration. Centres of expertise in the analysis phycotoxiof ns already identified in ICES member countries, as well as in non-member nations, should make concerted efforts to share technology and to ensure that personnel are adequately trained in the application of existing techniques. These training deficiencies could be addressed through practical workshops and demonstrations by recognized experts who are actively using such methods. In order to ensure consistency in analytical results which serve as the basis for regulatory decisions, extensive inter-laboratory calibration studies should be carried out at the international level. With the exception of the well-standardized mouse bioassay for PSP (AOAC, 1984), and to a lesser extent the limited intercomparisons of the PSP mouse bioassay and the Sullivan HPLC method (Sullivan et al., 1983; 1986; Fileman, 1988), the inter- calibration studies already completed for the quantification of other phycotoxins are inadequate to judge the suitability of these methods for routine analysis (Stabell and Cembella, 1990). Such ongoing or proposed calibration studies, particularly those involving bioassay techniques (which determine total toxicity) and the corresponding immunological and chemical analytical methods (which measure toxin concentration) should be completed rapidly.

d. The critical shortage of sufficient quantities of reference standards of adequate purity has hampered not only the development of new techniques, but also the implementation of existing methods. Although local efforts in some ICES member countries have resulted in the production of small quantities of certain toxin standards, no concerted international attempt has been made to resolve this problem. A clear distinction must be made between analytical reference standards (of certified purity) and reference material containing known amounts of toxin(s) in a poorly defined matrix, which may nevertheless be suitable for certain calibration purposes, particularly in the initial stages of method development and implementation. An example of the latter type of standard would be a relatively crude extract of shellfish tissue with a known toxin concentration and composition. Due to the limited availability of reference standards, proposals have been advanced to use analogues of similar chemical structure and chromatographic behaviour for the analysis of certain phycotoxins, such as domoic acid and DSP toxins. The substitution of an internal standard analogue has proven to be successful in the fluorescence- based HPLC method used for domoic acid (Pocklington et al., 1989), but the use of cholate- derivatives as substitutes for okadaic acid in the HPLC analysis of DSP toxins is presently considered to be unworkable (A. Fiksdahl, pers. comm.). Nevertheless, research on the use of phycotoxin analogues should be continued with the hope that this might eventually help to alleviate the present scarcity of primary reference material. Such standard analogues, which can often be produced inexpensively in reasonable quantities, are also useful in the evaluation of relative toxin recovery during sample preparation.

e. The development of novel techniques which can be applied to the identification and quantification of phycotoxins must be brought to the attention of the appropriate regulatory agencies in ICES member countries. However, before such methods can be incorporated into regulatory programs, detailed comparative clinical trials must be rigorously performed. One useful role of the ICES Working Group should be the identification of promising technologies and the dissemination of information regarding their application. Among such innovative approaches to the detection and quantification of phycotoxins, new HPLC techniques employing improved detection systems (Pocklington et al., 1989; Quilliam et al., 1989a), the introduction of mass-spectrometry as a detection mode (Pleasance et al., 1990a and b; Quilliam et al., 1989b; Lee et al., 1988), immunological techniques (Cembella et al., 1990; Trainer and Baden, 1990) and tissue culture methods (Underdal et al., 1989) may supplement or gradually replace the conventional mammalian bioassays.

f. In the previous cooperative report, only those phycotoxins with direct health human impacts, and the appropriate methods for their detection, were specifically considered. This term of reference should be expanded to include phycotoxins with toxic effects on marine resources (commercial and non-exploited marine species, including finfish, seabirds, invertebrates and marine mammals). In this context, it is important to underline the requirement for analytical techniques capable of detecting and quantifying phycotoxins in plankton, dissolved in seawater, and in marine sediments. In many cases, toxin levels in these ecological compartments may be orders of magnitude less than those accumulated in the shellfish tissues analyzed by routine conventional methods (Pocklington et al., 1989). The analysis of trace toxin levels requires methods of enhanced sensitivity, as well as modifications of the extraction and sample preparation techniques. Protocols for the preparation and analysis of phycotoxin in samples other than molluscan tissue are usually lacking in the primary literature. Obviously, studies on the transfer kinetics of phycotoxins in marine food webs cannot be adequately conducted in the absence of highly sensitive analytical methods. Certain algal species are known to produce ectocrine toxins, while other toxins which are primarily intracellular may be liberated into seawater through leakage during senescence, or due to degradation of algal cells following the termination of blooms. The fate of these toxins dissolved in seawater or associated with particulate or colloidal aggregates in the water column or sediments is largely unknown. With the recognition that bacteria may also play an important role in the biosynthesis and metabolism of toxins previously considered to be exclusively of algal origin (Silva and Sousa, 1981; Singh et al., 1982), analytical techniques for determining bacterial contribution to cellular toxicity and their relative importance to operationally-defined toxin compartments in marine ecosystems must be developed.

g. Since the preparation of the afore-mentioned co-operative research report, noxious blooms of several new species known or suspected to produce toxic metabolites have been recorded by ICES member counties. These species include Prymnesium parvum, Chrysochromulina polylepis, Gyrodinium aureolum, Heterosigma akashiwo, Pheocystis pouchetii, Aureococcus anophagefferens and the cyanobacterial species Nodularia spumigena, Gomphospheria lacustris and Aphanizomenon flos-aquae. In some cases, the toxic fractions have been partially characterized, but standard methodologies have not yet been established for the identification of specific toxins from most of these species. The working group proposes that increased research efforts and international co-operation be directed to the study of these emerging problems.

h. The WG wishes to specifically exclude a number of topics whose importance is recognized but which do not fall within the perceived limits of the expanded Term of Reference. Numerous harmful effects of algal blooms have been recorded which are unrelated to the presence of a known or suspected toxin. Study of such effects as oxygen depletion, mechanical damage to gill structures etc., fouling of fishing gear or foam accumulation on beaches does not require the use of specific techniques for phycotoxin analysis. These aspects are better addressed from physiological and ecological prospectives. The WG members do not feel competent to advise on the determination and establishment of maximum allowable toxin levels as théy relate to human health, nor on the examination and interpretation of pathological effects of phycotoxins on humans and animals. Such aspects should be referred to more specialized groups within or outside of ICES.

