Intergovernmental Oceanographic Commission
Reports of Governing and Major Subsidiary Bodies

IOC-FAO Intergovernmental Panel on Harmful Algal Blooms

First Session

Paris, 23-25 June 1992

UNESCO

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IOC-FAO/IPHAB-I/3
Paris, 23 October 1993
Original: English*

* For reasons of budgetary constraints, some of the Annexes have to remain untranslated and appear in English in the French, Russian and Spanish texts of the Report.

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SUMMARY REPORT

ANNEXES

1. OPENING

1 The First Session of the *Ad hoc* IOC-FAO Intergovernmental Panel on Harmful Algal Blooms (IPHAB) was held in Paris, 23-25 June 1992. On behalf of the Secretary IOC, who was unable to attend the opening, Prof. T. Osborn, Senior Assistant Secretary for OSLR, opened the Session and welcomed the participants who included Members representing 14 nations. The List of Participants is included as Annex III.

2 The Senior Assistant Secretary for OSLR addressed the Panel and stressed that the understanding and prediction of, and management responses for, harmful algal blooms are major concerns throughout the world. An important topic of discussion at a number of recent international conferences and workshops, has been whether a sustained global increase in the frequency, magnitude and distribution of harmful blooms is occurring in coastal waters, perhaps as a result of humankind's activities. Regardless of whether such an expansion is occurring, however, it is clear that the study and management of harmful algal bloom phenomena are major concerns throughout the world. The time is long overdue for an effort to co-ordinate, standardize and accelerate our efforts.

3 The IOC Assembly, at its Sixteenth Session, Paris, 7-21 March 1991, through Resolution XVI-4, formed an *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms in order to identify adequate resources for a sufficiently broad programme to solve some of the real problems caused by harmful algae. The Intergovernmental Panel was described as the key intergovernmental mechanism needed to address resource gaps. The Senior Assistant Secretary for OSLR urged that the HAB Panel be used intersessionally to identify and obtain new resources for critical Harmful Algal Bloom Programme (HAB Programme) elements. He concluded by suggesting that the HAB Panel identify specific actions required of responsible parties and support their recommendations to the IOC Assembly.

4 Mr. G. Gabrielides welcomed the participants on behalf of FAO, noted that FAO had agreed to co-sponsor the Panel, subject to no cost to FAO, and expressed the interest of his organization in the HAB Programme, especially the operational elements dealing with resource and aquaculture development and seafood quality.

5 At a later stage of the Session the Secretary IOC, Dr. Gunnar Kullenberg, addressed the participants and recognized that additional support from Member States would be needed to fully implement the HAB Programme. He noted the close interrelationship between harmful algae and the associated problems of mariculture and coastal zone-management, and the overall needs for research on, and better management of, the living resources in the oceans. He recalled that significant emphasis is given to management and conservation of Living Resources in Chapter 17 of Agenda 21, United Nations Conference on Environment and Development, UNCED, Rio de Janeiro, 1992, and that the Convention on Biodiversity will require consideration of the role of the ocean in the global ecosystem and biodiversity. The marine science community and the IOC have a large responsibility to respond to these results. The Secretary IOC pointed out that the goals of a focused programme such as the HAB Programme should be seen in this context, as one element in our effort to improve management and conservation of living resources. The Secretary IOC also recalled the considerations of the IOC Executive Council at its Twenty-fifth Session on the possible establishment of an IOC secretariat for the HAB Programme (see item 8.2 and Annex VIII).

1.1 OBJECTIVES OF THE *Ad hoc* INTERGOVERNMENTAL PANEL ON HARMFUL ALGAL BLOOMS

6 The Terms of Reference, as set out in Resolution XVI-4 of the Sixteenth Session of the IOC Assembly (Annex III), and the objectives of the Panel were outlined by the Senior Assistant Secretary for OSLR.

2. ADMINISTRATIVE ARRANGEMENTS

2.1 ADOPTION OF THE AGENDA

7 **The Panel adopted** the Agenda as given in Annex I.

2.2 ELECTION OF CHAIRMAN AND DESIGNATION OF RAPPORTEUR

8 **The Panel adopted** the proposal by Germany to elect Dr. B. Dybern (Sweden) as Chairman and Mr. Z. Mingyuan (China) as Vice-Chairman. The Panel adopted the proposal by Sweden to elect Dr. J. Alheit (Germany) as Rapporteur for the Session.

3. SUMMARY DESCRIPTION OF THE HAB PROGRAMME : SCIENCE BACKGROUND AND GOALS

9 The Senior Assistant Secretary for OSLR summarized the scientific background and goals for the HAB Programme. He outlined how harmful algal blooms have occurred throughout recorded history, yet the public health and economic impacts of these phenomena have increased during the last several decades. This expansion relates in part to the increasing exploitation of coastal waters (due to waste disposal, aquaculture, maritime commerce and other anthropogenic influences), as well as to the dispersal and proliferation of algal populations associated with natural oceanographic and meteorological processes. There are short-term, medium-term and long-term aspects to the problems arising from harmful algal blooms. In the short-term, the emphasis must be on mitigating effects of harmful algal events. In the medium-term, the focus will be on understanding, modelling and prediction, with the eventual long-term focus of preventing or eliminating the problems. The overall goal of the HAB Programme, as indicated below, embraces these 3 time scales as well as the range of related scientific and administrative problems:

> **To foster the effective management of, and scientific research on, harmful algal blooms in order to understand their causes, predict their occurrences, and mitigate their effects.**

10 There are two major divisions of the problem - scientific and operational. The scientific programme can be separated into 3 branches : ecology and oceanography; taxonomy and genetics; and toxicology and toxin chemistry. The operational problems can be divided into 4 branches : resource and aquaculture management; information network and training; monitoring; and public health and seafood safety. There are many interactions between the divisions, e.g., fisheries management questions benefit from knowledge of the ecology and dynamics of blooms; monitoring is based on information about ecology, oceanography, taxonomy, and toxicity.

Scientific Programme Elements

i) Ecology and Oceanography : to understand the population dynamics of harmful algae;

ii) Taxonomy and Genetics : to discriminate the causative organisms at the appropriate levels;

iii) Toxicology and Toxin Chemistry : to determine the physiological and biochemical mechanisms responsible for toxin production and accumulation, and to evaluate the effect of phycotoxins on living organisms.

Operational Programme Elements

iv) Resource and Aquaculture Management : to develop and improve methods to minimize the environmental and economic consequences of harmful algal blooms;

v) Information, Network and Training : to develop, maintain and co-ordinate a flow of information, technology and expertise to scientists and administrators;

vi) Monitoring : to assist and facilitate the development and implementation of appropriate monitoring programmes;

vii) Public Health and Seafood Safety : to protect public health and ensure seafood quality.

4. HAB IN THE CONTEXT OF RELEVANT PROGRAMMES OF UNEP, EEC, ICES AND SCOR

11 The Representatives of UNEP, EEC, ICES and SCOR were invited to outline their activities related to harmful algae and how these interact with a global programme on harmful algal blooms.

UNEP

12 Mr. G. Gabrielides highlighted UNEP's activities in the field of eutrophication and algal blooms undertaken in the framework of the regional seas programmes and especially the Mediterranean Action Plan. Studying eutrophication and concomitant plankton blooms has been one of the research activities of MEDPOL Phase II and a number of projects have been executed throughout the region. Recently, contracting parties to the Barcelona Convention decided that 50% of the MEDPOL research budget for the biennium 1992-1993 should be utilized for eutrophication and plankton blooms. An experts' group recommended the initiation of case studies in specific Mediterranean waters and such case studies are now under preparation. The programme aims at assessing the extent of the problem and the impact of actions under different scenarios; also at analyzing the effects of reducing nutrient inputs. The best tool for achieving the objectives would be a model, the development of which will form the basis of the programme.

EEC

13 The representative of the Commission of European Communities, Dr. C. Lancelot, outlined which aspects of HAB-related problems, relevant projects funded in the scope of Research and Development Programmes (4th, 5th, & 6th Environment Programme, MAST Programme) are focussing on. She brought to the Panel's attention the possibilities within the Environment and MAST Programmes for funding of training activities, workshops, meetings and field experiments. A sessional working group chaired by the United Kingdom was established to explore possibilities for a closer co-operation between institutions involved in HAB research and the European Community. An outline of the Research and Development Programmes of the CEC is included in Annex V.

14 Among the European countries it was decided to try to establish a "Scientific and Technical Co-operation Network on Harmful Phytoplankton" under the "Human Capital and Mobility Programme" of the Commission of the European Communities. It was agreed that IOC could serve as co-ordinator of this effort. The main aim of the scientific and technical co-operation networks of the Commission of the European Communities is the training of research scientists by mobility and the formation of networks.

ICES

15 Dr. B. Dybern introduced the International Council for the Exploration of the Sea (ICES) to the Panel. ICES deals with the North Atlantic area, in Europe from the Arctic Sea to Southern Spain, including the North Sea and the Baltic Sea, and on the American side from the Arctic Sea to about Cape Hatteras, including Greenland. There are two main lines in the work : i) fisheries and the productivity of the sea; ii) the natural and the man-influenced environment, especially in relation to fish and production. Besides a council and a bureau, ICES has a number of subject and advisory committees and about 80-85 working groups, study groups and planning groups, etc. A number of symposia and workshops are also arranged each year. The working groups and study groups, etc., report to one or two of the committees which generally meet at the ICES statutory meetings once a year.

16 Algae blooms have occurred many times in the ICES area and have caused considerable loss for fishery and aquaculture. Plankton research has for a long time been important and a number of working groups have in the past dealt with zooplankton and phytoplankton, mainly in connection with production questions. Presently dealing with plankton is the Working Group on Phytoplankton and the Management of their Effects which covers a wide field of plankton research. Recently, the Study Group on the Dynamics of Harmful Algal Blooms was established. It had a meeting in Vigo, Spain, on 6-9 April 1992, which was co-sponsored by IOC. Some other working groups within ICES are more indirectly interested in plankton and production problems, e.g., the Working Group on Shelf Seas Oceanography and the Baltic Marine Environment Working Group. ICES, with support from other organizations, also arranged the Symposium on Measurement of Primary Production from the Molecular to the Global Scale in La Rochelle, France, at the end of April 1992.

17 ICES has been involved in or has taken interest in a number of meetings and conferences arranged by other organizations, e.g., in IOC Executive Council and General Assembly meetings where the HAB Programme has been initiated and dealt with. ICES has also supported the setting up of the SCOR Working Group on the Physiological Ecology of Harmful Algal Blooms last year (1991), and there will certainly be close co-operation between that group and the ICES-IOC Study Group on Plankton Dynamics.

18 This short résumé may show that ICES is very interested in the problem of harmful algal blooms and that there is quite a lot to experience with several activities going on dealing with both the scientific and the management viewpoints. ICES is ready to take continued interest in the HAB Programme.

SCOR

19 The Scientific Committee on Oceanic Research (SCOR) was established in 1957 by the International Council of Scientific Unions (ICSU). It is the oldest of ICSU's interdisciplinary scientific and special committees, including scientists from the traditional oceanographic sub-disciplines of biology, physics, chemistry and geology and geophysics. SCOR is a Non-Governmental Organization (NGO) with member committees in 37 countries. The primary objective of SCOR, according to its Constitution, is to *"further international scientific activity in all branches of oceanic research"* - this is done through the establishment of subsidiary bodies to address specific scientific problems. Working Groups are established to undertake well-defined tasks which can reasonably be completed in a short time (from 2 to 6 years at most). The final product of SCOR Working Groups is expected to be a major publication or the organization of an international meeting which significantly advances the state of understanding of a topic.

20 In order to maintain the momentum of its activities, SCOR automatically assumes that each Working group is to be disbanded at the beginning of each SCOR General Meeting, and the reports received from each group must present adequate justification for its re-establishment for an additional two-year period. In combination with an increased effort on the part of the SCOR Executive Committee to ensure that the Terms of Reference for Working Groups are fairly narrowly focused, this approach has been successful in increasing the pace of their activities and in reversing the tendency to establish "open-ended" groups with indefinite lifetimes.

21 SCOR co-sponsored the Workshop on Programme Development and is continuing its commitment to the study of problems associated with harmful algal blooms with the establishment of a Working Group on the Physiological Ecology of Harmful Blooms (see 6.3).

5. HAB PROGRAMME INTERACTION WITH OTHER IOC AND FAO PROGRAMMES, AND SUBCOMMISSIONS

5.1 TRAINING, EDUCATION AND MUTUAL ASSISTANCE (TEMA)

22 The Senior assistant Secretary for TEMA, Dr. K. Kitazawa introduced the item. The IOC Committee for Training, Education and Mutual Assistance in Marine Science (TEMA), reconfirmed at its Fifth Session, Paris, 25 February - 1 March 1991, that elements of the TEMA Programme should be considered as inherent parts of the subject area programmes of IOC and that the TEMA Programme should operate in close liaison with both the global subject area programmes and their regional components. Strengthening of marine research capabilities relative to on-going programmes of the Commission should be carried out through :

(i) developing subject-oriented training packages for individual and group training;

(ii) organizing training courses and workshops at regional and global levels;

(iii) award of grants;

(iv) improvement of co-operation and mutual assistance between the developing and developed countries participating in the IOC programmes, and

(v) strengthening of the IOC Voluntary Co-operation Programme (VCP).

23 TEMA actions should accordingly respond to needs of individual Member States and needs of global, regional and sub-regional programmes. Therefore, each IOC programme should, in its implementation, include TEMA actions defined on the basis of the programme requirements. Each individual Member State should, depending upon its own commitment and priorities, define its needs with respect to TEMA, through appropriate mechanisms, including expert advice from IOC and UNESCO.

24 The regional structures created by IOC (e.g., IOCARIBE, WESTPAC) provide a potential mechanism to identify particular regional problems/needs and possible solutions to priority problems of interest to developed and developing Member States and thus help define and establish partnerships based on mutual interest in the marine environment and its development.

25 Dr. K. Kitazawa recommended that the subject programmes of IOC such as the HAB Programme, identify their goals and needs of capacity building not only in training and education, but also in provision of research facilities, as well as ways and means to these activities.

26 The Panel had a thorough discussion on training needs and requirements, particularly for developing countries, with reference to the HAB Programme. It recognized that training is an important element for the HAB Programme. In this context, it welcomed the initiative of the "Bremen Maritime Training Centre", Germany, to organize an international workshop on training aspects within the HAB Programme (Bremerhaven, 29 September - 3 October 1992). The German Delegation informed that the objectives of this workshop are to discuss and identify training needs and requirements in developing countries with respect to the HAB Programme. Based on the results of this Workshop, Germany will launch a training programme in the field of harmful algal blooms which will be particularly tailored to the needs of developing countries. The Panel recommends the IOC Secretariat to support this initiative and to assist in ensuring that a sufficient number of participants from developing countries will be able to attend the Bremerhaven Workshop.

27 **The Panel stressed** that training and knowledge transfer should have a high priority in the planning and implementation of the HAB Programme. The Chairman urged the Panel to provide the IOC Secretariat with proposals for training activities, and to investigate possibilities for co-sponsorship between national institutions and the international organizations.

5.2 GLOBAL INVESTIGATION OF POLLUTION IN THE MARINE ENVIRONMENT (GIPME)

28 Dr. C. Ibe, Senior Assistant Secretary for the GIPME Programme, informed the Panel of the activities undertaken within the Global Investigation of Pollution for the Marine Environment (GIPME) Programme. He outlined two levels of activities, the global and the regional which is essentially marine pollution monitoring, MARPOLMON. At the global level, programme implementation is carried out by three Groups of Experts: Group of Experts on Methods, Standards and Intercalibration (GEMSI), Group of Experts on Effects of Pollutants (GEEP) and Group of Experts on Standards and References Material (GESREM), whose activities under MARPOLMON are pursued through a network of national and regional laboratories.

29 GIPME is interested in the problem of harmful algal blooms because of the implications for public health and protection of living marine resources. For the GIPME Programme the problem is not just a peripheral one needing only a cursory attention, but indeed, it constitutes a core concern meriting attention and investment in resources. To illustrate this, he pointed out that during the Seventh Session of the Committee for GIPME, Paris, 21-25 January 1991, a small *ad hoc* group was set up to study issues of predominant concern identified within the regional elements of GIPME/MARPOLMON. Eutrophication was identified as a recurring problem in all but two of the 17 regions investigated. Similar conclusions had been recorded in 1989 by the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP).

30 In view of an increasing body of emerging knowledge that link harmful algal blooms to eutrophication and, by implication, to anthropogenic impacts, the IOC Committee of GIPME decided to make the subject of harmful algal blooms a major focus of its intersessional activities at its Seventh Session.

31 He noted that standardization of methods, improvement of such methods, identification of standards and reference material are core targets in several branches of the HABloom Programme.

32 The concerns obviously represented opportunities for co-operation with GIPME Groups of Experts, especially GESREM and GEEP but he also saw a major role for GEMSI where members have considerable experience in Quality Assurance/Quality Control Programmes. For example, the next GESREM meeting in September 1992 has the production of algal toxins and pigments/algal cultures on its agenda and the HAB Programme is invited to send representatives to this meeting. He therefore, called for co-operation between the two programmes in a way that would be mutually reinforcing and beneficial and announced that he would be willing to include Members of the HAB Programme in relevant Groups of Experts at GIPME.

33 The Senior Assistant Secretary for the GIPME Programme announced that as a potential demonstration of the envisaged co-operation, GIPME would be supporting participants to an international workshop on training aspects within harmful algal blooms and eutrophication in Bremerhaven, Germany, September 1992 (see 5.1).

5.3 IOC SUB-COMMISSION FOR THE CARIBBEAN AND ADJACENT REGIONS (IOCARIBE)

34 The IOC Secretariat informed the Panel about the regional Workshop on "Red Tides and Mass Mortality of Marine Organisms in the Caribbean". The Workshop will be held at Instituto Oceanografico de Venezuela, Universidad de Oriente, Cumana, Venezuela, 17-19 September 1992. The Workshop is supported through the IOCARIBE Programme of IOC. The main purpose of the Workshop is to analyze information on mortality of marine organisms in relation to harmful algal events in the greater Caribbean region. Also, it aims to plan for implementation of the ideas expressed by the *ad hoc* Group of Experts on Mass Mortality of Fish appointed by IOCARIBE in 1982.

35 The *ad hoc* Group of Experts submitted to IOCARIBE a report dealing with emergency plans in case of mass mortality of fish. The recommendations of the *ad hoc* Group are enclosed as Annex XI. These recent and past activities provides the basis for initiation of an IOC/IOCARIBE regional programme on Harmful Algal Blooms as a component of the global IOC-FAO Programme on OSLR.