Although the ecophysiology of toxin production by toxic algae and associated bacteria under different environmental conditions is seen as an essential part of any research program on phycotoxins, and should be properly considered by the this ICES WG, the sub-group on detection and quantification methods sees its role as limited to identifying and promoting the appropriate analytical methods adaptable to such specific research objectives. The same approach is also valid for the study of the kinetics of phycotoxin uptake and depuration in marine species.

5.5 The following terms of reference were discussed:

d) document a standard method for primary production estimates based on 14-carbon fixation, including description of confidence limits that can be applied to the estimates;

g) analyze the feasibility (in light of confidence to be placed on estimates) of the creation of a primary production data base and, if appropriate, specify characteristics of such a data base.

a. The WG considered the documents of previous Working Groups as a basis of discussion of terms of reference d and g. The rationale developing a standard method and incubator is a consequence of a preliminary ICES report (CM 87/L:27) on an intercomparison exercise in which different incubators and methods were used by 11 laboratories to measure the photosynthetic rate of a common sample. The coefficient of variation among measurements was large (more than 40%), possibly resulting from cumulative errors due to the type of artificial light incubator used, and the post-incubation procedure (e.g., filter type, removal of non-incorporated carbon-14). The report therefore recommended that a simple incubator be designed and that a standard protocol be developed, involving as few steps as possible. In this way, it was hoped that results from different laboratorties could be directly comparable, and that the standardized approach could be used for monitoring purposes. Data collected in this way could be used to analyze trends in primary production over time and space.

b. As a result of the preliminary report (CM 87/L:27), Colijn et al. built a simple incubator and proposed a standard method for measuring photosynthetic rate. This was presented as a manuscript by Colijn et al. at the ICES Working Group on Phytoplankton Ecology in Helsinki, 4-7 July, 1989, and in a revised form with additional data on 16 August. This document was reviewed, and suggested changes would be forwarded directly to the authors. It was agreed that the proposed protocol is over-simplified, but could'be developed into a physiologically-correct method for obtaining daily primary production estimates. There was considerable criticism of the proposed approach for measuring photosynthetic rate, and of the usefulness of collecting such data. It was evident from the discussions that the proposed method, in its present state, is inadequate for measuring primary productivity. The ecological utility of photosynthesis data obtained by this method was questioned, since samples would be collected at only one depth (within the mixed layer) and incubations would be made at only one irradiance level. The mean irradiance level used (360 µmol photons.m-2.s-1) may not always be saturating, and in some cases may even be inhibiting. The WG considered that the construction of a P-I curve was a minimum requirement for providing scientifically-correct data on primary production. It was suggested that the incubator could be modified to provide 11 irradiance levels (e.g., by surrounding the flasks with neutral density filters). This incubator could then be used to define a P-I curve from which Pmax and alpha values could be determined. Although the WG felt that Pmax may be a more meaningful variable than a photosynthetic rate obtained from an unspecified part of a P-I curve, a better approach would be to use Pmax and alpha to calculate primary production (Platt and Jassby, 1976). In view of the variability demonstrated by the inter- callibration experiments, the WG felt that standardization of methodology was desirable. However, it was recognized that a new standard protocol would not be widely accepted, even if simple and inexpensive to carry out, until it is first demonstrated that the method has a sound theoretical base and is a significant improvement in terms of accuracy and precision over existing methods.

c. The feasibility of creating a primary production database was discussed. It was generally felt that the purpose of the database should be clearly defined before its characteristics were determined. Whilst there was agreement that standardisation of methodology for photosynthetic measurements would greatly facilitate inter-comparison of data and analysis of trends, it was recognised that a vast range of data may be available which, although not directly comparable, might be useful in determining temporal and spatial trends. It was therefore suggested that any database should be designed to accommodate data obtained from different methodologies for determining photosynthesis, thus enabling the selection and evaluation of data meeting specific quality requirements. Attention was drawn to existing databases (e.g., NODC) which met this requirement, and to work in progress in other programmes (e.g., JGOFS) on this topic. The working group agreed that information on these and any other national databases should be sought by members of the working group during the inter-sessional period and that these should be evaluated at the next working group meeting.

6. Any Other Business

1) Mr Vagn Hansen drew the attention of members of the WG to a computer based identification guide to the protists of Norwegian coastal and open ocean waters which is being developed by K. Estup and co-workers. It is anticipated that this guide will be a valuable aid in monitoring programmes and in research studies.

With respect to phytoplankton identification Mr Black reported that a video recording of live phytoplankton including most of the harmful species has been produced by the British Columbia Ministry of Agriculture and Fisheries in conjunction with the University of British Columbia.

7. Recommendations

The WG recommends that:

1) Members of the WG on Phytoplankton and the management of their effects continue to compile annual, national reports on the occurrence of harmful events.

2) The directory of national expertise prepared by the former WG on Harmful Effects of Algal Blooms on Mariculture and marine fisheries should be amended to include individuals and agencies with access to phycotoxin analytical reference standards and secondary reference material and that the directory be adopted and published by ICES.

3) Term of reference c be revised as: review, evaluate and report on the known and suspected phycotoxins in toxin-producing algae and in marine ecosystems, including the methods for their analysis.

4) That an evaluation of the need and possible format for extensive inter-laboratory calibration studies be carried out, to ensure consistency of analytical results among various laboratories and to compare alternative methodologies.

5) That a practical demonstration workshop on the available techniques for the analysis of phycotoxins, specifically those which can be routinely applied, be set up.

6) That in its present form, the proposed incubator and method for measuring photosynthetic rate should not be accepted as a standard method.

The WG further recommends that it should meet in Vigo, Spain on the 17-20 April 1991 to undertake the following tasks:

a) Evaluate the results of trend analysis on the occurrence of harmful events and assess the utility of using the data collected for inclusion in a database of harmful events.

b) Assess currently available information on the role of nutrients in stimulating the formation of harmful events and to begin preparation of a review of the role of nutrients in the occurrence of harmful events.

c) Discuss and evaluate case histories on management techniques to carry stock through harmful events.

d) Continue the evaluation of different methods and documentation of a standard method for measuring primary production.

e) Evaluate the utility of a primary production database.

f) Continue to evaluate methods for the detection and quantification of phycotoxins.

8. Action List

1) Mr E. Dahl to prepare the format of tables to be used by each member of the WG to compile data on the occurrence of harmful events.

2) Each member of the WG to compile data on the occurrence of harmful events and to undertake trend analysis of the data for discussion at the next meeting.

3) Each member of the WG to review available literature and data from their own country on the role of nutrients in the occurrence of harmful events and this information be brought to the next meeting for discussion and evaluation.

4) Dr A. Cembella to prepare a draft directory of experts in phytotoxin detection and the location of toxin standards.

5) Each member of the sub-group on primary production to obtain information on databases which are currently used to store primary production data. A hard copy of the structure of each database should be brought to the next meeting for evaluation prior to advising the WG on Marine Data Management on the utility for a primary production database.

6) Each member of the WG to compile case histories on management techniques in mariculture which have been used during the occurrence of harmful events.

7) The chairman of the WG to liaise with ICES Secretariat and the chairman of the WG on Marine Data Management to clarify the state of the Mommaerts algal bloom records and the resources available within ICES for the establishment and maintenance of databases on harmful events and primary production.

8) The chairman of the WG to liaise with the director of the Phaeocystis research programme and advise members of the WG on the content and progress of the research.

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ANNEX I

WORKING GROUP ON PHYTOPLANKTON

AND THE MANAGEMENT OF THEIR EFFECTS

April 3rd - 7th 1990

Dunstaffnage Marine laboratory
Oban
Scotland

TENTATIVE AGENDA

1. Opening of meeting (0930 Tuesday April 3rd)

2. Election of Rapporteur(s).

3. Adoption of Agenda.

4. Overview of work by the Working Group on Harmful Effects of Exceptional Algal Blooms on Mariculture and Marine Fisheries.

5. Overview of work by the Working Group on Phytoplankton Ecology.

6. General discussion of Terms of References of new Working Group.

7. Establishment of sub groups for detailed discussion of Terms of Reference.

8. Preparation of Working Group Report.

9. Any Other Business.

10. Close of Meeting.

ANNEX II

List of Participants

Richard Gowen (Chairman)	United Kingdom
Edward Black (Rapporteur)	Canada
Stephen Bates	Canada
Claire le Baut	France
Catherine Belin	France
Allan Cembella	Canada
Einar Dahl	Norway
Jacqueline Doyle	Ireland
Lars Edler	Sweden
Santiago Fraga	Spain
Patrick Gentien	France
Eilif Gaard	Faeroe Islands
Kristinn Gudmundsson	Iceland
Matts Hageltorn	Sweden
Kr Vagn Hansen (IOC observer)	Denmark
Berit R. Heimdal	Norway
Alain Herbland	France
Mike Heath	United Kingdom
Ken Jones	United Kingdom
Kaisa Kononen	Finland
Odd Lindahl	Sweden
Ian Laing	United Kingdom
Jurgen Lenz	Federal Republic of Germany
Jennifer Martin	Canada
Mary Jan Pery	United States
María A. Sampayo	Portugal
D.V. Subba Rao	Canada
Thorunn Thordardottir	Iceland
Snorre Tilseth	Norway
Manuel Varela	Spain
Jean Worms	Canada
Bert Wetsteyn	Netherlands

ANNEX III

Participants in each sub-group

Sub-group 1 (chaired by Dr M.J. Perry)

C. Belin
E. Dahl
S. Fraga
P. Gentien
R. Gowen
M. Heath
A. Herbland
K. Jones
K. Kononen
J. Lenz
O. Lindahl
B. Heimdal
M. Sampayo
Kr Vagn Hansen
T. Thordardottir

Sub-group 2 (chaired by Mr E. Black)

J. Doyle
E. Gaard
I. Laing
J. Martin
S. Tilseth

Sub-group 3 (chaired by Dr A. Cembella)

C. le Baut
M. Hageltorn
J. Worms

Sub-group 4 (chaired by Dr L. Edler)

S. Bates
K. Gudmundsson
K. Jones
M.J. Perry
M. Varela
B. Wetsteyn
R.V. Subba Rao

ANNEX IV

A Format for the presentation of Data on harmful events

Information from monitoring for the occurrence of harmful species, and toxic shellfish together with historical records on harmful events (including mass mortality of marine organisms) should be separated into four categories and each data set entered onto a table or map. The format of the tables will be devised by Mr E. Dahl and circulated to erach member of the WG.

1) Events of Human Intoxication

This data should be presented as simple tables and maps. A separate table and map should be used for each type of intoxication for example PSP, DSP and ASP.

2) Mortality of marine organisms

This data should include mortalities of farmed fish and shellfish as well as other marine organisms. The data should be presented in the same format as Category 1.

3) Recordings of toxicity

Data from monitoring toxicity obtained through both bioassay and chemical methods of toxin detection. Information on the areas affected and where possible toxin profiles should be presented in separate tables. The persistence of the occurrence in each year should also be displayed in tabular form.

4) Geographical Spreading of Harmful Events

Data on the geographical location of harmful events should be presented on a series of small maps, one for each year. The species causing the event should also be recorded on the map.

Occurrence of toxic phytoplankton in 1989 in the coastal waters and shellfish of the Netherlands.

P. van Banning
The Netherlands Institute for Fishery Investigations, P.O.B. 68, 1970 AB IJmuiden, The Netherlands.

The research of the toxic phytoplankton in 1989 in the Netherlands was based on the rat bioassay for the detection of DSP in **mussels** (*Mytilus edulis*) together with a monitoring of *Dinophysis* sp. (*D. acuta* and *D. acuminata*) in **phytoplankton samples.**

The samples of mussels and water were taken from the two main commercial mussel-producing areas of the Netherlands, the **Eastern-Scheldt area** in the south, and the Dutch **Waddensea area** in the north, near the islands Texel and Terschelling (Fig.I). Samplings are carried out on fixed positions, with 3 sites for the Eastern-Scheldt, and 10 sites for the Waddensea.

In 1989 the sampling was started on 13/06 in the Eastern-Scheldt. From 27/06 to 27/11 a weekly sampling programme was carried out on all sites of the Eastern-Scheldt and the Waddensea, both for mussels and phytoplankton.

Occurrence of **DSP in mussels**, based on the rat bioassay test, was determined in the **period 9/10 to 13/11 in the Waddensea**, but only on the sites **near the island Terschelling**. No development of DSP could be traced in mussels of the Eastern-Scheldt.