5.4 IOC SUB-COMMISSION FOR THE WESTERN PACIFIC (WESTPAC)

36 The IOC WESTPAC region and the activities of the Sub-Commission on harmful algae was presented by Dr. D. Anderson. The IOC WESTPAC project on "Toxic and Anoxic Phenomena Associated with Algal Blooms" reflects the concern of WESTPAC Member States on the increasing inputs of harmful algae on coastal fisheries resources. Unfortunately, as these problems increase, the WESTPAC countries are frequently finding themselves less able to manage the affected resources. At the Second WESTPAC Symposium in Penang, Malaysia (2-6 December, 1991), the scientists met and discussed recent harmful algal events and planned strategies for training, research and networking in the coming years. It soon became clear that in the years since the last meetings of the Task Team in 1984 and 1987, the nature of the HAB problem has changed considerably in the WESTPAC region. When formerly, the predominant problem was paralytic shellfish poisoning (PSP) caused by the dinoflagellate *Pyrodirium bahamense*, countries are now threatened by several other PSP producing species, as well as other species that cause massive mortalities of fish and shrimp, both farmed and wild. These new problems threaten the rapidly growing aquaculture industry in the region.

37 At the Penang Symposium, a series of recommendations were formulated (Annex X). Implementation of these recommendations will be determined by the rate at which funding or other resources become available. At present, the WESTPAC budget is limited, and allocations have thus far only been made for the creation of a methods manual from regular budget. In addition, plans are underway for a regional HAB newsletter.

38 The Panel urged its members from the WESTPAC region to approach their governments and seek support for the WESTPAC sub-programme on harmful algal blooms.

6. STATUS OF HAB PROGRAMME ACTIVITIES AND PRIORITIES

6.1 *Ad hoc* PLANNING COMMITTEE ON THE HAB PROGRAMME

39 The expert groups and planning committees developing the HAB Programme have so far been established on an *ad hoc* basis. In order to ensure a well balanced planning and steering of the HAB Programme, a formalized guiding group of experts covering the related scientific and operational elements is required.

40 Based on a thorough discussion the Panel urged the IOC and FAO Secretariats to elaborate the Terms of Reference for the Guiding Group of Experts (see Recommendation IPHAB-I.3).

6.2 HARMFUL ALGAE NEWS, AN IOC NEWSLETTER ON TOXIC ALGAE AND ALGAL BLOOMS

41 The state of the IOC Newsletter on toxic algae and algal blooms "Harmful Algae News" was presented by the Editor, Dr. T. Wyatt. Currently, 7,000 copies of the Newsletter are distributed. Since the first issue was published in early 1992, the interest in receiving the "Harmful Algal News" on a regular basis has been

very strong. The Editor urged the Panel Members to advertise the existence of the newsletter at a national level and encourage scientists and managers dealing with harmful algae to contribute material for "Harmful Algal News". The Editor noted that his initial term as editor of the two first issues had ended, but that he was prepared to continue, if approved by the Panel.

42 **The Panel noted** with satisfaction the development of the Newsletter and encouraged the IOC Secretariat to continue its efforts and to distribute the Newsletter as widely as possible. **The Panel acknowledged** Dr. T. Wyatt's efforts as Editor and urged him to continue. Dr. Wyatt accepted.

6.3 SCOR-IOC WORKING GROUP ON THE PHYSIOLOGICAL ECOLOGY OF HARMFUL BLOOMS

43 SCOR established a Working Group at the SCOR Executive Council meeting, 12-14 November 1991, in Hamilton, New Zealand, to examine available data on the physiological ecology of harmful blooms. Dr. D. Anderson has been asked to chair the Working Group, and the membership is now being finalized. The Terms of Reference are :

(i) to review and analyze data on the physiological ecology and biochemical aspects of harmful algal blooms, especially those resulting in toxic episodes, paying particular attention to nutritional, environmental and physiological factors; and

(ii) to assemble within two years the Working Group findings and submit for publication a report summarizing the state of knowledge and identifying the areas of future research. ICES and IOC are being asked to co-sponsor this group.

The Panel noted with satisfaction the establishment of the Working Group.

6.4 ICES-IOC STUDY GROUP ON THE DYNAMICS OF HARMFUL ALGAL BLOOMS

44 Mrs. B. Reguera, Chairman of the ICES-IOC Study Group on the Dynamics of Harmful Algal Blooms, introduced the Study Group. The Group met in Vigo, Spain, 7-9 April 1992, to design and propose a programme for studying the dynamics of Harmful Algal Blooms. It was agreed that a population dynamics approach would be the most suitable way to attain a substantial improvement in our knowledge about the initiation, proliferation and dissipation of harmful algal populations. This multi-national, multi-disciplinary research programme is intended to include modelling, experimental and field components. The research programme requires investigators from several countries to work simultaneously in the same localities, in order to have the necessary variety of expertise. As well, sequential field studies in different localities will help to resolve the world-wide variation in the population dynamics of harmful algae.

45 The activities of this group can be considered as a development, by ICES, of the "Ecology and Oceanography" box from the Scientific elements of the IOC programme on Harmful Algal Blooms (IOC Workshop Report No. 80, pp. 7,8 & 14). The setting of this group was recommended at the last ICES Statutory Meeting by the Chairpersons of the Hydrography and the Biological Oceanography Committees. The Terms of Reference were : *"to plan and propose a programme to study the dynamics of HABs in coastal oceans"*. The ultimate goal of the programme for each regional case, would be to develop a numerical model that allows an accurate prediction of the blooms. A population dynamics approach to the study of the blooms was recommended, and the ways to evaluate the different gain and loss terms to the system were discussed. Four projects (Iberia (Spanish-Portuguese Atlantic Coast); Gulf of Maine (USA); Skagerrak/Kattegat (Scandinavia, and Mesocosm Experiments) were chosen as suitable sites where a pilot programme could be developed. The Mesocosms Experiments, will be independent as well as supportive to the field experiments. A common characteristic of the projects is that they are sites that experience recurrent blooms of the noxious species, and that basic information about the timing and circumstances of their occurrence is already available.(see 6.4).

46 **The Panel noted** with satisfaction the progress of the Study Group. Several participants suggested to work towards expansion of the Study Group to other geographical regions.

6.5 IOC TRAINING COURSE ON THE TAXONOMY OF HARMFUL MARINE PHYTOPLANKTON

47 The IOC Secretariat informed about an IOC Training Course on the Taxonomy of Harmful Marine Phytoplankton. The course is planned for late Summer 1993 at the University of Copenhagen. The organization will be a joint effort between the Danish Development Aid Agency (DANIDA), the University of Copenhagen and IOC. Together with the outcome of the Bremen Workshop in September 1992 (see item 5.1) the experience from this course will serve as a background for a more comprehensive training programme including several aspects of harmful algae events. The feedback will be valuable for the formulation of objectives and target groups for a future training programme.

6.6 IOC DIRECTORY OF EXPERTS

48 Dr. D. Anderson introduced the plans for an updated edition of the International Directory of Experts in Toxic and Harmful Algal Blooms and Their Effects on Fisheries and Public Health, first published in 1990. The first edition has been a very useful resource for scientists and managers. It is already out of date, however, due to the mobility of HAB scientist and agencies, and to the expansion of the research and management community. An agreement has been reached between Dr. A. White of the US National Marine Fisheries Service and the IOC to produce a new updated and expanded directory. Questionnaires are now being distributed to the international HAB community to collect the appropriate information. The plan is for the directory to contain information on 800 individuals, with eventual distribution of 2,000 copies through UNESCO.

49 **The Panel noted** the importance and usefulness of an updated directory of experts and managers and encouraged the IOC Secretariat to proceed with the publication.

6.7 UNESCO-IOC MANUAL ON HARMFUL MARINE PHYTOPLANKTON

50 On behalf of the potential Chief Editor of a Manual on Harmful Marine Phytoplankton, Dr. G. Hallegraeff, Dr. D. Anderson outlined the proposal. Developing countries have very limited access to outside literature and limited finances to buy books or to travel to overseas conferences. There is a need for a UNESCO-style manual (similar to the Phytoplankton Manual in the series Monographs on Oceanographic Methodology) which compiles widely different information on the taxonomy, toxicology and epidemiology of harmful algal blooms, and which should be distributed freely to developing countries. The IOC has agreed to support the creation and distribution of this manual, and Dr. G. Hallegraeff has accepted the responsibility as Chief Editor. Other editors are now being contacted, as are contributors for the many individual chapters.

51 **The Panel noted** with satisfaction the initiative and recognized the strong need for such a manual. The Panel encouraged as well the preparation of manuals with a regional focus.

6.8 INTERNATIONAL SOCIETY

52 **The Panel was informed** about the plans to form an international (harmful algal bloom) society. The society will be independent of any one country or organization, but attached to an international body such as the International Council of Scientific Unions (ICSU). Dr. T. Smayda, University of Rhode Island, will act as co-ordinator for the preparation of a proposal to be presented at the Sixth International Conference on Toxic Marine Phytoplankton to be convened in Nantes, France, October 1993.

53 **The Panel noted** with interest the plans for an international society. The Panel recognized the importance of such a society with respect to its potential contribution towards increasing communication and continuation of the broad interaction over the span of involved subjects.

7. NATIONAL STATEMENTS

54 National statements of Canada, China, France, Germany, Greece, Ireland, Italy, Japan, Mexico, Philippines, Spain, Sweden, UK and the USA on activities on harmful algae are summarized in Annex V.

8. IDENTIFICATION OF RESOURCE ISSUES REQUIRING NATIONAL ATTENTION

8.1 REVIEW OF THE PROGRAMME PLAN

55 **The Panel reviewed** in detail the Programme Plan outlined in IOC Workshop Report No. 80. Several corrections and adjustments were made. With background in the thorough discussions on the importance of training, information and network-building the Panel found that the training and network activities listed under Operational Elements should be emphasized by being a separate Educational Element of the Programme. After revision, the Programme consisted of three elements: A Scientific Element, an Operational Element and an Educational Element. The revised outline of the Programme is included as Annex VI. **Recommendation IPHAB-I.1 was adopted.**

8.2 REVIEW OF RESOURCES

56 Resource and action items emerging from the Session (IPHAB-I) were reviewed. These included actions for the IPHAB, for Member States and for Intergovernmental bodies.

57 It was stated that such a comprehensive undertaking as suggested in the Programme Plan on Harmful Algal Blooms demands quite a lot of resources. Both the need for, but also in many cases the availability of, different resources had been indicated in several contexts previously during the meeting, e.g., in connection with the statements of organizations, the national statements and the review of the Programme Plan.

58 It was considered that the need for more resources is most pronounced in developing countries and that developed countries in many cases could assist in filling these needs. On-going activities in ICES, SCOR and other NGO's and GO's could be of great help if extended to contain direct assistance to developing countries, and it was noted with satisfaction that IOC and FAO would do their best to facilitate resource transfer not the least through sub-programmes such as TEMA, GIPME and the Mediterranean Action Plan. It was also pointed out that the experience within WESTPAC could be of great help when planning activities in other regions and especially those including developing countries.

59 Since the problem of harmful algae is global, with local implications, it is suitable for Global Environment Facility (GEF) funding. A programme proposal should be prepared on basis of the IOC-FAO Programme on Harmful Algal Blooms and Panel Members should help obtain support in their governments for the proposal through their national focal points for GEF.

60 It was stated that training (including transfer of literature, preparation of manuals and spreading of the high-quality and informative Newsletter "Harmful Algae News") be the most important kind of resources, especially during the initial phase of HAB Programme. In addition to the training needs there is also a need for resources to carry out experimental work with multinational participation. This will require resources such as instrumentation, shiptime and other equipment. In this context the importance of co-ordination, not only on the national, but indeed on the regional and international levels was pointed out.

61 The IOC and FAO Secretariats were asked to look more specifically into these matters in the intersessional period and in particular to investigate how resources could be transferred from developed to developing countries.

62 **The Panel supported** the proposal on the establishment of an IOC-FAO HAB Programme Office to deal with matters related to development and implementation of a global research and management programme on harmful algal blooms. **The Panel reviewed** the Terms of Reference for the IOC-FAO HAB Programme Office. The revised Terms of Reference are included as Annex VII. There were different suggestions and tentative offers for the location of the Programme Office and the Panel decided to wait for a decision of the relevant IOC and FAO bodies. The Secretary IOC provided a statement, regarding the establishment and location of a Programme Office and a scientific project and communication centre for the HAB Programme. The Statement is included as Annex VIII. **Recommendation IPHAB-I.2 was adopted.**

63 Since the Programme Office cannot be expected to have all kinds of expertise needed, it was agreed that an IOC-FAO Guiding Group of Experts be set up to guide both organizations on practical scientific and

managerial items relevant to the HAB Programme, while the Intergovernmental Panel should continue the handling of general items at the intergovernmental level. **Recommendation IPHAB-I.3 was adopted.**

9. RECOMMENDATIONS OF THE PANEL

64 Having reviewed the Programme Plan as outlined in IOC Workshop Report No. 80 and the recommendations of the HABP Planning Committee, **the Panel adopted** a set of recommendations which summarized the findings of the First Session of the *Ad hoc* IOC-FAO Intergovernmental Panel on Harmful Algal Blooms, Paris, 23-26 June 1992. The Recommendations are included as Annex II.

65 In addition to the Recommendations **the Panel endorsed** the following inter-sessional activities to be implemented by (i) Member States, (ii) IOC Secretariat:

(i) Member States should promote the HABP by:

a) identifying national resources and resource personnel to support the programme planning process and, if possible, locate resources to support their participation in the necessary meetings;

b) carefully and explicitly identify training needs;

c) identifying institutions and organizations willing to operate, co-sponsor, and/or host training activities.

- in developed countries with visiting students;
- in developing countries with visiting and resident staff.

d) identifying personnel and organizations to interact with, and provide material for, the newsletter "Harmful Algae News";

e) obtaining national support for WESTPAC and IOCARIBE programmes (for Member states in the respective regions);

f) obtaining national support for Global Environment Facility and UNDP activities on harmful algae;

g) encouraging PICES (North Pacific Marine Science Organization) to include HAB activities in its programme formulation.

(ii) The IOC Secretariat should in co-operation with the FAO Secretariat and the Chairman of the IPHAB:

a) continue the planning process;

b) solicit offers from Member States to provide support for the establishment of the HAB Programme Office;

c) expand participation in the Harmful Algal Bloom Programme by other international organizations;

d) increase the interaction and participation of programme participants in other IOC activities, in particular TEMA, GIPME, and GOOS;

e) prepare a training programme based on identified training needs;

f) continue the publication of the IOC newsletter "Harmful Algae News";

g) proceed with the publication of an updated and expanded version of the International Directory of Experts in Toxic and Harmful Algal Blooms and Their Effects on Fisheries and Public Health;

h) proceed with the publication of a manual which compiles widely different information on the taxonomy, toxicology and epidemiology of harmful algal blooms, and which should be distributed freely to developing countries;

i) support national and international conferences related to harmful algae.

10. OPERATION OF THE *Ad hoc* IOC-FAO INTERGOVERNMENTAL PANEL ON HAB

66 **The Panel decided** to continue its activities intersessionally under the co-ordination of the Chairman.

67 **The Panel decided** that the next Session should be held not later than 6 months after the Seventeenth Session of the IOC Assembly, 25 February - 11 March 1993. **Recommendation IPHAB-I.4 was adopted.**

11. CLOSURE

68 In his concluding remarks, the Chairman thanked the Members of the Panel for their active involvement and participation. He expressed the hope that there would be even more participants for the next Session, and urged for support to secure participation from developing countries. He noted that the work the Panel had done during the Session had been very useful to the further development and implementation of the Programme but stressed that the resource identification issue needed more detailed discussion.

69 The Chairman thanked the Senior Assistant Secretary, Prof. T. Osborn, for his efforts in developing the HAB Programme, and the Rapporteur and IOC Secretariat for their support during the Session. The meeting stands adjourned until a date for the next Session has been communicated after the Seventeenth Session of the IOC Assembly, 25 February - 11 March 1993.

ANNEX I

1. OPENING

   1.1 OBJECTIVES OF THE *Ad Hoc* INTERGOVERNMENTAL PANEL ON HARMFUL ALGAL BLOOMS (HAB)

2. ADMINISTRATIVE ARRANGEMENTS

   2.1 ADOPTION OF THE AGENDA
   2.2 ELECTION OF CHAIRMAN AND DESIGNATION OF RAPPORTEUR

3. SUMMARY DESCRIPTION OF THE HAB PROGRAMME : SCIENCE BACKGROUND AND GOALS

4. HAB IN THE CONTEXT OF RELEVANT PROGRAMMES OF UNEP, EEC, ICES AND SCOR

5. HAB PROGRAMME INTERACTION WITH OTHER IOC AND FAO PROGRAMMES, AND SUBCOMMISSIONS

   5.1 TRAINING, EDUCATION AND MUTUAL ASSISTANCE (TEMA)
   5.2 GLOBAL INVESTIGATION OF POLLUTION IN THE MARINE ENVIRONMENT (GIPME)
   5.3 IOC SUB-COMMISSION FOR THE WESTERN PACIFIC (WESTPAC)
   5.4 IOC SUB-COMMISSION FOR THE CARIBBEAN AND ADJACENT REGIONS (IOCARIBE)

6. STATUS OF HAB PROGRAMME ACTIVITIES AND PRIORITIES

   6.1 *Ad hoc* PLANNING COMMITTEE ON THE HAB PROGRAMME
   6.2 HARMFUL ALGAE NEWS, AN IOC NEWSLETTER ON TOXIC ALGAE AND ALGAL BLOOMS
   6.3 SCOR WORKING GROUP
   6.4 ICES-IOC STUDY GROUP
   6.5 IOC TRAINING COURSE ON THE TAXONOMY OF HARMFUL MARINE PHYTOPLANKTON
   6.6 IOC DIRECTORY OF EXPERTS
   6.7 UNESCO-IOC MANUAL ON HARMFUL MARINE PHYTOPLANKTON
   6.8 INTERNATIONAL SOCIETY

7. NATIONAL STATEMENTS

8. IDENTIFICATION OF RESOURCE ISSUES REQUIRING NATIONAL ATTENTION

   8.1 REVIEW OF THE PROGRAMME PLAN
   8.2 REVIEW OF RESOURCES

9. RECOMMENDATIONS OF THE PANEL

10. OPERATION OF THE *Ad hoc* IOC-FAO INTERGOVERNMENTAL PANEL ON HAB

11. CLOSURE

ANNEX II

RECOMMENDATIONS

Recommendation IPHAB-I.1

PROGRAMME PLAN ON HARMFUL ALGAL BLOOMS

The IOC-FAO *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms,

Having reviewed the Programme Plan on Harmful Algal Blooms, suggested by the IOC-SCOR Workshop on Programme Development on Harmful Algal Blooms and outlined in IOC Workshop Report No. 80,

Recommends the modified Programme Plan on Harmful Algal Blooms (Annex V) to be adopted by the IOC Assembly.