Occurrence of ***Dinophysis* sp. in the phytoplankton monitoring** was observed in the period **17/7 to 30/10**, but only in the **Waddensea area near the island Terschelling**. The countings of *Dinophysis* sp. reached a maximum of 100 cells/L on 04/09 (table I). No occurrence of *Dinophysis* sp. could be determined in the phytoplankton samples of the Eastern-Scheldt.

DSP in imported lots of shellfish: in 1989 shellfish was imported in the Netherlands for commercial purposes from Danemark, Germany, U.K., France, Ireland, Turkey, Canada, U.S.A., and Korea. A few cases of DSP positive rat bioassays were found in of lots of shellfish (mainly mussels and oysters) imported from Germany, France and U.S.A.

07.03.1990

DATE 1989	NUMBER OF DYNOPHYSIS CELLS/L
17/07	11
25/07	15
02/08	13
08/08	2
14/08	6
21/08	58
28/08	67
04/09	100
11/09	4
18/09	14
25/09	25
02/10	18
09/10	17
16/10	60
23/10	2
30/10	0
06/11	0
13/11	0
20/11	0
27/11	0

Table 1. Number/L of *Dinophysis* sp. counted in the water samples of the sites near the island Terschelling, Waddensea, over the period 17/7 - 27/11, 1989.

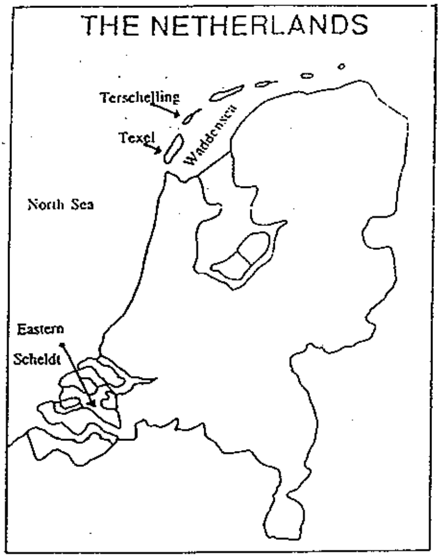

Fig.1. Geographical situation of the Eastern Scheldt and the islands Texel and Terschelling.

ICES Working Group on Phytoplankton and the Management of their Effects
Oban, Scotland, 3-7 April 1990
Poland, annual report on bloom events for 1989

There are no other reports except for **Heterocapsa triquetra**

1. **Location**: Gulf of Gdańsk (Southern Baltic)

2. **Dates**: Late May to early June, 1989

3. **Effects**: The fish seemed stressed and even some increase of mortality was observed

4. **Management**:

5. **Causative species**: Heterocapsa triquetra
   Maximum number of cells observed in a surface sample -
   $54 * 10^3\ ml^{-1}$ - June 1

6. **Environment**: No data. The weather was calm.

7. **Advected population or in situ growth**: Probably in situ growth combined with positive phototaxis of the algae.

8. **Previous occurrences**: Annually in June

9. **Additional comments**:

10. **Individual to contact**:

Tomasz Mackiewicz
Sea Fisheries Institute
Al. Zjednoczenia 1
81-345 Gdynia, Poland

ALGAL BLOOM REPORTS - UNITED STATES

1. Locations: Coast of Maine : Kittery to Spruce Head, Winter Harbor to Robbinston(Canadian Border).

2. Date of Occurrences: May - August 1989

3. Effects: Paralytic Shellfish Poisoning in shellfish. (*Mytilus edulis*, *Mya arenaria*, *Ostrea edulis*, *Spisula solidissma*, *Arctica islandica*, *Placopecten magellanicus*)

Shellfish extracts and mouse bioassays prepared and performed at the Department of Marine Resources, West Boothbay Harbor, Maine. Toxicity ranged from 58 to 9000 ug/100 g meat.

4. Management Decision: Effected areas closed to the harvest of specific species.

5. Causative Species: *Protogonyaulax tamarensis*

6. Environment:

7. Advected population or in situ growth: Seems to be in situ populations along the Maine coast.

8. Previous Occurrences: Every year since 1972; different areas of the coast effected in different years.

9. Additional Comments:

10. Individual to Contact: John Hurst
Maine Department of Marine Resources
W. Boothbay Hbr., ME 04575
(207) 633-5572

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Maine, New Hampshire, Massachusetts

   In Massachusetts: North and South Shores
   Southern extent - east entrance to Cape Cod Canal
   Offshore extent- unknown, but offshore toxicity reported on Georges Bank and as far south as Nantucket Shoals.

2. Date of Occurrence: mid-May to the end of July

3. Effects: 1) Toxin detected in *Mya arenaria, Mytilus edulis,* and other species in Me., N.H., and Ma.; Highest ever recorded shellfish toxicity in Ma.
   2) Toxin detected in surf clams and scallop viscera on Georges Bank.
   3) No known human or marine mammal illnesses, however, contaminated shellfish may have reached the marketplace because of the lack of offshore monitoring program.

4. Management Decision:
   1) Nearshore shellfish bed closures (>80ug toxin/100g shellfish) for several species in three states - independent decision at the state level.
   2) Offshore surf clam industry closed by emergency powers granted to NMFS (National Marine Fisheries Service) from the Mid-Atlantic Fisheries Management Council.

5. Causative Species:
   1) nearshore - *Alexandrium fundyense*
   2) offshore - unknown, but presumably *Alexandrium fundyense* which may have been advected in nearshore waters from the north or grew *in situ*.

6. Environment:
   1) Temperature - 6-7 °C at bloom initiation; 9-11 °C 1 month later during peak bloom.
   2) Salinity - 23-30 parts per thousand; Salinity front along coast associated with freshwater plume.
   3) Stratification - yes, cells preferred sigma t = 24.5
   4) Cell numbers - 200-5,000 cells/liter
   5) Nutrients - <1ug atom N/liter (NO_2 +NO_3)

7. Advected Population or *In situ* Growth:
   Source - most likely Maine; cells were advected alongshore to the south into Massachusetts waters, carried by the predominately counterclockwise currents in the Gulf of Maine during spring. *In situ* growth may have occurred during transport. Offshore cell source and bloom mechanism unknown, although advection from northern nearshore waters is most likely.

8. Previous Occurrences:
   Annual event in most years since Sept. 1972, usually in May/June, but may also occur later in summer and early autumn. Outbreaks in Maine prior to 1972. Offshore blooms appear to develop later in the summer. Last two years (1988 and 1989) have been intense with possible spreading to more southern offshore waters. First reported occurrence of PSP toxicity on Georges Bank.