Recommendation IPHAB-I.2

IOC-FAO PROGRAMME OFFICE FOR HARMFUL ALGAL BLOOMS

The IOC-FAO *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms,

Having reviewed Terms of Reference for the proposed IOC-FAO Programme Office for Harmful Algal Blooms (IOC/INF-880),

Recommends the establishment of an IOC-FAO Programme Office for Harmful Algal Blooms in accordance with the revised Terms of Reference (Annex VI).

Recommendation IPHAB-I.3

IOC-FAO GUIDING GROUP OF EXPERTS ON HARMFUL ALGAL BLOOMS

The IOC-FAO *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms,

Recognizing that a Programme Office and the IOC Secretariat cannot be expected to have all kinds of expertise needed in relation to the HAB Programme,

Recommends the establishment of an IOC-FAO Group of Experts to guide and advise IOC and FAO on scientific and managerial problems relevant to the Harmful Algal Bloom Programme,

Urges the IOC and FAO Secretariats, in consultation with the Panel, to elaborate the Membership and Terms of Reference.

Recommendation IPHAB-I.4

IOC-FAO *Ad hoc* INTERGOVERNMENTAL PANEL ON HARMFUL ALGAL BLOOMS

The IOC-FAO *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms,

Recommends that the Joint IOC-FAO *Ad hoc* Intergovernmental Panel on HAB continue its work on an *ad hoc* basis until otherwise decided by IOC and FAO. The Terms of Reference should remain unchanged.

ANNEX III

LIST OF PARTICIPANTS

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ANNEX IV

TERMS OF REFERENCE FOR THE IOC-FAO INTERGOVERNMENTAL PANEL ON HAB

The IOC Assembly, at its Sixteenth Session, Paris 7-21 March 1991, adopted the following resolution with respect to the formation of an *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms in order to identify adequate resources for a sufficiently broad programme to solve some of the real problems caused by algal blooms;

Resolution XVI-4

AD HOC INTERGOVERNMENTAL PANEL ON HARMFUL ALGAL BLOOMS

The Intergovernmental Oceanographic Commission,

Recalling that the IOC, at the Fourteenth Session of its Assembly, endorsed the development of the sub-programme on Harmful Algal Blooms, and that the Twenty-third Executive Council, through its Resolution EC-XXIII.1, endorsed the programme development so far,

Being aware of the increasing socio-economic risks posed by toxic algae and harmful algal blooms to marine organisms, fisheries, aquaculture, human health and the coastal environment,

Approves the formation of an *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms, with the Terms of Reference shown in the Annex hereto;

Invites FAO to co-sponsor the *Ad hoc* Panel;

Invites Member States which intend to be involved in the implementation of a programme on Harmful Algal Blooms to nominate their representatives for the *Ad hoc* Panel and inform the Secretary IOC accordingly;

Decides to review, at the Seventeenth Session of the Assembly, the Terms of Reference of the *Ad hoc* Panel, in conjunction with the Commission's review of the overall organization of the OSLR Programme;

Instructs the Secretary to convene the First Session of the *Ad hoc* Panel as soon as possible.

Annex to Resolution XVI-4
Terms of Reference
of the *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms

1. FUNCTIONS

The *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms is established to meet the scientific, managerial, implementation, and resource needs of the Harmful Algal Blooms Programme.

The Panel will carry out the following functions:

1.1 Review and identify programme requirements;

1.2 Promote efficient and cost-effective implementation of the HAB programme and prepare recommendations on this implementation to the Assembly and Executive Council;

1.3 Identify the resources necessary to meet HAB programme needs;

1.4 Ensure effective interaction and communication with regional intergovernmental (e.g., ICES, ICSEM and GFCM) as well as regional and global non-governmental (e.g., SCOR) organizations involved in research on toxic algae and harmful algal blooms; and

1.5 Report to the Twenty-fifth Session of the Executive Council and the Seventeenth Session of the Assembly.

2. COMPOSITION

The membership of the *Ad hoc* Panel is open to Member States of IOC (and FAO, if it agrees to co-sponsor the Panel) which have declared to the Secretary IOC their involvement or intention to participate in the development and implementation of the Harmful Algal Bloom Programme on a global, regional, or national scale. The Panel shall include the Chairman of the OSLR Guiding Group of Experts, representatives of IOC regional and other subsidiary bodies, and of other interested international organizations, particularly SCOR. Invitations to participate in Panel activities may be extended to scientific experts at the request of the Panel and with the approval of the Secretary of the IOC.

3. ORGANIZATION OF THE SESSIONS

3.1 The Panel will, prior to the closure of each Session, elect from its members a Chairman who will serve in that capacity until the closure of the next Session.

3.2 The Sessions shall, in principle, be arranged without financial costs to IOC. Sessions will be conducted, documentation will be provided, and the report of each session will be prepared in English and in other working languages of the Commission as appropriate and required.

3.3 Secretariat support for the Panel will be provided by the Secretary IOC.

ANNEX V

SUMMARY OF NATIONAL STATEMENTS

CANADA

EXECUTIVE SUMMARY

The Science Sector of the Canadian Department of Fisheries and Oceans (DFO) conducts a large national research program on harmful marine algae. Thirty-three projects are currently being conducted out of laboratories based in St. John's, Nfld., Halifax/Dartmouth, N.S., St. Andrews, N.B., Moncton, N.B., Joli, P.Q., Winnipeg, Man., Sidney, B.C., and Nanaimo, B.C., under the general categories of: 1) methodology and analytical support, 2) phytoplankton population dynamics, 3) biological and biochemical aspects of toxin production, 4) uptake, storage and depuration of toxins by marine organisms, 5) effects of toxins on marine organisms, 6) fate of toxins, and 7) physical oceanography, chemical oceanography, and sedimentology. The success of the program is very dependent upon collaboration with DFO Inspection Services Branch, the National Research Council, the Department of Health and Welfare, universities, provincial departments that deal with fisheries and aquaculture, and industry. In addition, DFO scientists organize national workshops and participate in international working groups and committees dealing with harmful marine algal issues. In collaboration with regulatory agencies, research results are applied to the management of harmful marine algal episodes to protect consumers of seafood as well as the fishing industry (wild and aquaculture). The results of Canadian research are widely published in the international scientific literature.

INTRODUCTION

Harmful marine algae are widely distributed on both the Pacific and Atlantic coasts of Canada. Three major groups of well-defined toxins, of concern to human consumers of shellfish - paralytic shellfish poisons (PSP), amnesic shellfish poison (ASP), and diarrhetic shellfish poisons (DSP) - are produced by a limited number of marine algal (phytoplankton) species. Some phytoplankton species, such as *Heterosigma akashiwo*, cause toxic reactions in fish that are poorly understood. Other species, such as *Chaetoceros concavicornis*, can cause harmful effects by damaging the gills of fish.

In order to help solve the problems created by harmful marine algae, the Science Sector of DFO conducts a substantial research program on harmful marine algae. This program was expanded in 1988 following the ASP (domoic acid) outbreak in Prince Edward Island (PEI) mussels.

In 1989, DFO created a national advisory body called the Phycotoxins Working Group (PWG) which is made up of representatives from all DFO Regions as well as National Headquarters. The PWG reports to the Biological Sciences Subcommittee composed of Biological Sciences directors from all DFO Regions.

The present review of the national DFO phycotoxins program has been prepared by the PWG with the intent to inform research scientists, managers, industry and the interested public. It contains: 1) a table summarizing all current DFO phycotoxins research projects across the country, 2) highlights of recent research, 3) general observations and recommendations from the PWG, 4) a list of hypotheses developed by the PWG to help guide future research, 5) a list of publications on phycotoxins research since 1988, and 6) lists of PWG members and phycotoxin project leaders. It is proposed that this report, which is more extensive than produced by the PWG in previous years, be updated annually and circulated widely.

LISTING OF CURRENT PROJECTS

The list shows current DFO research projects on harmful marine algae from all Regions, categorized by topic. Projects are assigned to one of the seven categories but are cross-referenced to other categories where appropriate. The DFO Regions are abbreviated as follows: GUL = Gulf Region, S/F = Scotia-Fundy Region, QUE = Québec Region, C&A = Central and Arctic Region, and PAC = Pacific Region. Addresses and telephone numbers for project leaders are given in Appendix 2.

Region	Project title (Scientific leader)	Toxins/species	Cross-reference
1. METHODOLOGY AND ANALYTICAL SUPPORT			
S/F	Techniques and improvements (Zitko)	ASP, DSP	
S/F	Investigations into shellfish toxins (Pocklington)	ASP, DSP, PSP	2,3,4,6
2. PHYTOPLANKTON POPULATION DYNAMICS			
PAC	Toxic algal blooms (Forbes)	All species	1,7
C&A	Phytoplankton nutrient status (Guildford)	All species	
QUE	Programme de suivie des populations d'algues nuisibles dans l'estuaire et le nord du golfe Saint-Laurent (Levasseur)	PSP, DSP	
QUE	Introduction d'algues toxiques par les eaux et sédiments de ballast aux Iles-de-la-Madeleine (Golfe du Saint-Laurent) (Gosselin)	PSP, DSP	
QUE	Dynamique de population des algues toxiques et nuisibles dans le Saint-Laurent: 1) Germination des kystes d'*Alexandrium excavatum* (Levasseur)	PSP	
GUL	Physiological ecology of harmful and benign phytoplankton (Smith)	All species	1,2,4,5,6,7
GUL	Nutrient dynamics and phycotoxin production in the field and laboratory (Cormier, Smith)	All species	1,3,7
S/F	Coastal phytoplankton dynamics (Keizer)	All species	
S/F	Phycotoxin bloom dynamics in the Fundy Isles area (Martin)	All species	2,7
S/F	Physiological ecology of toxic algae (Subba Rao)	ASP, DSP	3,4
S/F	Ballast waters as a source of algal blooms (Subba Rao)	All species	
3. BIOLOGICAL AND BIOCHEMICAL ASPECTS OF TOXIN PRODUCTION			
PAC	Toxic algae (Whyte)	ASP, *Heterosigma*	1,2,4,5
QUE	Growth and physiological studies of *Alexandrium* spp. (Hsiao)	PSP	
GUL	Biology of toxin producing phytoplankton (Bates)	ASP	2
S/F	Factors controlling the production of domoic acid in the Bay of Fundy (Martin)	ASP	2

Region	Project title (Scientific leader)	Toxins/species	Cross-reference
4. UPTAKE, STORAGE, AND DEPURATION OF TOXINS BY MARINE ORGANISMS			
C&A	Investigation of freshwater mussels from the Northwest Territories for unknown, low level toxicity (Hendzel)		
QUE	Approche flux cytométrique de l'etude de la sélectivité du broutage de la moule bleu (Mytilus edulis) (Demers)	PSP	
GUL	Effects of phycotoxins and other stressors on the condition, production, and marketability of molluscs (Smith)	All species	1,2,3,5,6
S/F	Molluscan culture and phycotoxin research (Scarratt)	ASP	
5. EFFECTS OF TOXINS ON MARINE ORGANISMS			
QUE	Hydrodynamisme, distribution des phytotoxines et effets sur le réseau alimentaire et la survie d'especes commerciales (Gagné)	PSP	
QUE	Feeding responses and toxin accumulation by zooplankton grazing on toxic dinoflagellates (Runge)	PSP	
S/F	Effects of toxic microalgae on finfish (Wildish)	All species	
S/F	Aquatic toxicology and marine phycotoxins (Haya)	ASP, PSP	2,3,4
6. FATE OF TOXINS			
S/F	Microbial-marine toxin interactions (Stewart)	ASP, PSP	1,3
7. PHYSICAL OCEANOGRAPHY, CHEMICAL OCEANOGRAPHY, AND SEDIMENTOLOGY			
PAC	Red tide prediction (Hurty and Gower)	All species	2
S/F	Long-term temperature monitoring (Petrie)	All species	2
S/F	Exchange between coastal and offshore waters (Bugden)	All species	2
S/F	Physical oceanography in support of phytoplankton profiling program (Bugden)	All species	2
S/F	Classification of estuaries, inlets and coastal embayments (Petrie)	All species	2
S/F	Suspended particulate matter associated with phytoplankton variability (Kranck)	All species	2
S/F	Nutrient dynamics in Ship Harbour (Strain)	All species	2

CHINA

PROGRAMME ON HARMFUL ALGAE BLOOMS IN CHINA

Department of Ocean Management and Monitoring,
State Oceanic Administration

As one of the world-wide marine disasters, harmful algae bloom occurs along the coast of China and shows a clear increasing trend in recent years. It not only causes serious economic loss to the aquaculture and fisheries, worsens the marine environment, but also threatens public health and even human life. It is one of the most urgent environmental problems needed to be solved. Therefore, Chinese Government and scientists pay great attention to it.

1. The harmful algae bloom events happened in China

The first record of HAB in China was that appeared near north coast of Zhejiang Province in 1933. In 1952, Dr. Hongnian Fei reported a HAB in the coast water of Bohai Sea caused by Noctiluca scientillans. From 1972 to 1989, there were 85 HAB recorded (those in the region of Taiwan and Hong Kong not included). Among them, 28 occured in South China Sea, 42 in East China Sea, and 15 in Yellow Sea and Bohai Sea. In 90's the appearance of HAB goes further up. There were 34 and 38 HAB along the Chinese coast for 1990 and 1991 respectively. The cause of the HAB can be mainly attributed to the eutrophication.

The HAB organisms in China belong to more than 20 genus and above 70 species. The most dominant species are

Noctiluca scientillans,
Trichodesmium erythraeum,
Skeletonema costatum,
Prorocentrum micans,
Coratium furea,
Dactyliosolen mediterraneus,
Mesodinium rubrum,
Prorocentrum minimum,
Rhizosolenia alata f. gracillima,
Gonyaulax polygramma etc.

2. The research and management effort on HAB in the Past

As the HAB becomes more and more severe, the State Oceanic Administration, the local government along the coast and many scientists give their close attention to it. After getting permission from the State Council, SOA issued an announcement of "Strengthen the measures to minimum the harmful effects of HAB in coastal waters". SOA initiated and organized many scientific and

operational project.

Many research institutes and universities are involved in the study and management on HAB in China. They are:

SOA system

First Institute of Oceanography
Second Institute of Oceanography
Third Institute of Oceanography
Institute of Marine Environmental Protection
North Sea Branch
East China Sea Branch
South China Sea Branch
the marine management authorities of coastal provinces

Fisheries Institutes

Yellow Sea Fishries Research Institute
East China Sea Fishries Research Institute
South China Sea Fisheries Research Institute
Fisheries Institute of Zhejiang Province
Fisheries Institute of Fujian Province

Academy Sinica

Institute of Oceanology
South China Sea Institute of Oceanology

Ministry of Education

Ocean University of Qingdao
Xiamen University
Jinan University

Their research fields cover the population structure of HAB organisms, the new red tide species, the monitoring and surveillance of the whole process of a HAB event, the ecological characteristics of red tide organisms, the species succession and reproduction competition, the environmental biology of HAB algae, bacteria and red tide, toxicology etc. About 100 papers have been published.

We would like addess here a little more about two important projects. One is "The study of appearance and mechanism of red tide along the coast water of South East China Sea". It was supported by the National Science Foundation of China as a key project. There are four subprojects titled "The biology of red tide organisms", "The ecology on reproduction dynamics of red tide organisms", "the ecological factors in the water with high frequencies of red tide", and "Mathmatics model for red tide". This is a comprehensive basic research on red tide in China with more than 100 investigators from 10 institutes or universities. In north China, after suffering the heavy loss in shrimp culture caused by HAB, a network for monitoring, investigation, research,

management and information exchange on red tide was formed in March 1990. The body of this network consists of North Sea Branch, SOA, the local marine management authorities of Shandong, Hebei, Liaoning Province and Tianjin City, as well as the Fishery Management Department in Yellow Sea and Bohai Sea. The surveillant ship and helicopter will be available in the case needed. Along the coast, especially in the area of shrimp culture, there are volunteer patrolers. They received short time training and if there were a red tide, they would report to the network. It was estimated that the loss in aquaculture reduced by 50% in 1990, as the farms followed the advice given by the network.

Since the Forth International Conference on Toxic Marine Phytoplankton, Chinese Scientists actively participated in the international activities in this field, and many established experts all over the world visited China.

3. The future plan on HAB

In order to strengthen the study and management on HAB, China plans to establish a leading committee and a technical group at national level. They will coordinate and initiate both scientific and operational projects. The activities proposed for near future are:

(1). A network for surveillance, monitoring, management on HAB

A network formed by fishery management department, environmental protection agency and marine management authorities will be the main structure of operational element on HAB. It's work should be included in the marine environmental pollution network and fisheries monitoring network in China. This network will be divided into North, East, and South China Sea regional branches, which take responsibility for their own coastal areas and could reduce the effects of HAB.

(2). Strengthen the measures for shellfish poison management and prevention

In the main aquaculture or high HAB occurrence area, the examination of shellfish poison should be taken routinely, as well as for the selling of shellfish from big aquaculture farms. It is essential to secure the public health.

(3). The joint research group on HAB

The cause of HAB is complicated. And the research on HAB is often multidisciplinary. The joint research group should have scientists from institutes of oceanography, universities, institute of fishries and environmental protection. We will continue the taxonomy work on HAB organisms and investigate the cause, pattern and process of HAB events. Meanwhile, the studies of physiology, ecology, mechanism, toxicology, as well as the way to pridict or prevent the occurrence of HAB are also concerned.

TO do this ,scientists need support from Chinese government and international organizations.

(4). The control of pollution

It is highly necessary to reduce the amount of land pollutants, improve the sea water quality, prevent the eutrofication. This is a important measure to reduce the appearance of HAB.

(5). Participating the international programme on HAB

China will actively take part in the internationa projects on HAB organized by IOC, SCOR, ICES, WESTPAC or other organizations and societies. China agrees to establish the intergovernmental panel on HAB and secretariat. We appeaciate the IOC's effort in training, IOC newsletter, UNESCO-IOC manual and the global or regional cooperation. By carring the research on HAB in China and participating the international activities, China will make her contribution to minimum the consequence of Harmful Algae Bloom on our planet.

FRANCE

NATIONAL PROGRAMME ON HARMFUL MARINE ALGAL BLOOMS

Coordinator - Serge Y. MAESTRINI(1)
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In french coastal waters, has shown by BELIN *et al.* (1989) from a review of all available reports of harmful-algal events, three dinoflagellates represent at the moment a serious potential nuisance or jeopardy. The most dangerous one is *Alexandrium minutum*, a PSP producer (ANDERSON, 1990 ; ANDERSON *et al.*, 1990 ; CEMBELLA *et al.*, 1990), which was first observed in 1985 in the Vilaine bay and the Arcachon basin. It has been since scarcely present in North Brittany, although sometimes at rather high cell densities : up to 23 x 10^5 cells$\cdot l^{-1}$, during the summer 1988 (E. ERARD, personnal communication). As a whole, however, *A. minutum* has hitherto remained sparse and has given no noxious effects. On the contrary, the second species, *Gyrodinium cf. aureolum*, which was unknown in the whole North Sea until 1966, has recently generated heavy losses of Bivalves in the bights of Brest and Douarnenez (ERARD-LE DENN *et al.*, 1990), due to the production of an hemolytic toxin (YASUMOTO *et al.*, 1990 ; GENTIEN, personnal communication). Lastly, several species of *Dinophysis* seem to have sharply shifted from a modest and sparse presence to cell densities high enough to be indirectly surveyed by their commercial and health consequences for Man (*i.e.* ban from the market and diarrhoea ; BERTHOME and LASSUS, 1987). To date : in June 1983, several thousands intoxications caused by consumption of DSP-poisoned mussels were reported in South Brittany (LASSUS *et al.*, 1987). Blooms of *Dinophysis spp.* have since become the most frequent harmful-algal events in France (BELIN *et al.*, 1989), and have continuously increased their geographic area. They now occur in almost all french coastal waters, including those of the Mediterranean Sea (BERTHOME *et al.*, 1986 ; LASSUS *et al.*, 1987).

The number of scientists focusing on problems related to these events, nevertheless, remained low until a recent past and practically

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(1) First President of the "Scientific Board" managing the National Program ; actual acting President : Dr Brigitte BERLAND.

limited to IFREMER teams (LASSUS, 1990). On the other hand, the production of sea food is rather important for France and expected to increase in the near future (MAESTRINI *et al.*, 1990), whereas the sea-based recreation activities are growing as well. Thence, there is an increasing demand for basic knowledge on the actual status of the marine coastal environment to be used for prediction and management. To bridge the gap between demand and availability, or try to, the Ministeries of the Environment, of the Sea, and of Scientific Research, and two national research agencies, CNRS and IFREMER, decided on late 1988 to encourage fundamental research dedicated to "**Environmental conditions and ecophysiological mechanisms which lead to harmful phytoplankton blooms in french coastal marine waters**". Practically, not only an higher number of scientists accepting to contribute to this field of research was expected, but also a much better integration of laboratory and field researches once scattered was hopped.

OUTLINES OF "MARINE PHYCOTOXINS" NATIONAL RESEARCH PROGRAM

Coordinator : P. LASSUS

1 - Toxin origin : are toxin producing marine bacteria associated to some dinoflagellate species ? Metabolic pathways involved in exotoxin release from "fish killers".

2 - Okadaïc Acid and DTX_1. Extraction and purification procedures, from P. lima cultures and/or contaminated bivalves. Long term effects on test animals, especially as tumor promoters.

3 - O. A. detection by biochemical and biological screening tests : development and improvement of an immunological method., comparison of different standardized bioassays (cytotoxicity, mouse test, Daphnia test, Microtox, etc.).

4 - Improvement of HPLC method for PSP toxins detection and development of immunological tests with specific antibodies of GTX_2/GTX_3.

5 - PSP expérimental contamination/decontamination of bivalves : incidence of toxin bioaccumulation on final toxin profiles.

6 - Development of specific bioassays for hemolytic compounds detection, purification and chemical structure of these compounds (Gyrodinium cf aureolum Ichthyotoxins), effects on fish and shellfish.

7 - Improvement of cytotoxicity testing for Maitotoxin and purification of this compound. Chemical analysis (HPLC) of Ciguatoxin.

REPHY : THE PHYTOPLANKTON MONITORING NETWORK IN FRANCE

The study of disturbances caused by phytoplankton has been carried out in France since 1984 through a monitoring and warning network set up by the French Institute for Sea Research and Exploitation (IFREMER) as a result of the extensive development of the dinoflagellate *Dinophysis* which led to poisoning of shellfish consumers during the summers of 1983 and 1984 (BERTHOME ans LASSUS, 1985).

The network REPHY has three objectives :

* to collect data on phytoplankton populations in France, and to provide very clos monitoring of discolored waters, blooms, etc...

* to detect and monitor the presence of species toxic to man and then to propose administrative measures to ensure maximum limitation of harmful effects.

* to detect and monitor the presence and development of species toxic to marine animals.

REPHY consists of 110 sampling stations :

* 37 survey stations on which sampling is performed systematically throughout the year ;

* 73 warning stations which can supplement the monitoring stations if toxic species appear.

These stations are distributed along the entire length of the Atlantic and Mediterranean coasts (Fig. 1 and Fig. 2).

Monitoring stations

These stations, located at regular intervals along the coast, are considered to be relatively representative of a particular zone. Water samples are taken throughout the year at a frequency which varies with the season : twice a month from September to April and once a week from May to August.

Samples are taken at the surface ; they are fixed in lugol (2.5 ml. l^{-1} and formol (2 ml. l^{-1}) and examined by inverted microscopy according to the method of UTERMÖHL (1958), using 10 cm^3 (or 25 cm^3) water volumes. Systematic counting of all phytoplankton species is carried out twice a month on these water samples. In summer, only toxic species are counted on the additional samples.

Warning stations

Samples are only taken on these stations if a species reputed to be toxic to man has been detected on a nearby monitoring station or if the zone is affected every year by a toxic species.

Water and shellfish sampling is conducted weekly on the warning stations, and the following analyses are performed :

for water samples : determination and counting of toxic species or those suspected to be toxic ;

for shellfish samples :

* If a toxic species producing DSP toxin is present : a mouse-test on a shellfish hepatopancreas extract (method adapted from Yasumoto's method) is used, with a threshold equal to five hours (MARCAILLOU-LE BAUT *et al.*, 1985). If mouse survival time is including between 5 and 24 hours, the test is considered as negative, but there is a suspicion of toxicity.

* If a toxic species producing PSP toxin is present : a mouse-test is conducted using the Association of Official Analytical Chemists' (AOAC) method (1984).

The warning system is activated according to a procedure requiring close administrative cooperation (Fig. 3). In the event that suspected toxicity is confirmed by tests, official administrative measures are taken to prohibit the marketing of shellfish from the incriminated sector. The ban of shellfish marketing is lifted after two negative successive mouse-tests.

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GREECE

HARMFUL ALGAL BLOOMS IN GREEK COASTAL WATERS

Studies in the open waters, surrounding Greece, have confirmed the *oligotrophic* character of the Aegean and Ionian Seas. However, recent studies have demonstrated that harmful phytoplankton blooms had recently appeared in some Greek gulfs, such as Saronikos, Pagassitikos, Kavala and Amvrakikos, which are exposed to municipal, industrial and agricultural effluents (Fig.1).

These phenomena appears either as discoloration of seawater, usually of a local character, or as gel patches floating on the sea surface. They usually have a seasonal character, are localized and generally are brief occurrences lasting several days or weeks. In Tables 1 and 2, the existing data of the most important appearances of harmful phytoplankton blooms causing red tides, and mucilage mass in Greek coastal waters, are presented.

Research in Greece cover oceanography and phytoplankton ecology as well as public health and seafood safety.

GERMANY

Germany wishes to state its continuous interest in the subject of "Harmful Algal Blooms (HAB)" and in the IOC Programme on "HAB". So far, harmful algal blooms have not had a too serious impact on German coasts, but one is fully aware that this could happen anytime.

There are several groups of different German institutions doing research and monitoring on harmful algal species. In addition, the new "Institute for Baltic Sea Research" in Warnemunde will soon establish a group working on harmful algal blooms aspects in the Baltic. The new "Centre for Tropical Marine Ecology" at Bremen University is interested in establishing co-operation with developing countries in the tropics with respect to harmful algal blooms.

Germany has a continuing interest in support of and co-operation with developing countries in marine science. Germany is somewhat concerned about insufficient participation of developing countries in the IOC Programme on "HAB" and wishes to urge the Panel to particularly consider the needs and requirements of developing countries with respect to harmful algal blooms.

Germany wishes to draw the attention of the Panel to the international workshop on "Marine Environmental Protection and Coastal Living Resources" which will take place in Bremerhaven (29 September - 3 October 1992), and which will deal particularly with the subject of "HAB" in developing and Eastern European countries. This workshop will be devoted mainly to training aspects. IOC will be a co-sponsor of the Workshop. Germany wishes to express its strong interest in co-operating with IOC in training matters for developing countries with reference to "HAB".

Germany wishes to acknowledge the continuing efforts of IOC with respect to the "HAB" Programme, particularly those of the two Technical Secretaries Drs. T. Osborn and H. Enevoldsen.

The following proposals for activities (foreseen in Germany) based on the goals and objectives formulated in the IOC Workshop Report N° 80. The chemistry of PSP and DSP toxins was taken into particular consideration.

Goal : To determine the physiological and biochemical mechanisms responsible for toxin production and accumulation.

Justification : Detailed knowledge of toxin production and accumulation as well as the chemical and pharmacological properties of toxic metabolites is required to design effective strategies for human health protection and marine resource management.

Objectives : With respect to physiology

i) Determine the physiological mechanisms underlying variable toxicity among strains of species or within single strains grown under different conditions.

ii) Define the toxin accumulation and depuration processes in contaminated seafood.

iii) Determine chemical conversions of toxin within tissues of contaminated seafood.

With respect to chemistry

iv) Isolate, identify and/or elucidate the structure of toxins.

v) Prepare and supply toxin standards.

vi) Develop new chemical analytical methods for toxins, specifically:

1. alternative assay methods to replace such tests as mouse and other bioassay organisms, while improving the sensitivity, specificity and reproductibility of all methods; and,

2. simple field assay kits.

vii) Prepare a technical manual on methods for toxin analysis (with clear indication of where each method is appropriate, where there potential pitfalls for each technique, etc.) and a list of chemistry experts for each of the various toxins.

IRELAND

Activities Related to Harmful Algal Blooms and their effects in Ireland.

The Fisheries Research Centre of the Department of the Marine is the designated laboratory for marine algal toxin monitoring in Ireland.

The main concerns of the laboratory are the protection of human health, certification of aquaculture produce for export and the development of the aquaculture industry. In 1990 the aquaculture industry contributed some IR 28m to the econcomy. In the southwest the episodic occurrence of exceptional phytoplankton blooms ("red tides") which kill fish and the regular occurrence in the plankton of species which induce toxicity in shellfish, leading to the ban on harvest, make it essential that a compreheensive programme of monitoring is maintained in the area. In the main blooms of the dinoflagellate Gyrodinium aureolum have been responsible for the fish kills while the occurrence of Dinophysis acuta and D. acuminata have been responsible for the regular occurrence of DSP toxins in shellfish.

Ongoing monitoring programmes of the laboratory include:

1. Routine monitoring of phytoplankton species composition at all finfish and shellfish aquaculture areas.

2. Intensive monitoring of phytoplankton in high risk areas.

3. Testing of shellfish meats for presence of algal toxins, using both bioassays and HPLC techniques.

4. Oceanography and phytoplankton ecology of the waters off southwest Ireland.

Planned programmes include

1. National survey of the distribution of cysts or resting stages of toxic phytoplankton.

2. Investigation of the feasability of toxin depuration from shellfish.

ITALY

The environmental and economic impact of harmful algal blooms along the Italian coasts is not easily quantifiable. In the last years, the accumulation of high quantities of "*mucilage*" has been recorded in the Adriatic Sea, which had a severe impact on fishery and touristic activities. The full explanation of this phenomenon, as well as the identification of the organisms which produce the mucilage, is still the object of study.

An intense production of marine snow was noticed in South Tyrrhenian waters below the thermocline in the summer of 1991, which also affected fishing activities in the area. The production of mucilagineous material due to the activity of *benthic* algae was also recorded in some coastal areas of the Tyrrhenian Sea. As for toxic algal blooms, the only ascertained case of human diseases related to algae was the *DSP* event, caused by *Dinophysis* species, which occurred in the Adriatic Sea in the late Spring of 1989.

However, several other toxic or potentially toxic species, such as *Alexandrium minutum, A. lusitanicum, A. tamarense, Gymnodinium catenatum*, have been identified in plankton samples collected in Italian coastal waters and, in some cases, in cyst-containing sediments. One of these species, *Gymnodinium catenatum*, bloomed in 1985, 1987 & 1989 in a coastal lagoon near Naples. Fortunately, the blooms had no consequence on human health, because shellfish farming had been prohibited in the lagoon since 1973 after a cholera epidemic in the area.

Notwithstanding the importance of marine resources within the Italian economy, there is not a co-ordinated national project on HAB. Research activities in the fields of taxonomy, ecology and toxicology are being conducted in different laboratories only based on individual projects.

JAPAN

HARMFUL ALGAL BLOOMS IN JAPAN : JAPANESE PERSPECTIVE

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Harmful algal blooms are causing serious problems to coastal aquaculture development and public health. A global expansion of the affected area by the blooms has been recently occurring. It is urgently necessary to establish an adequate research/study program to clarify the cause and mechanism of the blooms and to develop countermeasures. However, considering the Japanese experience described below on the basic study and practical operation, it might be rather difficult technically and financially to hold a broad program with substantial results within a short time by one country. In this context the program proposed by the *ad hoc* planning committee is considered as a reasonable one based on accumulated scientific information. We pay our sincere respects to the effort to construct the program. We expect that our scientific knowledge and techniques gained by our experience will be utilized to facilitate the implementation of the program, and that sciences concerning the harmful algal blooms will progress smoothly through cooperative studies among member countries in the program.

Research on harmful algal blooms in Japan

In Japan the algae causing harmful blooms are subdivided into two groups according to their effects: noxious species which has implication to mass mortality of marine organisms, and toxic species which cause human illness. They differ from each other not only on their consequence, but on their ecological features such as the highest cell concentration and distribution. Noxious species often bloom to make red tides, and kill marine organisms after the formation of red tide. They are distributed mainly in western Japan. The species producing paralytic or diarrhetic shellfish toxin usually appear in northern Japan. They bloom only in low concentration, but the concentration is unfortunately enough to make shellfish toxic. Therefore different field monitoring system and research program are adopted for each group.

1. Noxious algal blooms (Red tide)

1.1. Occurrence of noxious algal blooms

Frequency of occurrence of red tide has been increased in 1970's along the coast of western Japan, especially in Seto Inland Sea where aquaculture fisheries mostly has been developed. Associated with the increase of occurrence of red tides, number of cases of mass mortality of cultured fish and amount of economic loss by harmful algae had also increased. After implementation of the Seto Inland Sea Environment Conservation Law in 1973, the number of red tide cases became small along with decrease of nutrients such as nitrogen and phosphate. Red tides by harmful algae, however, have been occurring about 10 times almost every

year. The total economic loss by fish mortality between 1972 and 1991 in Seto Inland Sea was 21.5 billion yen (165 million US $).

Figure 1 shows the annual change in number of cases of red tides and associated mass mortality of fish in Seto Inland Sea. Table 1 and 2 represent number of red tide cases and amount of economic loss within 5 years in Seto Inland Sea and Kyusyu area, respectively.

1.2. Studies on noxious algal blooms

The first scientific research project was started from 1966, when the number of red tide occurrence was about 50, but the damage made by noxious species started to appear. Then, universities and national research institutes belonging to the Fisheries Agency, the Environment Agency, the Ministry of Education, Science and Culture, and the Ministry of International Trade and Industry, collaboratively with prefectural fisheries experimental stations, have been conducting many scientific researches related to the various aspects of red tides (Table 3). International cooperative studies and researches has been supported mainly by the Ministry of Education, Science and Culture, and the Japan Society for the Promotion of Science.

The biological and ecological knowledge on noxious red tide accumulated through these projects were compiled in the book "Science on Red Tide" (eds. by Okaichi 1987, written in Japanese) and a comprehensive overview by Shirota (1989). A manual named "A Guide for Studies of Red Tide Organisms" (eds. by Takano et al. 1987, written in Japanese) and a taxonomic monograph named "Red Tide Organisms in Japan: An Illustrated Taxonomic Guide" (eds. by Fukuyo et al. 1990, written in Japanese with short English description) were also published to standardize techniques for species identification.

1.2.1. Basic Scientific Studies

i) Taxonomy and Genetics

Most of noxious species belong to class Dinophyceae and Raphidophyceae (Table 4). Although these species were identified by their morphological characteristics at regular monitoring and in laboratory studies, detailed subdivision within a genus or species level has been tried to characterize local strains using physiological features such as monoclonal antibody.

More than 500 culture strains including red tide organisms have been kept in NIES-Collection at Microbial Culture Collection, the National Institute for Environmental Studies, Environment Agency. These culture strains are readily provided to the requesting scientists.

ii) Ecology and Oceanography

The basic studies on biological aspects of red tides such as classification, life history of causative organisms, nutrients requirement and other physiological characters has been continued mainly in the research projects listed in Table 3. Ecological aspects has been also studied on interrelationship among species during the formation of red tide, triggering factors for the initiation of the bloom, and physical and chemical environments

of the blooming area.

From these studies many important results to comprehend red tide has been obtained. Number of occurrence of red tides has closely related with the nutrient amount in the environment, i.e., trophic level. Noxious red tide occurred after the starting of eutrophication, and continues occurring even after decrease of nutrients. Each red tides organism has its own specific range of ambient physical, chemical and biological environmental conditions to initiate and maintain its bloom. Therefore it is necessary in continuing studies to clarify biological specificity of each organism together with features of environment of blooming area. Only the cooperative research among scientists working on physical, chemical and biological oceanography can describe the total mechanism of red tide bloom.

iii) Toxicology and Toxin Chemistry

Mechanism of fish mortality has not yet clarified. Fish died by anoxia after showing unusual swimming behavior which starts by contact with red tide. The anoxia may be caused by several factors such as mechanical damage of gill, excreted neurotoxin or unsaturated fatty acid, and change of blood pH.

1.2.2. Operational Systems

i) Resource and Aquaculture Management

At present perfect measures has not yet developed to mitigate the consequence from harmful algal blooms, although various kinds of projects has been tried and some of them show useful effects. The measures tried can be subdivided into 2 groups, direct and indirect methods (Fig. 2). The indirect methods aim to prevent eutrophication due to water pollution, because the eutrophication stimulates the occurrence of red tides. Table 5 shows important laws enforced in Seto Inland Sea Area. The direct methods aim to decrease cell concentration of red tide not to expose cultured fish to noxious algae. Shirota (1989) reviewed the methods and effects of these counterplans.

ii) Information, Network, and Training

The information system in Fisheries Agencies shown in Fig. 3. The information of red tide detection is reported by the fisherman to the Seto Inland Sea Fisheries Coordination Office, which distributes all necessary information after collection and selection to the Fisheries Agency, national institutions, and prefectural authorities concerned. All the information dissemination is completed within one hour.