9. Additional Comments:
   1) No reported toxicity in the salt ponds of Cape Cod, usually an annual event in several of the ponds.
   2) NMFS is currently accepting the Federal responsibility for field monitoring of surf clams and scallops in the offshore areas; while Massachusetts Dept. of Public Health continues to monitor catches at dockside. Authority to continue closing the shellfish beds under emergency powers beyond 90 days (with 1 renewal of the 90-day ban) appears unclear at this time.

10. Individual to Contact: Dr. Donald M. Anderson
    Woods Hole Oceanographic Institution
    Woods Hole, Ma. 02543
    (508) 548-1400

ALGAL BLOOM REPORTS - UNITED STATES

1. Locations: New Jersey Coast north to at least Asbury Park and south at least to Barnegat Light; at least five miles offshore between Manasquan and Barnegat Inlets.

2. Date of Occurrence: October 26-30, 1989

3. Effects: Red water over an extensive area; transparency as low as 0.5m

4. Management Decision: Several samples collected and analyzed

5. Causative Species: (phytoflagellates) total cell counts >5 X 10^4 ml^{-1}

   Dominant: K. rotundatum
   Gyrodinium estuariale
   Eutreptia lanowii
   Chroomonas amphioxiea

   Abundant: Gyro. pellucedium, dominans
   Chrysochromulina sp.
   Tetraselmis sp.
   Pyramimonas sp.

6. Environment: Coastal water abnormally warm for the time of the year.

7. Advected population or in situ growth: *in situ* population

8. Previous Occurrences: These species are normally abundant in summer and responsible for water discoloration (especially K. rotundatum).

9. Additional Comments: This bloom followed a period of heavy runoff, abnormally warm temperatures and probable occurrences of the autumn turnover to replenish nutrients on the photic layer.

10. Individual to Contact: Paul Olsen
    New Jersey Department of
    Environmental Protection
    (609) 633-7003

ALGAL BLOOM REPORTS - UNITED STATES

1. Locations: Raritan/Sandy Hook Bay, New Jersey coast (most intense and persistent in the estuary)

2. Date of Occurrence: Mid July to early September, 1989

3. Effects: Brown water discoloration throughout, especially in the estuary and adjacent coastal waters; resultant brown flocculent material and foam deposits on area shores.

4. Management Decision: Continued surveillance; intensive survey of the estuaries area.

5. Causative Species: (diatoms)
   Skeletonema costatum* Thalassiosira spp**
   Cylindrotheca closterium* Hemiaulus sinensis**
   Chaetoceros spp**
   dominant*
   sub-dominant**
   (several other flagellates and diatom species abundant) Total cell counts attaining well in excess of 10^5 ml^{-1}

6. Environment: Water turbid; chlorophyll *a* >30 to >100 ug l^{-1}; salinity 21-27 °/oo

7. Advected population or in situ growth: Primarily *in situ*, except possible in the estuary; C. closterium is the only dominant species more characteristic of the estuary than of these coastal waters.

8. Previous Occurrences: These blooms normally occur earlier or later in the year; however, summer diatom blooms have been common in recent years.

9. Additional Comments: Prevailing weather patterns (e.g., predominance of easterly winds) probably precluded stratification and caused influx of diatoms when phytoflagellates are normally abundant.

10. Individual to Contact: Paul Olsen
    New Jersey Department of
    Environmental Protection
    (609) 633-7003

ALGAL BLOOM REPORTS - UNITED STATES

1. Locations: Barnegat Bay, New Jersey

2. Date of Occurrence: Mid June to early October, 1989

3. Effects: Brownish water discoloration; large mats of dead eelgrass on shores coincident with brown water; sport fish catches probably affected.

4. Management Decision: Continue routine surveillance (NJ DEP/USEPA); A eutrophication study by NJDEP Div. of Science and Research (DSR) is underway.

5. Causative Species: (coccoid picoplankton) Nannochloris atomus (dominant, total picoplankton $>10^6$ cells ml^{-1}); we did not analyze for Aureococcus this year, but it was detected in low numbers last year (<7.5%)

6. Environment: Water turbid; chlorophyll *a* levels 20 to >30 $\mu g l^{-1}$ during bloom; (salinity, temp., dissolved oxygen may be available from NJDEP, DSR)

7. Advected population or in situ growth: *in situ* population of N. atomus

8. Previous Occurrences: Presence of N. atomus first recorded in mid 1960s; intense bloom first noted in 1985; A. anophagefferens detected in 1988.

9. Additional Comments:

10. Individual to Contact:

Paul Olsen
New Jersey Department of Environmental Protection
(609) 633-7003

ALGAL BLOOM REPORTS - UNITED STATES

1. Locations: Throughout Hudson/Raritan estuary into upper NY Bay, Bight area at least to Ambrose Light; NJ coast South to Manasquan Inlet.

2. Date of Occurrence: June 20 to July 1, 1989, most intense June 26-28; (bloom persisted for more than one week)

3. Effects: Amber or golden-colored water over an extensive area; most intense in the estuary and adjacent NJ coast; temporary localized hypoxia in Raritan/Sandy Hook Bay (as low as 3.0 mgl^{-1} on bottom); no significant fish kills reported (as occurred in this vicinity the previous year).

4. Management Decision: NJDEP/USEPA Joint Surveillance. Intensive phytoplankton and dissolved oxygen survey of the area being conducted in response to fish kills which occurred last year; coastal monitoring ongoing. (USEPA/NJDEP joint surveys)

5. Causative Species: *Katodinium rotundatum* (dominant to 5×10^4 cells ml^{-1}) (maximum counts in the estuary and briefly off northern Monmouth County)

   Eutreptia lanowii Abundant
   Cryptomonas sp. Abundant
   Gymnodinium sp. Abundant

6. Environment: Water turbid; chlorophyll a 50 to 170 ugl^{-1} in estuary and adjacent coastal waters; slight water column stratification (in estuary 22.4 °C on surface; 21.4°C on bottom); salinity 18-24 0/00 in the estuary.

7. Advected population or in situ growth: *in situ* population

8. Previous Occurrences: Chronic annual blooms

9. Additional Comments: Bloom preceded by heavy rains the week before and subsequent raw sewage discharges from surrounding urban areas; bloom dissipated by a cold front prior to July 4.