Although no regular training course is prepared for scientists and administrators of national and prefectural institutions and universities, they are encouraged to conduct cooperative research, and exchange their results of researches and studies at annual meetings held by the Fisheries Agency and related scientific societies.

iii) Monitoring

Regular monitoring of oceanographic condition and cell concentration of all plankton communities were conducted at fixed

stations by prefectures and fisherman cooperative unions. The plankton succession and occurrence of the harmful algal species are known by monitoring. Oceanographic data which include weather condition, current, and nutrients of the water and sediments also simultaneously collected.

iv) Public Health and Seafood Safety

As dead fishes by red tide are not sold in market, there is no public health and seafood safety problem.

2. Toxic species blooms

2.1. Occurrence of toxic algal blooms

Two different types of toxic algae causing paralytic shellfish poisoning (PSP) and diarrhetic shellfish poisoning (DSP) were found in Japan. The area where cultured shellfish was affected by toxic algal blooms has been expanding along with the development of shellfish aquaculture and consolidation of monitoring system. Figure 4 shows the affected areas by the two blooms. Shellfish industry in northern Japan was seriously affected. Ban of collection is being administrated every year from spring to summer, and sometimes it continues more than one year.

2.2. Studies on toxic algal blooms

2.2.1. Basic scientific studies

Several scientific research projects have been operated by the Fisheries Agency and the Ministry of Education, Science and Culture cooperatively with prefectural institutes such as fishery experimental station and public health center.

i) Taxonomy and Genetics

The toxic algae appeared in Japanese coastal waters are species belonging to Dinophyceae (Table 6). They are identified by morphological characteristics. For PSP species, physiological characters such as isozyme, monoclonal antibody, and toxin composition has been tried to differentiate clonal character within genera and species.

The PSP species can be cultured easily in common enriched medium. Some strains are maintained in NIES-Collection. However, there is no report on successful culture of the DSP species.

ii) Ecology and Oceanography

Most toxic species grow slowly, and rarely become dominant in plankton community. Coastal area in northern Japan, where the species appear regularly every year, is not in eutrophic condition. Such features are distinctive in toxic species, comparing with noxious red tide algae. Therefore ecological aspects such as the relationship between the occurrence of blooms and physical and chemical environmental conditions become obscure, although intensive field survey in wide coastal area has been conducted.

In laboratory, biological characters of the PSP species such as life history and optimum growth condition are studied using clonal cultures. But biology of the DSP species has not yet been

elucidated mainly because of lack of cultures.

iii) Toxicology and Toxin Chemistry

Structure of almost all toxins produced by the toxic species are clarified already. But mechanism of toxin production in the algal cell and mechanisms of accumulation and excretion in shellfish have not yet been elucidated.

2.2.2. Operational Systems

i) Resource and Aquaculture Management

There is no direct method to terminate the toxic species, because the cell density is too low to apply any method without effect to environment ecology. As environmental factors which regulate the bloom of toxic species are not well known, indirect method to change environmental condition cannot be chosen and decided as effective. Only intensive monitoring on shellfish toxicity is useful to prevent occurrence of poisoning.

ii) Information, Network, and Training

When toxicity exceeds to the permitted level is detected in shellfish by prefectural authority, the information is immediately reported to the Fisheries agency and the Ministry of Health and Welfare. Then, the governmental agencies will impose to the fishermen and processing factories not to collect and sell shellfish through prefectural authorities concerned, and fisheries cooperative union (Fig. 5).

iii) Monitoring

Regular monitoring of shellfish toxicity and occurrence of toxic algal bloom were conducted at fixed stations in prefectures. Mouse bioassay is used in toxicity test.

iv) Public Health and Seafood Safety

As the monitoring system works well after consolidation in 1980, no case of poisoning occur from shellfish sold in the market.

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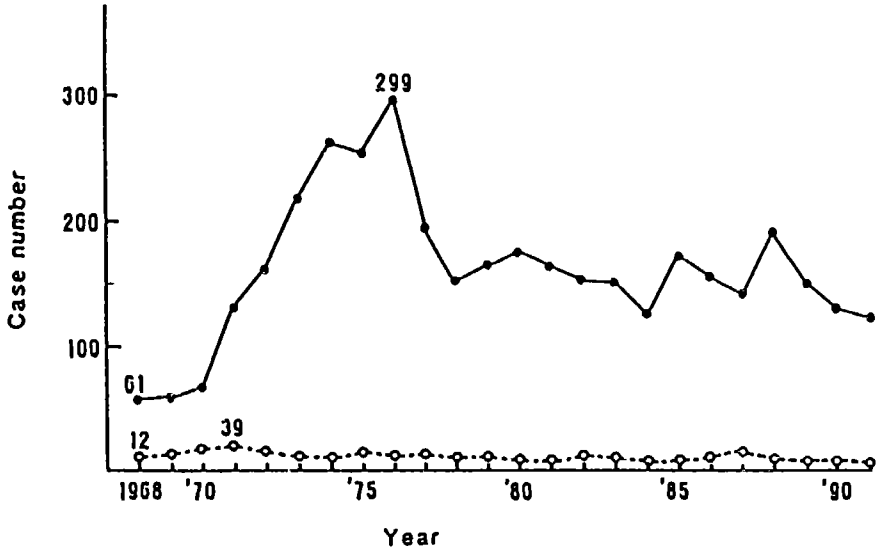


Figure 1. Case number of red tides in Seto Inland Sea.
● : red tides
○ : red tides with fish kills

(Revised from Okaichi 1989)

Table 1. Red tides in Seto Inland Sea during 1987 and 1991.

Causative organisms	1987 No. of cases	1987 Economic loss	1988 No. of cases	1988 Economic loss	1989 No. of cases	1989 Economic loss	1990 No. of cases	1990 Economic loss	1991 No. of cases	1991 Economic loss
Skeletonema costatum	11(1)		14		19(1)		11(1)	2	14	
Prorocentrum spp.	13(1)		12		16		8(1)		10	
Noctiluca scintillans	12		23		15		34		19(1)	28
Gymnodinium spp.	20(4)	22	32(9)	9	13(5)	4	5(1)		19(3)	1,501
Chattonella spp.	18(10)	2,400	0		6(1)	486	1		0	
Heterosigma spp.	20(1)		24		22		27(1)		23(1)	
Mesodinium spp.	12		8		23		6(2)		8	
Others	35		67(1)		43		41(1)		26	
Total	141(17)	2,422	180(10)	9	157(7)	490	133(7)	2	124(5)	1,529

Numbers in bracket are red tides with fish mortality. Economic loss is expressed by unit of million yen.

Table 2. Red tides in Kyusyu district during 1987 and 1991.

Causative organisms	1987 No. of cases	1987 Economic loss	1988 No. of cases	1988 Economic loss	1989 No. of cases	1989 Economic loss	1990 No. of cases	1990 Economic loss	1991 No. of cases	1991 Economic loss
Chaetoceros spp.	9		6(3)		5		6		5(3)	
Skeletonema costatum	10		13(5)		6(3)		7	2	13(3)	
Prorocentrum spp.	17		9(1)		12(1)		10		15	
Noctiluca scintillans	5		9		7		6		7	
Cochlodinium spp.	1(1)	-	1		3		3(3)	51	6(2)	48
Gymnodinium spp.	10(4)	59	15(2)	5	10(2)	256	12(1)		17(5)	173
Chattonella spp.	1		7(6)	41	6(3)	63	9(5)	1,579	0	
Heterosigma spp.	6(1)		11(3)	3	10(1)		10(2)		7(2)	3
Mesodinium spp.	14		13		17		9		20	
Others	29		19(6)		17(6)		18(1)	74	42(12)	1
Total	102(6)	61	103(26)	49	93(16)	319	90(12)	1,709	132(27)	225

Numbers in bracket are red tides with fish mortality. Economic loss is expressed by unit of million yen.

Table 3. Main research projects concerning red tide and conservation of water quality.

(Shirota 1989)

Fiscal year			
Ministry of Agriculture Forestry and Fisheries	Environment Agency	Ministry of Education, Science and Culture	Ministry of International Trade and Industry
1966-68 Research on red tides in the Inland Sea.	1979-81 Eutrophication and red tides in the coastal marine environment.	1966-68 Studies on the causes of outbreak of red tide in neritic waters.	1973-79 Prediction study of pollutant diffusion in the Seto Inland Sea.
1969-73 Technical development on prevention of occurrence of red tide to fishery damage.	1973-82 Comprehensive research for prevention of pollution in the Seto Inland Sea and other coastal waters.	1969-70 Studies on environmental mechanism of outbreak of red tide.	1974-77 Behavior of suspended materials in coastal waters.
1975 Research on prediction for the appearance of red tide.	1980-82 The development and evaluation of remote measurement methods for environmental pollution.	1974-77 Studies on toxic phytoplankton.	1978-81 High speed measuring technique of suspended particles in sea water.
1976 Studies on growth mechanisms of red tide.	1981-84 Effects of toxic substances on aquatic ecosystems.	1978 Biological studies on red tides.	1978-82 Dissolution mechanisms of pollutants out of bottom sediment in the Seto Inland Sea.
1977-81 Dynamic analytics on material income and outgo in bays, connected with the bottom sediments.	1982-85 Modeling of red tide blooms in the coastal sea.	1978 Study of the physical, chemical and biological processes leading to the generation of the red tide.	1978-02 Mathemetical study of coastal marine ecosystem.
1977-81 Technical development on remote sensing in sea waters.		1980-81 Fundamental studies on the effects of marine environment on the outbreaks of the red tides.	1979-81 Sediment pollution caused by red tide.
1977-89 Technical developments on prevention of red tides.	1983-84 Comprehensive studies on effective use of natural ecosystems for water quality management.	1982-84 Studies on marine ecosystem models on outbreaks of red tides in neritic waters.	1982-86 Remote sensing techniques for marine pollution analysis.

Fiscal year			
Ministry of Agriculture Forestry and Fisheries	Environment Agency	Ministry of Education, Science and Culture	Ministry of International Trade and Industry
1979-83 Development of violent red tide and its damage.	1988 Integrated analysis on red tide organisms.	1984 Man and the sea: to what extent can the sea accept anthropogenic impingement.	1983-87 Measurement of environment and development of monitoring system in aqua-benthic boundary layer.
1981-84 Physiological and ecological characteristics of red tide organisms in the Inland Sea.	1990-1991 Comprehensive research for prevention of pollution in coastal waters.	1986 Relationship between environmental characters and biological succession in coastal marine ecosystem.	1985-89 Quality enhancing technology for stagnant waters of the Seto Inland Sea.
1982-86 Cooperative studies on purificatory function and biotic production in the intertidal zone and adjacent shallow water.	1986-1990 Studies on the assessment of the eutrophication to coastal ecosystems.		1986-90 Effective application of microalgal functions on resources.
1984-88 Technical development for the prediction of the occurrence of red tide.			1987-90 Study of anoxic water mass formed in the stagnant waters of Inland Sea.
1989-93 Technical development on the ecological control to noxious red tide. (Provisional name).			1988-92 Structure of lower trophic ecosystem in an eutrophicated bay.-Automated measurement and prediction of plankton organisms succession.
			1988-92 Development of new removal method of polluted sediment in a coastal sea water area.

Table 4. Noxious species causing mass mortality of marine organisms in Japanese coastal waters.

Dinophyceae
Cochlodinium polykrikoides
Gymnodinium mikimotoi

Raphidophyceae
Chattonella antiqua
Chattonella marina
Fibrocapsa japonica
Heterosigma akashiwo

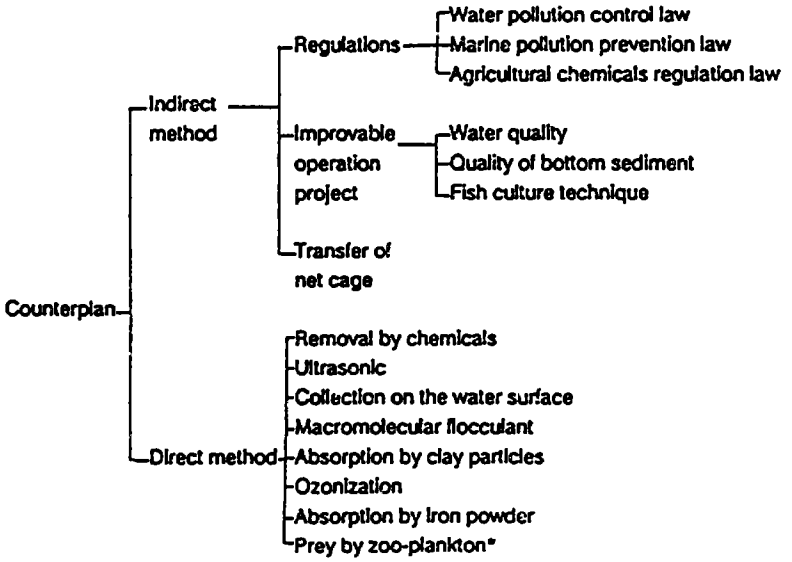


Figure 2. Counterplans against noxious red tides. (Shirota 1989)

Table 5. Important laws on conservation of environment in Seto Inland Sea.

(Shirota 1989)

1) 1973 : Revision of provisions in "Public water body reclamation law" is promulgated
   - Consideration for preservation of environment is clearly described regarding permission criterion for reclamation.

2) 1973 : "Seto Inland Sea conservation law" are put into force (1973).
   - Fundamental policy to preserve the environment in Seto Inland Sea is to be established.

   As an temporary measure prior to the fundamental policy.
   1) The pollution discharge (indicated by COD) shall reduce to a half of 1972 within 3 years.
   2) Permission regarding installation/modification of special equipment specified by Government.
   3) Special consideration for reclamation of foreshore
   - Establishment of council for preservation of environments in Seto Inland Sea.

3) 1976 : Revision of provisions in Seto Inland Sea conservation law.

4) 1976 : "Marine pollution prevention law" is revised into and damage due to shipwreck.

5) 1978 : Revision of provisions both in "Seto Inland Sea conservation law and Water pollution control law" are promulgated (In 1979 it is changed into special measure: regulation on preservation of environment in Seto Inland Sea.
   - Prefectural policy based on the fundamental policy.
   - Regulation on total emission (amount).
   - Prohibition to use phosphorus in order to prevent the damage due to eutrophication.
   - Conservation of natural beach by designation of "natural beach conservation area."
   - Prevention of oil leakage in case of shipwreck.
   - Research project on mechanism of red tide occurrence.

6) 1984 : Special measure on conservation water quality in lakes and marshes is promulgated (It is put into force 1985).

7) 1986 : Revision of provisions in "water pollution control law" is promulgated.

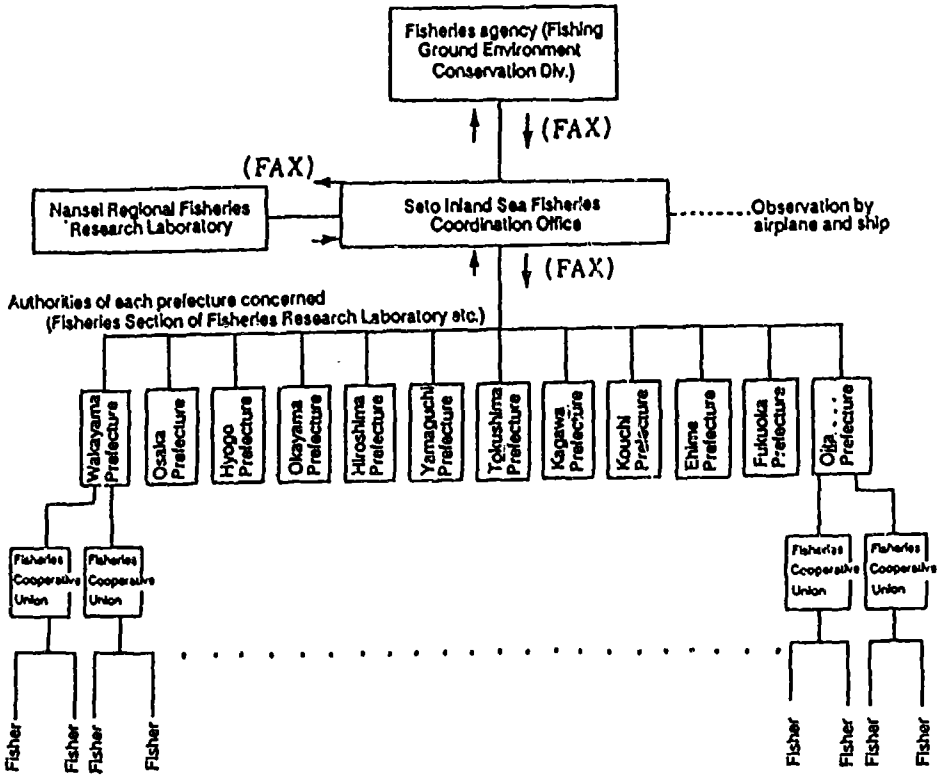


Figure 3. Information system on red tide in Seto Inland Sea. (Shirota 1989)

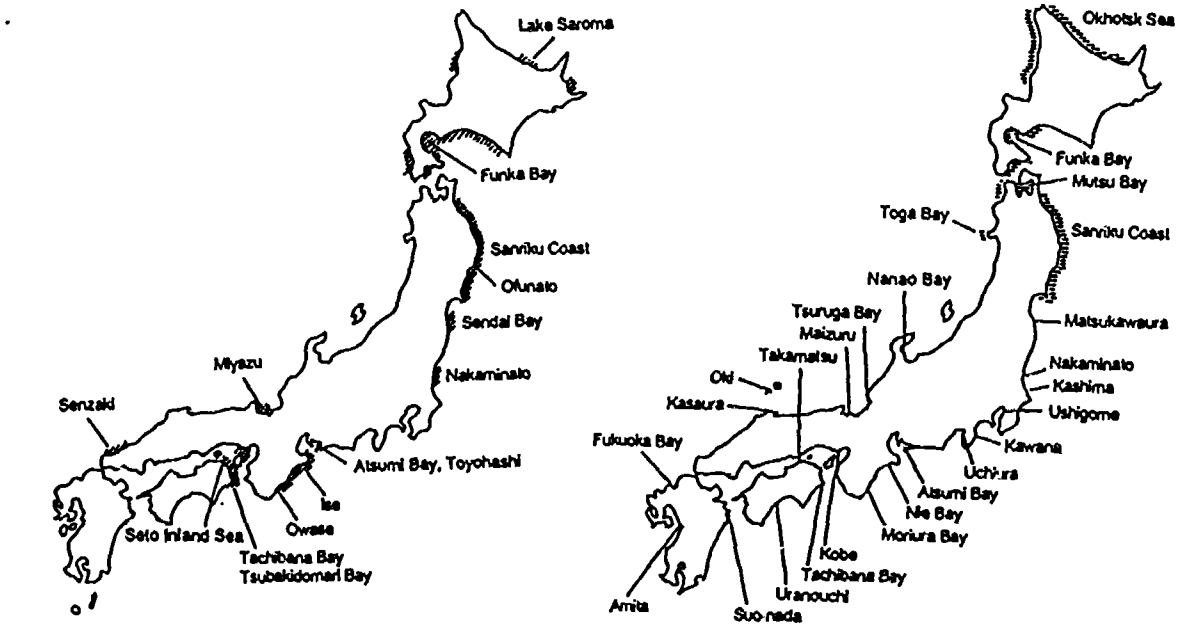


Figure 4. Areas where toxicity is detected in shellfish.
Left: Paralytic toxin, Right: Diarrhetic toxin

Table 6. Toxic dinoflagellates responsible for human poisoning in Japanese coastal waters.

Paralytic shellfish poisoning
Gymnodinium catenatum
Alexandrium catenella
A. cohorticula
A. tamarense

Diarrhetic shellfish poisoning
Dinophysis acuminata
D. acuta
D. fortii
D. mitra
D. norvegica
D. rotundata
D. tripos

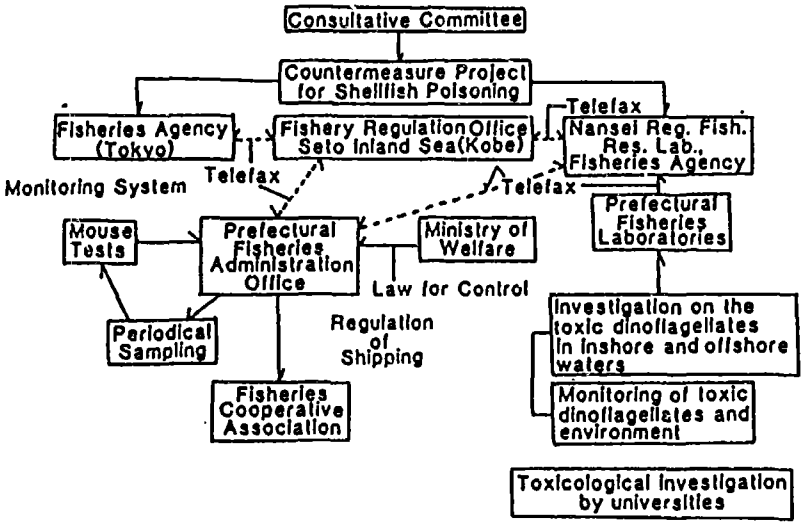


Figure 5. Shellfish toxicity monitoring and investigation systems in Seto Inland Sea. (Okaichi 1989)

MEXICO

In Mexico, the Harmful Algae Blooms have been present in both littorals: the Gulf of Mexico and Pacific Ocean. For this reason, it is very important for Mexico to study the detection and solutions for this problem.

The investigation work is related to taxonomic aspects, ecology and toxicology.

There are many institutions in Mexico, governmental institutions and universities, investigating this type of bloom. Mexico also has an integrated Committee for different institutes such as the Fisheries Secretariat, the National Institute of Fisheries, a Health Secretariat, a Social Development Secretariat and the Water National Commission, which work together on monitoring toxicology aspects.

When the blooms are present, the National Institute of Fisheries, and the Secretariat stop any activity to extract sea products that could be dangerous for the community until the organisms eliminate their toxicity.

Mexico has accredited laboratories for the Food & Drug Administration for the detection of toxins.

Our request is to have training in aspects of taxonomics of phytoplankton.

PHILIPPINES

Toxic red tides caused by *Pyrodinium bahamense var.compressum* occurred for the first in the Philippines in 1983. Since then, there had been 15 outbreaks, affecting 11 areas and causing PSP (paralytic shellfish poisoning) in at least 1,500 persons. These events have resulted in great economic losses to the shellfish and fishing industries. In Manila Bay alone, the shellfish industry suffered an estimated loss of about Pesos 50M (=US$ 2M) during the first red tide outbreak in the area in 1988. Aside from this, the country's fishery exports, particularly prawns, suffered heavily due to cancellation of orders from importing countries, even though there was no toxicity in the prawns.

Beginning in 1988, the Philippines, through the Inter-Agency Committee on Environmental Health (IACEH) which was created by an Executive Order from the Office of the President and is composed of various government agencies tasked to protect the environment, had implemented a National Red Tide Programme focusing on the monitoring of toxic phytoplanktons and toxins in shellfish. The programme also includes epidemiological surveillance, training, research and an information campaign on toxic red tide.

During toxic blooms, the Committee imposes temporary bans on the harvesting, transporting and marketing of shellfish from areas where the toxin levels in shellfish reach 80 micrograms of toxin/100 g of shellfish meat. During such shellfish bans, public markets and fish landing sites are placed under close watch by the sanitary inspectors of the Department of Health (DOH). Public market administrators also help in ensuring that shellfish coming from contaminated waters are confiscated. Weekly updates are released to both the print and broadcast media to guide the consumers. The Committee also enlists the assistance of the Coast Guard and local government officials in the enforcement of the shellfish ban.

In order to discourage the movement of contaminated shellfish to other places, the issuance of auxiliary invoices, a requirement for the transportation of marine products, is suspended by the Department of Agriculture (DA) during harvesting closures.

Due to economic dislocation of affected shellfish farmers, workers and vendors, as well as sustenance fishermen, who are adversely effected by the red tide scare during toxic phytoplankton blooms, the government is currently developing an alternative livelihood programme for them.

Local training courses on the detection, identification, and monitoring of toxic phytoplankton blooms were conducted since 1987 for government personnel from the DA and DOH.

Public information campaigns in the form of public seminars, dialogue with fishermen, shellfish farmers and vendors, and consumers are also conducted, especially during red tide outbreaks.

Due to the increasing number of harmful algal blooms, the Philippines needs human resource development to strengthen its present capabilities on the research and monitoring of harmful algal blooms. This may come in the form of short-term training, post-graduate scholarship, long-term training fellowships at expert laboratories or visits by foreign experts, as has been recommended by the IOC WESTPAC Task Team on HAB during its meeting in Penang, Malaysia, in December 1991.

SPAIN

Spain established a monitoring programme in various localities in 1977 following a major PSP outbreak in 1976 which affected several European countries. Since then, the monitoring of potentially harmful algae and associated environmental parameters has been carried out by the Instituto Espanol de Oceanografia (I.E.O.), and the monitoring of toxins by the regional and the national health authorities (Conselleria de Sanidade e Consumo; Ministerio de Sanidad y Consumo).

The main areas presently involved are the coastal waters of Galicia (NW Spain) and the Ebre Delta Region (Northern Mediterranean coast). Following the EEC directive on "Quality of Waters for Marine Cultures", monitoring of coastal waters is being expanded to all Spanish coastal waters and the responsibility is being transferred to the regional governments.

The main problems relevant to the HABP are associated with Paralytic Shellfish Poisoning due to *Gymnodinium catenatum* and *Alexandrium lusilonicum minutum*, and DSP associated with *Dinophsis spp.* These species render the mussels and other bivalves toxic at concentrations of a few thousands per litre (PSP), or even a few hundreds per litre in the case of DSP outbreaks associated with *Dinophsis spp.* These occur annually and create serious problems for the mussel culture industry in Galicia, the largest in the world with an annual production of around 2×10^5 t yr^{-1}. In recent years, PSP outbreaks associated with *Gymnodinium catenatum* have been recorded in Malaga (Southern Mediterranean coast). Problems associated with excess biomass and mucus production (similar to those in the Adriatic) have taken place in the last two years on the coast of Valencia (Central Mediterranean Coast).

The on-going research and the future plans related with the HAB topic can be summarized as follows:

1. A programme of the I.E.O. about "Harmful Algal Blooms (taxonomy, ecology, toxicology)" carried out in Galicia, will be one of the major Marine Environment programmes of the Institute during the next 4 years. Two more projects of the Institute about :

   - "Study of the Eutrophication in Ria de Huelva (Southern Atlantic coast)",
   - "Environmental Factors in the Coastal Waters of Murcia and Alicante in Relation to the Appearance of Mucilaginous Aggregations and Eutrophication".

2. Two recently approved toxicology projects (3 years) funded by the "Comision Interministerial de Ciencia y Tecnologia" (C.I.C.Y.T.):

   - "Determination of PSP Toxins in Bivalves and in Dinoflagellate Cultures". "Dynamics of Intoxication and Detoxification in Cultured Mussels",
   - "Effects of Industrial Processing on the Destruction of PSP and DSP Toxins".

3. A MAST-I project about "Dominance of Phytoplankton Populations" (Comparative study between the Galician Rias and the Irish and Scottish Lochs), to be finished by the end of 1992 (Spain, UK, Ireland).

4. Two recently approved MAST-II projects:

   - "Classification of Dinoflagellates by Neural Networks" (UK, Spain, Italy),
   - "Multidisciplinary Oceanographic Research in the Eastern Boundary of the North Atlantic" (Portugal, Spain, UK).

5. The Central Health Department (Ministerio de Sanidad y Consumo), the Health Department of the Galician Government and the I.E.O. are participating in the intercalibration exercises for toxin analysis methods organized by the "Community Bureau for Reference Material" (BCR).

6. The laboratory of the Central Health Department in Vigo has been chosen as the Community Reference Laboratory for Dinoflagellate Toxin Analyses.

SWEDEN

Harmful algal blooms on the Swedish west coasts were observed particularly during the last decade. This is mainly due to the fact that during this decade, aquaculture of mussels (*Mytilus edulis*) have started at a larger scale than before, and to the fact that eutrophication has increased in parts of the sea area. There are, however, indications that harmful algal blooms may have occurred even earlier.

The toxification of mussels has mainly been caused by Dinphysis species. *Gyrodinium aureolum* may have caused minor fish kills. *Ceratium ssp* blooms have occurred occasionally along the whole west coast. In the southern Kattegat, where eutrophication has been pronounced, they temporarily have caused oxygen deficit conditions at their breakdown. In 1988, occurred the famous bloom of *Chyrsochromulina polylepis* causing damage to fish, invertebrates and algae in the greater part of the Skagerrak-Kattegat area. This and related species have since then been observed every year but in relatively small quantities only.

In the Baltic proper, the major problem is large blooms of blue-green algae. When dying algae have drifted onto shores and beaches, allergic reactions in children and killed dogs have been reported. Many other potentially toxic algae are found in the Baltic, but toxic effect have not been reported. Thus, harmful algal blooms are of great concern for Swedish Scientists and authorities especially after *Chrysochromulina* bloom in 1988. A special group for surveillance of the environmental algal situation was established at the Swedish west coast with a Secretariat at the local county government in Goteborg. The surveillance group has contact with similar programmes in Norway and Denmark. During 1992, similar groups were established for surveillance also of the Baltic proper and the Gulf of Bothnia with Secretariats of the county government in Stockholm and Umeoa respectively.

The Swedish National Marine Monitoring Programme includes one regular coastal pelagic station, situated in the northern Baltic proper, including measurements of phytoplankton, besides hydrographical and other parameters. This station is investigated about 25 times a year since 1976. On the Swedish west coast, a similar project was set up engaging scientists and local authorities in monitoring plankton and some hydrographical parameters (i.e., nutrients) after the 1988 *Chrysochromulina* bloom. At the same time, intense pelagic monitoring has also been carried out in the Gulf of Bothnia and in the open Baltic proper. During 1993, all marine monitoring programmes are going to be evaluated by an international expert panel in order to establish the future national monitoring programme. The expert panel will have to also consider the problem of harmful algal blooms.

After the Chrysochromulina bloom, a series of research projects was started, in addition to the algal research already going on. They embrace the fields of ecology, taxoconomy and toxicology. Several of the now on-going taxonomy algal projects deal with dynamics of algal blooms or with algae that may be toxic also in "normal" quantities, like those showing toxic effects when concentrated by mussels. International contacts with scientists in the neighboring countries around the Baltic Sea and the Skagerrak-Kattegat area become increasingly important in dealing with the problem on harmful algal blooms.

UNITED KINGDOM

Summary of U.K. Research and Monitoring Related to Harmful Algal Blooms

1. Bloom occurrence and cause of toxicity.

PSP

Outbreaks of PSP occur regularly on the north east coast of England and Scotland from approximately the Humber to the Forth estuaries. PSP toxicity appears to intensify in certain years. A particularly severe outbreak was experienced in 1968, and in the last two years, 1990 and 1991, the occurrence has been widespread and toxicity high on the Scottish east coast. Out breaks have usually resulted in closure only of bivalve fisheries, but during recent outbreaks high PSP levels have also been detected in some crustaceans resulting in the closure of these fisheries also. Until 1990 there had been no reports of high toxicity levels from Scottish west coast sites. However in 1990 and 1991 bivalve and crustacean fisheries were closed for the first time for periods during the summer due to PSP toxicity.

DSP

Although *Dinophysis* species are common and sometimes abundant in U.K. coastal waters, documented cases of DSP are rare in the U.K.

Ichthyotoxic blooms

Ichthyotoxic blooms have caused the death of farmed salmon at a number of locations in fjordic sea lochs on the Scottish west coast where the industry is particularly well developed. The outbreaks have been sporadically distributed both geographically and in time. The principal causative organisms have been *Heterosigma akashiwo* and *Gyrodinium aureolum* although deaths have also occurred associated with blooms of *Chrysochromulina* sp., *Prymnesium saltans*.

Other Mortalities

Mortalities of wild fish stocks and littoral invertebrates have been recorded at a number of locations during blooms of *Gyrodinium aureolum* and *Gymnodinium* spp.

Chaetoceros sp. have caused physical damage to gill surfaces of farmed fish resulting in their deaths.

2. Current U.K. Research and Monitoring Activity on Toxic Algal Blooms

There is no coordinated national U.K. research programme looking specifically at the problem of harmful algal blooms. Work which is in progress and which is relevant to the HAB problem is funded from a wide range of sources including European Community (EC) research programmes, research budgets of government departments and funding from the Natural Environment Research Council. Fundamental research in this area is primarily funded

through the Natural Environment Research Council (NERC) and from EC sources. Projects usually run for 1-3 years. Government departments, principally the Ministry of Agriculture, Fisheries and Food (MAFF), the Scottish Office Agriculture and Fisheries Department (SOAFD)*and the Department of the Environment (DOE) in addition to in-house projects, fund a number of external R&D projects at NERC institutes and universities. The objectives of these projects are closely coupled to the research priorities of the customer (i.e. the government department concerned). The NERC also funds Laboratory Projects at its component institutes and Community Projects which involve institutes and HEI's. None of these projects are currently focused on the problem of algal blooms, however several of these programmes have elements which are highly relevant to understanding processes which control the dynamics algal blooms development. In addition to those projects listed below it is anticipated that the new NERC Community Research Programme, LOIS (Land-Ocean Interaction Study) to run initially from 1992-1997, should contain elements of relevance to the HABP and in the future a NERC Community Project currently in the development stage, Plankton Reactivity in the Marine Environment (PRIME) may also have some relevance.

In the past there has also been some support of projects from the aquaculture industry, the Nature Conservancy Council (NCC) and the Crown Estates Office (CEO), but this has been small relative to other sources.

The research currently being carried out in the U.K. fits into one of three categories:

a) Fundamental research on the taxonomy, physiology of potentially toxic organisms and processes controlling their growth, distribution and toxicity.

b) Research, some of which might be of a fundamental nature, focused on topics which aid government departments to decide policy or improve approaches to monitoring techniques and the management of the effects of toxic blooms on other marine organisms and human health.

c) Research not directly aimed at harmful algal bloom problems but which may make significant inputs to an understanding of their dynamics.

A summary of existing or recently completed research projects in the U.K. are given in ANNEXE 1.

3. Current Monitoring Programmes

In addition to research activity a number of monitoring programmes are operated in the U.K for detection of shellfish toxicity and harmful or noxious algal blooms. These programmes are operated by government departments or agencies which have a statutory responsibility for enforcement of EC directives on shellfish hygiene and on quality of bathing waters. The programmes are summarised below according to agency.

*and Department of Agriculture of Northern Ireland (DANI)

MAFF

Routine Monitoring for Shellfish Toxicity and Toxic Phytoplankton.

Shellfish toxicity and bacteriological monitoring is presently conducted in shellfish harvesting areas. This will be supplemented by a limited phytoplankton monitoring programme at selected sites from this year which will be extended to all shellfish harvesting areas in the future.

SOAFD

Monitoring of Algal Blooms and Microbiological Factors in Respect to Fish and Shellfish Harvesting.

The objectives of this programme are a) to advise on water quality and other aspects of the EEC Shellfish Hygiene Directive and the need for public health warnings in relation to algal toxins; b) to prepare an annual summary of the incidence of toxic algal blooms in Scottish waters and c) to produce a preliminary classification of Scottish bivalve shellfish producing areas. The programme involves routine monitoring of shellfish toxicity and phytoplankton at monitoring sites on the east and west coast of Scotland.

National Rivers Authority (NRA)

EC Bathing Waters Monitoring Programme

The NRA is primarily concerned with inland freshwaters but its remit also extends to coastal waters. The NRA has incorporated a phytoplankton bloom monitoring element into its EC Bathing Waters Monitoring Programme. This involves routine visits to EC Designated Bathing Water during the bathing season and visual observation of beaches, near-shore and offshore areas for signs of algal bloom. Positive observations require a water sample to be collected and analyzed for species composition. The programme is to be extended to cover periods outside the bathing season and at selected areas not designated as EC Bathing Areas.

ANNEXE 1

Current or Recently Completed Research Projects Relevant to the IOC Harmful Algal Blooms Programme *

Summarised below are existing or recently completed U.K. projects, listed according to funding agency, which have relevance to the HAB programme. Duration of projects is given where known.

European Community

Title: EC MAST Project 017 - Control of Phytoplankton Dominance.
Participants: Republic of Ireland - U. Galway; U.K.- NERC, Dunstaffnage Marine Laboratory and Queens University Belfast; Spain - Instituto Invetigaciones Marinas, Vigo.
Duration: 1990-1992.

Natural Environment Research Council

Title: The C-N Status of Dinoflagellate populations and Interaction with Dissolved Free Amino Acids.
Participants: University of Wales, Swansea; NERC, Dunstaffnage Marine Laboratory.
Duration: 1991-1992.

Title: Carbon-Nitrogen Relations in Dinoflagellates subjected to Changes in Availability of Nitrogen and Phosphorus.
Participants: University of Wales, Swansea; NERC, Dunstaffnage Marine Laboratory.
Duration: 1992-1994.