10. Individual to Contact:

Paul Olsen
New Jersey Department of Environmental Protection

(609) 633-7003

ALGAL BLOOM REPORTS - UNITED STATES

1. Locations: Nassau County, Long Island, New York
Near shore L.I. Sound and within the North Shore harbors, especially Hempstead Harbor.

2. Date of Occurrence: Initially observed on August 1,1989, with distinct brown water discoloration.

3. Effects: One possible illness episode later in fall (2 persons with DSP like symptoms) from local clams; awaiting results from new joint NOAA (National Marine Fish)/Mass. State Health project.
UBE test results indicate 2 stations greater than .5 Mu, several between 15 and .05 and several positive, but less than .05 Mu.

4. Management Decision: Increased surveillance and sampling Toxicity testing with new Japanese "UBE" test - check for DSP by ELISA.

5. Causative Species: *Dinophysis acuminata* bloom; Highest observed count = 700,000 cells/liter

6. Environment: Estuarine Immediately succeeding "crashing" diatom bloom of *Eucampia zoodiacus* and *Chaetoceros socialis*

7. Advected population or in situ growth: Most of highest counts came in with the incoming tidal waters; lowest counts usually occurred at low tide.

8. Previous Occurrences: One of our most frequent dinoflagellates

9. Additional Comments: Except for the 700,000 c/l station, where *Dinophysis acuminata* was dominant, this species during this episode was observed as a component of mixed plankton communities, affording shellfish other species for food.

10. Individual to Contact: Anita R. Freudenthal, Ph.D.
Chief, Office of Marine Ecology
Nassau County Department of Health
240 Old Country Road, Mineola, NY 11501
(516) 781-7373; 826-6416

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Florida
   Pinellas and Manatee counties

2. Date of Occurrence: March 23 to May 5, 1989

3. Effects: Dead fish - offshore and beach (Gulfport beach was closed on 4/9)
   Respiratory and eye irritation
   Shellfish harvesting bans

4. Management Decision: Shellfish bans - 3/24-5/5-Pinellas and Manatee counties

5. Causative Species:
   Gymnodinium breve (=Ptychodiscus brevis)
   coastal surface water samples ranged from negative to 850,000 cells/l offshore (up to 10 miles out) surface water samples ranged from negative to 12,700 cells/l, offshore bottom water samples ranged from 1,000 to 14,700 cells/l

6. Environment: Occurred in coastal and nearshore waters with wide salinity (>25^{o}/oo) ranges and nearshore temperatures of 18 to 27.5^{o}C.

7. Advected Population or In Situ Growth:
   Advected population from offshore waters

8. Previous Occurrences: Oct.-Dec. 1988, Jan./Feb., May-July, Sept./Oct. 1987, Sept.-Dec. 1986, Sept.-Dec. 1985, Jan.-March, May-Aug. 1984, Jan./Feb., Oct.-Dec. 1983, Jan.-April, July-Oct. 1982, Sept./Oct. 1981, Jan./Feb., June-Nov. 1980, and before

9. Additional Comments:
   Offshore population probably maintained between January and March 1989; no offshore sampling with depth to confirm

10. Individual to Contact: Dr. Karen Steidinger
    Florida Marine Research Institute
    100 Eighth Avenue S.E.
    St. Petersburg, FL 33701-5095
    (813) 896-8626

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Humboldt County, California areas affected: Humboldt Bay (Mad River, Bird Isl., Indian Isl. Chan., Sand Isl., North Jetty #1 & #2, Comm. Grow Station, Shelter Cove, Trinidad Head, Trinidad Pier, Samoa Bridge (center span)

2. Date of Occurrence: September, October, November 1989

3. Effects: Extremely elevated concentrations of paralytic toxins in sentinel (3500 ug) wild (2200 ug) bay mussels, wild (4400 ug) sentinel (14000 ug) sea mussels, cultured Pacific oysters (270 ug).

4. Management Decisions: Although the annual mussel quarantine was in effect during the bloom an emergency quarantine was initiated for clams, scallops, native oysters, cockles, and other bivalves. The quarantine was extended beyond the Oct 31 normal deadline to Nov 30, 1989.

5. Causative Species: Protogonyaulax catenella

6. Environment: Data not available.

7. Advected Population or In Situ Growth: It appeared to be an in situ growth and it may have been exacerbated by an advected population.

8. Previous Occurrences: 1969, 1973

9. Additional Comments: It is interesting to note that the concentration of toxin of toxin in the oysters was more than ten fold less than that in the mussel samples. Detectable but below alert toxin levels in mussels persisted through the end of December.

10. Individual to Contact:

Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Mendocino County, California areas affected: Bruhel Point, Anchor Bay, Caspar Point, South Caspar Headlands, MacKerricher State Park, Pt. Arena Lighthouse (85 ft depth).

2. Date of Occurrence: September, October 1989

3. Effects: Paralytic toxin levels in wild sea mussels reached a concentration of 6300 micrograms per 100 grams of meat. Rock Scallop adductor from 85 ft depth had detectable toxin (53 ug/100gr)

   Two non fatal cases of paralytic shellfish poisoning, one adult and one two year old child, were reported to the Department of Health Services on Sept. 10, 1989. Both had eaten mussels collected at Anchor Bay Sept. 9th.

4. Management Decisions: The annual mussel quarantine was in force but emergency quarantine was instituted in mid September on the taking of clams, cockles, scallops, native oysters, and other bivalves along the north coast.

5. Causative Species: Protogonyaulax catenella

6. Environment: No available data

7. Advected Population or In Situ Growth: Most probably both conditions existed This bloom first detected August 18 in counties south of Mendocino appeared to be moving northward and increasing in intensity.

8. Previous Occurrences: 1966, 1967, 1975

9. Additional Comments: In November and December the toxin levels had decreased to below the alert level but were in the high detectable concentrations.

   A mussel sample taken at Anchor Bay on Sept. 11, 1989 two days after the those causing the illnesses, yielded a toxin level of 4900 ug/100 gr mussels. The adult who apparently ate about 50 mussels surprisingly developed only mild symptoms including lip numbness and tingling fingers. The two year old child ate about 15 mussels was unable to describe any paresthesia, in the evening lost part of her meal through natural emesis was unable to crawl or walk the next morning

10. Individual to contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Sonoma County, California areas affected: Schoolhouse Beach, Bodega Bay South Jetty, Bodega Head, Mussel Point, Salt Point State Park, Duncan Point/Wrights' Beach, Sea Ranch/Black point.