Title: Nutrient/Phytoplankton Interactions in the North Sea
Participants: NERC, Plymouth Marine Laboratory

Title: The importance of Light for Initiation of Phytoplankton Blooms.
Participants: NERC, Plymouth Marine Laboratory.

Title: Use of Mesocosms to Investigate Grazing Control of *Phaeocystis* and Toxic Dinoflagellates.
Participants: NERC, Plymouth Marine Laboratory.

Department of the Environment

Title: Nutrient Atlas: Qualitative assessment of nutrient measurements, September 1988 to August 1989. Data from the NERC North Sea Programme.
Participants: NERC, Institute of Oceanographic Sciences, Deacon Laboratory.

* Not necessarily complete.

Title: North Sea Nutrient Model.
Participants: NERC, Institute of Oceanographic Sciences, Deacon Laboratory.

Title: Nutrient Inputs and Phytoplankton Blooms in the North Sea.
Participants: NERC, Plymouth Marine Laboratory.

Title: Chlorophyll Atlas: Phytoplankton Biomass and Production in the North Sea.
Participants: NERC, Plymouth Marine Laboratory.

Title: Appraisal of *in situ* Fluorometers in Contrasting Areas of the North Sea.
Participants: University College of North Wales, Bangor.

Title: A Study to Relate River Inputs to the North Sea to the Occurrence of Algal Blooms.
Participants: NERC, Plymouth Marine Laboratory.

<u>Department of Agriculture, Fisheries and Food</u>

Title: Identification of the Toxin and Mechanism of Scombrotoxin Fish Poisoning.
Participants: Torry Research Station, Aberdeen.

Title: Development of Reliable, Sensitive and Specific Analytical Methods and Rapid Assay Procedures for Phycotoxins (algal toxins) - Paralytic Shellfish Poisoning (PSP) toxin.
Participants: Torry Research Station, Aberdeen.

Title: Development of Reliable Analytical Methods and Rapid Biological Assay Procedures for Diarrhetic Shellfish Poison (DSP)
Participants: Torry Research Station, Aberdeen.

Title: The Effects of Processing, Storage and Cooking of Shellfish Containing PSP on the Composition and Toxicity of the Toxins.
Participants: Torry Research Station, Aberdeen.

Title: Isolation and Purification of PSP Toxins
Participants: Nottingham University, Torry Research Station.

Title: Immuno-detection of Toxic Dinoflagellates.
Participants: NERC, Institute of Freshwater Ecology, University of Dundee, Department of Agriculture, Northern Ireland.

Title: Detection of Sodium Channel Blocking Toxins in British Coastal Waters.
Participants: University of Glasgow.

Title: The Isolation and Culture of Dinoflagellates Potentially Associated with Diarrhetic Shellfish Poisoning.
Participants: NERC, Dunstaffnage Marine Laboratory, Royal Holloway and Bedford New College, London.

Title: A Study of **Alexandrium** Cysts Off the East Coast of Britain.
Participants: Polytechnic of Central London.

Title: A Preliminary Investigation of the Distribution of Dinoflagellate Cysts in the Sediments in the Ardtoe/Loch Kentra Region of the West Coast of Scotland.
Participants: Polytechnic of Central London.

Title: Possible control of Nuisance Blooms by Planktonic Grazers.
Participants: NERC, Plymouth Marine Laboratory.

Scottish Office Agriculture and Fisheries Department

Title: Nitrogen Cycling in Coastal Waters
Participants: SOAFD, Marine Laboratory Aberdeen, University of Strathclyde, Glasgow, NERC, Plymouth Marine Laboratory.
Duration: 1988-1992

In addition to these projects there is some relevant activity supported by miscellaneous small funding bodies and university departmental funds. These projects are itemised below:

Quentin Hogg Trust

Title: A study of *Alexandrium* cysts in Northern Ireland Coastal Waters.
Participants: Polytechnic of Central London, Department of Agriculture, Northern Ireland.

Department of Botany, University of London

Title: Long Term Survey and Monitoring of Marine Planktonic Dinoflagellates in the NE Atlantic Area 0°E to 25°W; 20°N to 70°N.

Title: Detailed Study of the Shore-line (psammobic) Dinoflagellates around the British Isles and their Culture.

Title: Taxonomy of Dinoflagellates
Participants: Protist Network, Expert Centre for Taxonomic Identification, Amsterdam.

Title: Studies on algal toxins (freshwaters and marine)
Participants: Department of Biological Sciences, University of Dundee.

USA

HARMFUL ALGAL BLOOMS IN THE UNITED STATES

BACKGROUND:

Marine biotoxins and harmful algae represent a significant and expanding threat to human health and fisheries resources throughout the US. We have experienced different toxic or harmful algal species, more frequent and larger outbreaks, different toxins and a growing list of affected resources. In spite of this trend, the reasons for the increasing scale of the problem and understanding of the biological, physical and chemical processes that regulate harmful algal (HABs) remain elusive.

The nature of the problem has changed considerably over the last two decades in the US. Where formerly a few regions were affected in scattered locations, now virtually every coastal state is threatened, in many cases over large geographic areas and by more than one harmful or toxic algal species. There is a growing consensus in the scientific community that the number of harmful events in US waters and the economic costs associated with them have increased dramatically over the last several decades. Amnesic Shellfish Poisoning (ASP), unknown before 1987, occurred on the West coast in 1991. The causative organism has been identified in Northeast and Southeast waters of the US as well. Paralytic Shellfish Poisoning (PSP), at first thought to be only a problem in shellfish, has been found in mackerel and the toxins were implicated in whale deaths. Prominent examples of HAB-related problems in the US include:

- o Recurrent PSP outbreaks now affect the states of Maine, New Hampshire, Massachusetts, Oregon, Washington and Alaska. PSP problems constrain the development of a shellfish industry in Alaska. Offshore shellfish on Georges Bank became toxic for the first time in 1989, and have remained toxic ever since. Low levels of PSP have been found in the states of Rhode Island, Connecticut and New York. In 1987, 19 whales died from PSP toxin contained in mackerel they had consumed.

- o Neurotoxic Shellfish Poisoning (NSP), traditionally a problem only in the state of Florida, caused closures of major shellfish harvesting areas in the states of North Carolina and South Carolina in 1987 & 1988. Hundreds of Atlantic dolphin died in 1988, possibly due to brevetoxin, the toxin which causes NSP.

- o A brown tide caused scallop and other shellfish mortalities in New York and Rhode Island in 1985. Another major brown tide occurred along the south Texas coast from 1990 through 1992.

- o ASP toxin was detected in Nantucket scallops in 1990 & 1991. Toxic Nitzschia species have been identified in the Gulf of Mexico. Seabird mortalities in the state of California in 1991 have been linked to levels of the toxin found in the flesh of fish that were consumed. In 1991, the ASP toxin also occurred in the state of Washington, where contaminated clams and crabs caused human illness.

- o In 1990, the first confirmed outbreak of Diarrhetic Shellfish Poisoning (DSP) in North America occurred in Canada. Two more DSP outbreaks occurred in Canadian waters in 1992. Scattered, unconfirmed cases of DSP have been reported in the US and the causative organisms have been positively identified in US waters. If DSP proliferates in the US, as PSP has done, the impact on the shellfish industry will be devastating.

- o Mortalities of farmed salmon in the Pacific Northwest due to blooms of the diatom, *Chaetoceros* and the *Chloromonad, Heterosigma* have been a serious detriment to the development of this new industry.

- o *Pilayella*, a noxious macroalga which washes up in large quantities on beaches and then decays, is spreading within Massachusetts Bay on the northeast US coast.

- o The incidence if *ciguatera* poisoning, caused by toxins produced by a dinoflagellate associated with coral reefs, appears to be rising in Florida, the Caribbean and the Pacific. These toxins pass up the food chain from herbivorous reef fishes to larger carnivorous, commercially valuable finfish. *Ciguatera* traditionally was limited to tropical regions, however, modern improvements in refrigeration and transport have augmented commercialization of tropical reef fishes and increased the frequency of this type of fish poisoning in temperate regions.

While there has been no overall national estimate of economic costs associated with HABs, the problem is extensive and expensive, affecting virtually every coastal state in the US. Known losses due to major bloom-related events since 1980 are in the hundreds of millions of dollars. The cumulative dollar losses in coming years will be significant. Examples of major economic costs include:

o A $20 million scallop mortality due to a brown tide off the coast of New York state during 1985 & 1986.

o Three to 5 million dollars lost per year due to PSP toxins in shellfish beds on Georges Bank from 1989 through 1991.

o Fifty million dollars per year in unexploited shellfish resources in the state of Alaska due to persistent PSP toxin contamination.

o Fifteen to 20 million dollars per event in lost tourism due to recurrent red tides on the West coast of the state of Florida.

o Millions of dollars for state monitoring programmes in 10 high-risk coastal states.

Development of a National Plan for Marine Biotoxins and Harmful Algae:

Funding for field-oriented studies of HABs in the past has been limited in all regions of the US. Research teams have made some progress in developing methodologies for toxin analysis, in understanding the structure and pharmacology of some of the toxins, in investigating the physiology of toxin production in algae and depuration from shellfish and in documenting the abundance and distribution of some harmful species during blooms. However, the overall US approach has been to manage threatened resources through harvesting restrictions and toxin monitoring, and to provide relatively minor and often unsustained research support at the local or regional level. Thus, the limited scope of past studies has precluded an in-depth examination of the many factors that regulate the distribution and abundance of species involved in HABs.

Because studies of HABs necessarily involve all of the oceanographic disciplines, a comprehensive programme will involve several state and federal agencies, as well as the academic community. The US is creating a National Plan for Marine Biotoxins and Harmful Algae to direct and co-ordinate a concerted attack on the problem, rather than continuing the *ad hoc* responses to individual outbreaks. Much near-term US planning is based on the Plan's recommendations, the result of a workshop held in Charleston, South Carolina, in April 1992.

The overall goal of the National Plan is to foster the effective management of and scientific research on harmful marine algae and associated toxins. The Plan identifies impediments to our current state of knowledge on HABs, with recommendations in the areas of toxin chemistry, monitoring, epidemiology; bloom biology and ecology; and effects on marine organisms. Impediments to progress in effective management of and scientific research on marine biotoxins and harmful algae were identified in 3 major areas:

- Lack of information on harmful algae: Life history; effects of natural and anthropogenic phenomena on frequency of blooms; algal physiology that promotes toxin production in both cultured and natural populations; and lack of research assays and toxin standards.

- Deficiencies related to biotoxin production: Unavailability of toxin standards; lack of sensitive research assays; diminution of toxin production in laboratory algal cultures; difficulties in mass culture of some species; and fate and metabolism of toxins in humans, fish and shellfish following acute and chronic ingestion.

- Public health concerns: Lack of sensitive dockside assays and toxin standards; inability to predict occurrence of algal blooms; need for advisories and risk evaluation; and inadequate databases and epidemiological records.

The lack of sensitive assays (research and/or dockside) and toxin standards were noted as a significant problem in each of the impediment categories. Six objectives identified in the Plan are designed to ultimately overcome these impediments:

1. Develop forecasting capabilities for the occurrence and impacts of harmful marine algae.

2. Determine the sources, fates and consequences of algal toxins in marine foodwebs and fisheries.

3. Isolate toxins and their natural derivatives and characterize their chemical structures and pharmacological actions.

4. Develop specific tests based on the unique chemistry and/or pharmacology of individual toxins.

5. Identify and improve access to databases for bloom incidence, toxin occurrence in shellfish, mass mortality incidence and epidemiology.

6. Develop communications programmes that incorporate educational and public health materials, electronic communication, on-site training; and provide for rapid response to events.

While laboratory research helps define factors that could be significant in causing blooms, field research is essential to determine actual conditions under which blooms form. Only through comprehensive studies will we begin to understand the complex mechanisms underlying the growth and accumulation of individual algal species in blooms, the transfer and fate of toxins, and the influence of human activities on these processes.

The Federal Role in Implementing the National Plan:

The National Oceanic and Atmospheric Administration (NOAA) is developing plans to examine the HAB problem on a comprehensive scale through its Coastal Ocean Programme, its National Marine Fisheries Service (NMFS) laboratories and grant programmes such as Saltonstall-Kennedy and the National Sea Grant College Programme.

Specific recommendations from the National Plan are being incorporated into planning by the Coastal Ocean Programme to initiate region-scale research into the causes and effects of HABs, focussing on objectives 1 and 2 above. The main components of NOAA's research efforts on HABs will include:

Core Research - small-scale, laboratory and field studies focused on particular species or relatively narrowly defined aspects of HAB problems including algal physiology, environmental factors, trophic dynamics, detection and possible control mechanisms including migitation.

Regional Field Studies - large-scale, multidiciplinary field studies occurring in single geographic regions, concentrating on the interaction of various environmental and biological factors leading to specific, regional HAB problems. The scale of the regional studies will be determined by the scale of the problems.

Rapid Response - regional teams will be organized for rapid response to sudden bloom outbreaks.

To further the goal and meet the objectives of the National Plan, NOAA scientists in the NMFs are concentrating their efforts on providing pure toxin standards, elucidating toxin chemical structures and pharmacological action, and developing sensitive analytical and dockside assays to protect public health (objectives 3 and 4, above). In addition, over the past few years NOAA has funded academic research through Saltonstall-Kennedy grants for biotoxin research.

The National Sea Grant College Programme has been funding academic research on various aspects of harmful blooms, including all of the objectives listed above. NOAA expects to continue this effort. The National Sea Grant Programme's Marine Advisory Service is well-equipped to deal with the scattered literature and the numerous databases related to marine biotoxins (objective 5, above). Fostering communication among university researchers, federal experts and aquatic user groups will expedite reporting and improve assessment of the causes and extent of toxic events and assist in educating US seafood consumers and the public at large (objective 6, above).

NOAA and the US Food & Drug Administration are co-operating to address seafood safety concerns including marine biotoxins, expanding the focus on the seafood safety issue. The National Institute of Environmental Health Sciences is examining toxin pharmacology and physiological effects related to human health issues, and the National Science Foundation continues to support scientific studies on toxin physiology, algal genetics, taxonomy and other less applied topics.

COMMISSION OF EUROPEAN COMMUNITIES

CEC ACTIVITIES RELATED TO HARMFUL ALGAL BLOOMS

1. Research projects funded in the scope of R&D programmes

1.1. Environment programmes

Contact: Dr. H. Barth DG XII, SDME 3/65, tel: 32-2-2356452

- 4th ENV programme (1986-1990) -

* *Dynamics of Phaeocystis blooms in nutrient-enriched coastal zones of the Channel and the North Sea*

This project fulfilled two major goals:

- The creation of an operative network of scientists from 5 European countries working together for surveying and understanding *Phaeocystis* bloom dynamics. Five-year survey data are available.

- The establishment of a predictive mathematical model integrating refined knowledge of biological processes determining the ecological functioning of the perturbated ecosystem. This model can be used as a management tool in order to optimize the measures to be taken to reduce coastal eutrophication in this area.

- 5th ENV programme or STEP programme (1989-1992) -
(Science and Technology for Environmental Protection)

* *Modelling Phaeocystis blooms, their causes and consequences*

This project constitutes an extension of the previous one. Its major goals are the following:

- the continuation of the survey;
- the improvement of the ecological model;
- the coupling of the ecological model with a river system model on the one hand, and a socio-economic model on the other hand.

* *An ecosystem approach to understanding pollutant inputs and algal blooms and mucilage problems in the Adriatic Sea*

The objectives of this project are the following:

- the development of an integrated approach of field measurements, experiments and laboratory investigations to identify the main physical, chemical and biological mechanisms controlling the initiation and maintenance of mucilaginous algal blooms;
- the relationship between past and present climatic conditions with bloom occurrence;
- the establishment of a predictive 3-D mathematical model of mucilaginous blooms.

- 6th ENV programme (1991-1994) -

No contract has been signed yet but two proposals relating to the development of harmful blooms in the Northern Adriatic Sea with nutrient river discharge have been considered for potential funding.

1.2. MAST (Marine Science and Technology) programme

Contact: Dr. C. Lancelot DG XII, SDME 3/1, tel: 32-2-2350491

- MAST-I programme (1989-1992) -

* *The control of phytoplankton dominance*

Geographical area: SW Ireland, NW Spain

The general objective of this project is the investigation of factors determining the pattern of phytoplankton dominance in European coastal waters. Its specific objective is the identification of physiological mechanisms responsible for exceptional blooms of flagellates.

The following projects are not directly related to harmful algal blooms. Their scientific approach could however be considered as a positive input in this matter.

* *ERSEM (a generic European regional seas ecosystem model)*

The overall goal of this project is to provide the scientific basis to support decision making on environmental quality and biological resources. Its specific objective is to develop a generic ecosystem model that dynamically simulates the seasonal cycle of carbon and inorganic nutrients through the pelagic and benthic ecosystems of the North Sea.

* *SAFE (structure and functioning of coastal ecosystems)*

This project is closely associated to the ERSEM project. It will provide the necessary information on relevant biological mechanisms through mesocosm experiments. Both projects have been extended in MAST-II.

- MAST-II programme (1991-1994) -

* *MEICE (microbiological element cycling in coastal environments)*

* *ERSEM-II*

* Additional proposals are now being considered to establish a coupled physical-biological model in the scope of the Mediterranean targeted project (budget 1993 of the MAST programme). No commitment has yet been taken by the Commission.

2. CCR - Ispra

Environment Institute

* *MITO project in the Northern Adriatic Sea*

The objective is to determine the mechanisms of phytoplankton bloom formation in the Northern Adriatic, with particular reference to toxic species.

3. Studies (report available on request)

- The occurrence of *Chrysochromulina polylepis* in the Skagerrak and Kattegat in May-June 1988: an analysis of extent, effects and causes.
  H. Barth and A. Nielsen
  Water Pollution Research Report 10

4. Workshops (reports available on request)

- Eutrophication and algal blooms in North Sea coastal zones, the Baltic and adjacent areas: prediction and assessment of preventive actions.
  Brussels, October 1989
  Editors: C. Lancelot, G. Billen, H. Barth
  Water Pollution Research Report 12

- Eutrophication-related phenomena in the Adriatic Sea and in other Mediterranean coastal zones.
  Roma, May 1990
  Editors: H. Barth and L. Fegan
  Water Pollution Research Report 16

- The ecology of *Phaeocystis*-dominated ecosystems.
  Brussels, January 1992
  Editors: C. Lancelot and P. Wassmann
  J. Mar. Syst., in press

5. Training activities

- Summer courses: contact K.-G. Barthel
  tel: 32-2-2351242

- Scholarships: contact C. Lancelot
  tel: 32-2-2350491

ANNEX VI

REVISED OUTLINE OF THE HAB PROGRAMME COMPONENT OF OSLR
(Revised extract from IOC Workshop Report No. 80)

6.1. EDUCATIONAL PROGRAMME ELEMENTS

6.1.1 Information Network

Goal: To develop, encourage and maintain the flow of information, technology and expertise to scientists, administrators and the general public.