2. Date of Occurrence: End of January, beginning of February 1989, August, September, October, November, December 1989

3. Effects: Increased Paralytic Shellfish Toxin levels in natural sea mussels and abalone jingle. High detectable concentrations but below alert levels during January and February. From August through October PSP levels increased astronomically to 5500 ug/100gr wild bay mussel, 1900 ug/100 gr wild sea mussel, 2200ug/100 gr sentinel bay mussel.

4. Management Decisions: Quarantine imposed on sport harvesting of mussels during. Jan. Feb. 1989. Public PSP alert via news media describing and warning about the developing bloom and the importance of complying with the annual mussel quarantine was issued in August 1989. The quarantine was extended the October 31 deadline.

5. Causative Species: *Protogonyaulax catenella*

6. Environment: No data available

7. Advected Population or In Situ Growth: Probably both conditions contributed to the bloom but no firm available data exists.

8. Previous Occurrences: 1968, 1976, 1980, 1981, 1987

9. Additional Comments: A count of 26,000 micrograms toxin was obtained from a from a sample of rock scallop viscera from Timber Cove, Sonoma County on August 10, 1980.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Marin County, California areas affected: Drakes Estero areas #12 #17, Drakes Bay Chimney Rock Boat Launch, Kehoe Beach, Stinson Beach, Tomales Bay Lawson's Landing.

2. Date of Occurrence: December 1988, January, February and an isolated occurrence March 4, 1989 Stinson Beach (wild sea mussels).

3. Effects: Paralytic Shellfish Toxin Activity in shellfish; sentinel bay mussels, natural bay mussels, sentinel sea mussels, natural sea mussels, pacific oysters, sentinel Japanese scallops, gapers clams (viscera).

4. Management Decisions: Closure of commercial shellfisheries, emergency quarantine on sport-harvested shellfish from the entire Marin County coastline, which was completely lifted on March 20, 1989.

5. Causative Species: *Protogonyaulax catenella*

6. Environment: No data available.

7. Advected Population or In Situ Growth: No data available but most probably in situ growth. No visible red tide conditions reported for this period, however there was a reference to "the year's highly unusual winter bloom".

8. Previous Occurrences: 1962, 1963, 1964, 1965, 1980, 1982, 1984, 1986, 1988

9. Additional Comments: It would be most helpful if a red tide watch program can be initiated. The environmental data is needed as well as identification of the source of the causative species.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Marin County, California areas affected for the second time: Drakes Bay Chimney Rock, Drakes Estero Area (#7, #8, #12, #20, #38), Limantour Beach, Tomales Bay (Tomales Point, Lawson's Landing, lease M430-11), Rodeo Beach (high and low rock)

2. Date of Occurrence: August, September, early October, December 1989

3. Effects: Elevated paralytic toxin levels as per mouse bioassay per 100 gr meat Japanese scallop (1800 ug), cultured Pacific oyster (360 ug), cultured bay mussel (1500 ug), wild bay mussel (900 ug), sentinel sea mussel (1800 ug), wild sea mussel (210 ug), and unidentified mussel (460 ug)

4. Management Decisions: Department of Health Services issued an immediate public PSP alert via the news media warning about the developing bloom. Since the annual mussel quarantine was still in effect the importance of of complying with it was stressed.

5. Causative Species: Protogonyaulax catenella

6. Environment: No data available

7. Advected Population or In Situ Growth: Both advected and in situ growth ap appeared to have contributed to bloom conditions.

8. Previous Occurrences: 1962, 1963, 1964, 1965, 1980, 1982, 1984, 1986, 1988, and early 1989

9. Additional Comments: Levels of PSP remained under the 80 ug/100 gr alert level but in the high detectable concentrations in Marin County coastal areas to the end of December. Quite a few isolated instances showed levels above the alert concentration.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: San Mateo County, California areas affected: Linda Mar, Moss Beach, Pescadero State Beach, Tunitas Creek

2. Date of Occurrence: From middle of August through September, October, and November 1989

3. Effects: Paralytic toxin levels in wild sea mussels assayed at 800 ug/100 gr although the concentration decreased with time it remained above the level alert level through November.

4. Management Decisions: Annual mussel quarantine was extended beoynd the Oct. 31 deadline. Public PSP alert was issued confirming a potentially dangerous widespread toxic dinoflagellate bloom in progress.

5. Causative Species: Protogonyaulax catenella

6. Environment: No data is available

7. Advected Population or In Situ Growth: In all likleyhood this appears to be in situ growth.

8. Previous Occurrences: 1970, 1971, 1983

9. Additional Comments: In July 1989 measurable but below alert levels of PSP were reported.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Santa Cruz County, California areas affected: Santa Cruz/San Mateo Co. Line, Natural Bridges

2. Date of Occurrence: August, September, October 1989

3. Effects: PSP concentration in wild sea mussels per 100 gr assayed by the mouse method reached 930 ug

4. Management Decisions: Annual mussel quarantine was in effect and public PSP alert was issued.

5. Causative Species: *Protogonyaulax catnella*

6. Environment: No available data

7. Advected Population or In Situ Growth: Both situations may have contributed to the dinoflagellate population.

8. Previous Occurrences: None has been reported

9. Additional Comments: These appear to be new areas where toxic dinoflagellates have encroached. Measurable high levels but below the alert have been assayed.

10. Individual to Contact:

Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Monterey County, California areas affected: Pacific Grove Point Pinos, Pfeiffer Beach Big Sur

2. Date of Occurrence: August 18, December 1989

3. Effects: Slight eleveation of PSP in wild sea mussels/100 gr (110 ug) in August, and in December (130 ug)

4. Management Decisions: Annual mussel quarantine was in effect and in December emergency quarantine was issued.

5. Causative Species: Protogonyaulax catenella

6. Environment: No available data

7. Advected Population or In Situ Growth: May have been an advected population

8. Previous Occurrences: None

9. Additional Comments: Measurable levels of toxin below alert were assayed in August and September however in December levels surpassed the alert concentration.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: San Louis Obispo County, California areas affected: Moro Bay, Moonstone Beach, Cambria, North Estero Bay, Estero Bay Cayucos.

2. Date of Occurrence: Late August, September, October, December 1989

3. Effects: Paralytic toxin levels elevated in shellfish - cultured and wild bay wild bay mussels, wild sea mussels, and cultured pacific oysters reaching 1600 micrograms in sea mussels and 540 micrograms in oysters.

4. Management Decisions: The annual mussel quarantine, May 1 to October 31, was in was in effect, however in December emergency quarantine was issued and. commercial oyster operations in Moro Bay were shut down.

5. Causative Species: Protogonyaulax catenella

6. Environment: No data available

7. Advected Population or In Situ Growth: The bloom originated in San Louis Obispo and Santa Barbara Counties.

8. Previous Occurrences: 1979

9. Additional Comments: This area has been fairly free of toxic episodes until now, however it must be monitored more aggressively in the future.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Santa Barbara County, California areas affected: Civilian Beach, Minute Man Beach, Santa Barbara Channel

2. Date of Occurrence: Mid March, mid April, early May, early June, early July, mid October, mid December 1989

3. Effects: Detectable but below alert levels of PSP throughout the year in in cultured and wild bay mussels as well as in wild sea mussels. In Oct. and Dec. the levels of PSP in wild sea mussels exceeded the alert level.

4. Management Decisions: Mussel quarantine was issued in December

5. Causative Species: Protogonyaulax catenella

6. Environment: No available data

7. Advected Population or In Situ Growth: Because of the persistence of the detectable PSP levels this may be in situ growth.

8. Previous Occurrences: 1978, 1985

9. Additional Comments: The PSP level detected in 1985 reached 41,000 micrograms per 100 grams of mussel meat. This area must be monitored very carefully and more closely.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Ventura, Los Angeles, Orange, San Diego - California Counties Throughout the year isolated incidences of detectable high but below the alert paralytic toxin concentrations have been reported.

2. Date of Occurrence: January & October (Orange), July & October (Los Angeles), January (San Diego)

3. Effects: None

4. Management Decisions: Annual Mussel Quarantine in force May 1 - October 31 of each year.

5. Causative Species: Protogonyaulax catenella

6. Environment: No data available

7. Advected Population or In Situ Growth: Have no data

8. Previous Occurrences: 1972 Los Angeles County, 1974 Orange County

9. Additional Comments: A red tide condition was observed by Dr. Ross on July 2, 1989 in Ventura County. I was unable to identify the organism. Since at that time I was at the beginning of a week long vacation on our sailboat I could not collect a sample for future identification. The Water temperature was 65 degrees F; the extent of the red waters approximately 1 mile wide located Southwest of the Oxnard breakwater. Was unable to find a report regarding this episode. Ventura County does not submit samples for assay of toxin levels on regular bases, however, during this period samples were submitted and no detectable toxin concentrations were found.

10. Individual to Contact: Dr. Maria R. Ross
Biology Department
University of California at Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024
(213) 206-3528

1. Locations: Cypress Island, Washington
   Port Angeles, Washington

2. Date of Occurrence: Cypress Island: peak fish mortality occurred from 5-9 September 1989
   Port Angeles: 8-10 September 1989

3. Effects: Massive kills of Atlantic salmon in net pens; also chinook salmon and rainbow trout. The smallest fish survived; larger fish died first, especially brood stock.

4. Management Decision: Rapid harvest of dead and moribund fish; stopped feeding and other activity around the pens. Port Angeles had more warning and placed tarps around the pens to cut down water circulation. Port Angeles had little loss.

5. Causative Species: Heterosigma akashiwo (Hada) Hada

6. Environment: warm sunny weather, calm conditions; water temperature 17-18°C in shallow (ca. 1 m deep) water. Cells generally concentrated in upper 2 m of water.

7. Advected population or in situ growth: May have been advected from British Columbia and probably associated with the Fraser River plume or plume fringe.

8. Previous Occurrences: Probably in same area in 1976. There has been no systematic monitoring at Cypress Island in previous years and there was no evidence of Heterosigma occurrence at Port Angeles in 1988 where monitoring was done.

9. Additional Comments: Losses to three farms and four separate net-pen systems: 2,000,000 lbs or about 95% of the total crop.

10. Individual to Contact: Rita Horner
    School of Oceanography WB-10
    University of Washington
    Seattle, WA 98195

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: American Lake
Pierce County, Washington

2. Date of Occurrence: 18 November 1989 (first reported animal illness) to present (10 January 1990). The toxic bloom is still present.

3. Effects: As of 10 January 1990, there have been 5 dead cats, 1 ill cat, 1 dead dog, 5 ill dogs, and 3 dead waterfowl that are suspected to have been due to the algae. A few necropsys have been performed, but were inconclusive.

4. Management Decision: Media notified; fact sheets distributed to residents around the lake, public access sites posted with warning signs. Some treatment was attempted using copper sulfate, but was, for the most part, ineffective.

5. Causative Species: *Anabaena flos-aquae* The toxin is Anatoxin-A.

6. Environment: Water temperature has been about 9.0-10.0 C, specific conductivity has been measured from 118 to 147 µmhos/cm; pH ranged from 7.2-7.8. A few fecal coliform samples have been collected and found to contain between 45 and 61 fc/100 ml.

7. Advected Population or In Situ Growth: In situ growth

8. Previous Occurrences: None in the area that we know about.

9. Additional Comments:

10. Individual to Contact: Ray Hanowell
Tacoma-Pierce County Health Department
3629 South D St.
Tacoma, WA 98408

(206) 596-2845

HARMFUL ALGAL BLOOMS IN 1989 - UNITED STATES

1. Locations: Oregon coast (see attached sheets)

2. Date of Occurrence: Elevated levels of PSP in shellfish collected in October and November 1989. Closures from 15-28 November 1989

3. Effects: None reported in humans

4. Management Decision: Closure of portions of the central Oregon coast during time of elevated PSP as tested by the Oregon State Health Division

5. Causative Species: Gonyaulax catenella appears to be the causative species, but the Oregon State Health Lab did not screen for this.

6. Environment: Shallow waters of central Oregon coast

7. Advected Population or In Situ Growth: Uncertain

8. Previous Occurrences: Unknown in Lincoln County; last occurrence on north Oregon coast in July 1987

9. Additional Comments:

10. Individual to Contact: Gail Stater/John Paeth
Lincoln County Health Department
255 SW Coast Hwy.
Newport, OR 97365