Objectives:

i) Produce a regular newsletter for reporting bloom occurrences, recent publications, meetings, new techniques, requests for assistance and general information.

ii) Prepare and publish a manual containing standardized methodology for the study of harmful algae (this book could be modelled after the UNESCO Phytoplankton Manual).

iii) Prepare identification sheets and reference slides for harmful species, preserved material and video documentation, updated as necessary.

iv) Compile lists of experts grouped according to areas of expertise, updated as necessary.

v) Ensure rapid communication of harmful events, new problem species, methodologies and other common information to researchers, administrators and medical personnel.

vi) Prepare, distribute and maintain fact sheets on toxin for administrators, the medical community and the general public.

vii) Facilitate worldwide distribution of reference books, conference proceedings and equipment.

viii) Ensure the distribution of material with respect to public safety and education.

6.1.2 Training

Goal: To promote and facilitate the development and implementation of appropriate training programmes in order to distribute the necessary knowledge and expertise on a global basis.

Objectives:

i) Facilitate workshops and training programmes on taxonomy, ecology, toxin extraction and analysis, management strategies, public health and safety and mitigation techniques.

ii) Promote access to equipment and the extensive training of selected individuals in regions that lack adequate facilities and properly trained personnel for toxin analysis.

6.2 SCIENTIFIC PROGRAMME ELEMENTS

6.2.1 Ecology and Oceanography

Goal: To understand the population dynamics of harmful algae.

Objectives:

i) Develop the necessary understanding of bloom dynamics of harmful algae, which includes the phases of bloom progression (excystment or bloom initiation, exponential growth, aggregation, toxicity, as well as death, grazing, encystment, sinking or dispersal) and the succession of phytoplankton species.ii) Develop numerical models (and eventually reliable predictions) of toxic blooms based on hydrodynamic, chemical and biological principles as well as the unique hydrography, chemistry and plankton composition determined by regional research programmes.

iii) Determine the role of nutrients (total amounts and ratios) in the dynamics of harmful algal events; investigate the relative importance of natural versus anthropogenic sources.

iv) Elucidate the importance of human activities in the dispersal of certain harmful species (e.g., via ship ballast water; transfer of shellfish stocks).

v) Derive quantitative relationships among the biological, physical and chemical parameters with respect to the bloom-forming species which can be used in a local management context through predictive models and management strategies.

vi) Determine the ecological role of toxicity in the population dynamics of toxic species and the consequences of toxicity to living resources.

vii) Design appropriate experimental and field studies to develop the required understanding of the hydrography, ecology and oceanographic conditions controlling the population dynamics of harmful species.

viii) Determine the ecophysiological capabilities of causative species (K_ρ, v_{max}, allelopathic substances, grazer repellant, life-cycle strategies).

ix) Establish long-term trend monitoring stations to document changes in phytoplankton species composition and associated physical and chemical variables over decadal time-scales.

x) Develop studies on cyst assemblages to document the areal distribution of harmful, cyst-forming species in order to identify risk areas for harmful algal blooms.

xi) Encourage analysis of sediments, especially from anoxic basins, that can provide evidence (cysts, frustules, etc.) for the prior occurrence of harmful species in regions where recent introductions are suspected.

6.2.2 Taxonomy and Genetics

Goal: To establish the taxonomy and genetics of the causative organisms at the appropriate levels.

Objectives:

i) Develop and maintain the capability to recognize, characterize and identify harmful species by morphological criteria, including ultrastructural and phenotypic variability and also by different life stages such as resting cysts.

ii) Establish a group to make taxonomic recommendations and to develop identification standards for preparation of manuals, reference materials and training standards.

iii) Determine the genetic heterogeneity within species and isolates with respect to mating compatibility and molecular characteristics.

iv) Support existing and establish new regional culture collections specializing in harmful species and create a centralized international culture collection of harmful species.

v) Promote the development of new, rapid, automated identification, discrimination and counting techniques such as, image analysis, flow cytometry and immuno-labelling.

vi) Encourage and enable the development of computerized taxonomic data bases of harmful species.

vii) Organize and conduct intercalibration exercises.

6.2.3 Toxicology and Toxin Chemistry

Goal: To determine the physiological and biochemical mechanisms responsible for toxin production and accumulation and to evaluate the effect of phycotoxins on living organisms.

Objectives:

With respect to physiology:

i) Establish the biosynthetic pathways of toxin production in algae including defining the role of endo- or exocellular bacteria and viruses.

ii) Determine the physiological mechanisms underlying variable toxicity among strains of species or within single strains grown under different conditions.

iii) Define the toxin accumulation, chemical conversion and depuration processes in contaminated seafood.

iv) Determine the processes of toxin degradation.

With respect to chemistry:

v) Isolate, identify and/or elucidate the structure of toxins.

vi) Prepare and supply toxin standards and reference materials.

vii) Develop new chemical analytical methods for toxins, specifically:

1. alternative assay methods to replace such tests as mouse and other bioassay organisms, while improving the sensitivity, specificity and reproductibility of all methods; and

2. simple field assay kits.

With respect to toxicology:

viii) Define the fate and effects of algal toxins in the marine food web.

ix) Elucidate mechanisms of toxicity to marine animals.

x) Determine the mechanisms responsible for the mass mortalities of fish and other marine organisms caused by toxic substances.

xi) Establish pathological indicators to determine toxins responsible for mortalities and other impacts.

6.3 OPERATIONAL PROGRAMME ELEMENTS

6.3.1 Resource Protection

Goal: To develop and improve methods to minimize the environmental and economic consequences of Harmful Algae.

Objectives:

i) Assist managers in designing, evaluating and improving cost-effective procedures for selecting and protecting aquaculture sites; applying methods for early warning of toxicity and mass mortalities; and developing management strategies.

ii) Assist managers in applying scientific results as quickly and effectively as possible to resolve management, mitigation, public safety, public education and public relations problems.

iii) Assist managers in developing strategies and procedures for protecting the tourist and amenity value of coastal areas.

6.3.2 Monitoring

Goal: To promote and facilitate the development and implementation of appropriate monitoring programmes.

Objectives:

i) Provide a source of information and guidance on design and implementation of monitoring programmes.

ii) Interact with, and encourage, long-term regional, national and international monitoring plans and programmes to identify trends and cycles in the frequency of harmful algal blooms, their resulting toxicity for marine life, and suspected causes (e.g., climatological, hydrographical, or nutrient changes).

iii) Ensure the compatibility (e.g., techniques, type of data collected) of plankton and toxin monitoring programmes with basic studies of algal bloom dynamics and ecology.

6.3.3 Public Health and Seafood Safety

Goal: To protect public health and ensure seafood quality.

Objectives:

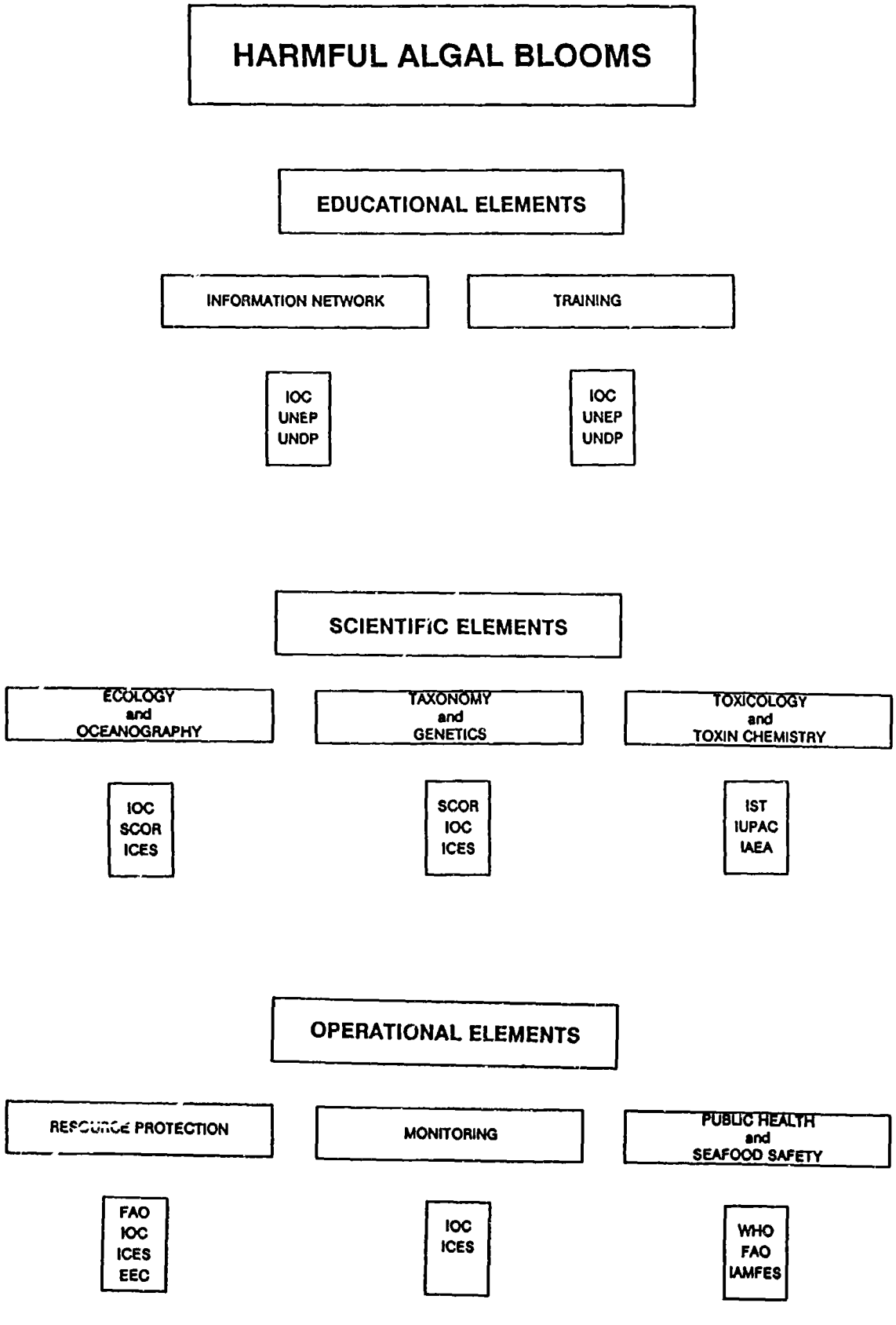
i) Facilitate monitoring for toxic species and seafood toxins.

ii) Encourage standardization of methods for toxin detection and levels for market closure.

iii) Facilitate testing of techniques for the mitigation of noxious blooms: (e.g., forced sedimentation, aeration, sea surface scum collection).

iv) Where appropriate, assist with measures to avoid or mitigate harmful events.

v) Develop antidotes against seafood toxins.


HARMFUL ALGAL BLOOMS
EDUCATIONAL ELEMENTS
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SCIENTIFIC ELEMENTS
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OCEANOGRAPHY
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ANNEX VII

REVISED TERMS OF REFERENCE FOR A HAB PROGRAMME OFFICE

Terms of Reference for Intergovernmental Oceanographic Commission's Programme Office for the Harmful Algal Bloom Programme.

Purpose

To Facilitate and Co-ordinate Programme Development and Implementation.

Activities and Responsibilities

a) Advise on and assist with the formulation of proposals for the support of the programme,
b) Organization of planning and implementation meetings,
c) Preparation and dissemination of reports,
d) Distribution of information,
e) Supervision of newsletter, directory, manual and other programme activities,
f) Interaction and co-ordination with other IOC/MRI programmes and activities,
g) Interaction and co-ordination with other international governmental and non-governmental Organizations that sponsor the programme as well as other organizations which participate in the Activities,
h) Provision of staff support for workshops on development and implementation,
i) Executive director for the steering group of the HAB Programme,
j) Helping in identification of resources and work with IOC and FAO Member States towards Implementation of funded projects.

Level of Staffing

It is anticipated that initially the Programme Office will be composed of two full-time professionals (one leading, one junior) and one part-time secretary.

Preliminary Description of the Potential Position of the IOC Programme Director for the Harmful Algal Bloom Programme

Duties and Responsibilities:

1. Assist with the formulation, promotion and development of the international programme on Harmful Algal Blooms.

2. To interact with the Senior Assistant Secretary for the IOC-FAO/OSLR Programme, providing guidance on and assist with the preparation, organization and servicing of other IOC subsidiary bodies dealing with the problems of Harmful Algae.

3. Interact with related IOC Programmes (e.g., TEMA, GIPME, GOOS).

4. Provide guidance and technical backstopping to the activities of Regional Subsidiary Bodies of the Commission with respect to harmful algae.

5. Liaise with the appropriate units of the United Nations organization, as well as other Intergovernmental and Non-Governmental bodies, on matters concerning Harmful Algae in the marine environment and coastal zone, and act as a focal point and technical Secretary for the Group of Experts on Harmful Algae.

6. Assist with the promotion and implementation of training, education and mutual assistance (TEMA); provide backstopping to technical assistance and operational projects; and participate in advisory missions to member states.

Qualifications and experience required:

a) High academic grade at the Ph.D. level, or equivalent qualifications, preferably in oceanography or other appropriate discipline with good knowledge of the relevant aspects of physical, chemical and biological oceanography and modelling. Experience in research and management of harmful algae is preferable.

b) Broad experience in developing and managing scientific research programmes and/or monitoring programmes, including the related logistic and administrative aspects.

c) Ability to organize meetings, including the preparation of relevant background documentation and final reports.

d) Adequate experience of international co-operation in the field of marine science, ocean services and related aspects; familiarity with the work of the IOC is desirable.

d) Excellent knowledge of English, working knowledge of one or more of the languages of the Commission (French, Spanish, Russian) is desirable.

ANNEX VIII

STATEMENT BY DR. GUNNAR KULLENBERG, SECRETARY IOC, CONCERNING THE PROPOSED ESTABLISHMENT OF A SECRETARIAT-PROGRAMME OFFICE FOR HARMFUL ALGAL BLOOMS

As an opening remark, and with the proposed establishment of a secretariat or programme office for the HAB Programme in mind, I should like to point out to Delegates that the Secretariat for the Intergovernmental Oceanographic Commission in Paris is the Secretariat and Programme Office for all programmes of the Commission and as such is responsible for related implementation and intergovernmental aspects.

It is my understanding that, in the opinion of the scientific community its scientific interests would be well served additionally by the establishment of a scientific project and communication centre on HABs in an appropriate scientific environment and staffed by scientific personnel participating in the international HAB Programme. Steps for the setting-up of such a centre, and its direct link to the IOC Secretariat, are reliant on action at the national level in this respect. The project and communication centre could serve as the scientific focal point for the global HAB Programme and its research activities and as such be responsible for providing information and literature to developing countries, establishing contacts between scientists, or partnerships between laboratories in developed and developing countries; and building up a data-base and, eventually, serving as a data-centre. It would require resources in the form of staff and running costs from the host institutions or country/countries. A formalized linkage should be established with the IOC Secretariat to ensure communication and avoidance of duplication of efforts and so that contributions could be regarded as provisions to the implementation of the IOC programme activities.

During the Twenty-fifth Session of the IOC Executive Council (Paris, 10-18 March 1992) and the First Session of the IOC-FAO *Ad hoc* Intergovernmental Panel on Harmful Algal Blooms (Paris, June 1992), several delegates voiced the willingness of their national scientists to have a "secretariat" for the Harmful Bloom Programme located in their respective countries, with national support. At the Twenty-fifth Session of the Executive Council, some delegates also expressed the view, which I share, that the secretariat for the Programme should be co-located with the other IOC Programme components in the IOC Secretariat, in light of the need to ensure harmonization, co-ordination and exchange of information with other IOC Programmes and activities in its implementation.

For a global programme, or components thereof, the intergovernmental aspects must be based within the IOC Secretariat in Paris, in order to avoid duplications, confusion, lack of co-ordination and tardy response. It is one thing if the organization is large enough to locate an office outside Headquarters based on a formal agreement between the host country Government and UNESCO with appropriate UNESCO Staff and services to run the whole programme and maintain co-ordination with the Secretariat at headquarters. However, we do not have the means for such a move, neither is it the intention. Therefore, I should like to repeat that the Programme Office for the IOC-FAO Harmful Algal Bloom Programme should remain in the IOC Secretariat.

What we can do, provided the necessary resources are identified by Member States, is to have a Programme Office for the HABP located at the IOC Secretariat in Paris, and establish a scientific project and communication centre on HABs in an appropriate scientific environment, as stated above.

ANNEX IX

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ANNEX X

RECOMMENDATIONS OF THE IOC/WESTPAC SCIENTIFIC SYMPOSIUM ON MARINE SCIENCE & MANAGEMENT OF MARINE AREAS OF THE WESTERN PACIFIC (Extract from Workshop Report No. 76)

4.1 TOXIC AND ANOXIC PHENOMENA ASSOCIATED WITH ALGAL BLOOMS

Recommendations:

(i) **The IOC and the IOC/WESTPAC Secretariat should convene a Working Group and commit funds for the creation and distribution of a manual on techniques used in field and laboratory studies on harmful algal blooms.**

Comment: This manual is to be a compilation of new material together with existing protocols that are now scattered throughout the literature. The emphasis should be on the species and techniques that are appropriate for the WESTPAC region, recognizing the limitations many countries have with respect to expensive or highly technical equipment. The manual will initially be distributed to individuals for comments and revisions, and then tested and refined further at a training workshop. Translation of this manual into national languages of the WESTPAC countries should be considered as a possible future WESTPAC activity.

(ii) **The IOC and WESTPAC should support the creation and distribution of a regional newsletter on harmful algal blooms.**

Comment: This effort will only succeed if Task Team members actively contribute to the newsletter. Initial efforts to distribute a newsletter twice each year to approximately 100 individuals will be co-ordinated by Mr. D.M. Anderson (USA) and Ms. R. Corrales (Philippines) but the eventual goal will be for a publication entirely sustained by workers from the region. On occasion, rapid communication will be needed (e.g., large-scale red tide out breaks), so special bulletins can be distributed from the WESTPAC Secretariat via fax to selected individuals in each country.

(iii) **The IOC and WESTPAC should provide funds for training workshops and scientific exchange visits.**

Comment: Once a protocol manual is available, a regional training workshop should be convened at a marine field station within the region where there is easy access to waters where harmful red tide blooms occur. The training activities will be centered around the manual, as this will not only provide valuable feedback on the usefulness of the material but will also enhance the training process. Participation in the workshop should be strictly controlled to include only those who have had, and will continue to have, direct activities in the collection and analysis of field samples. Participants will be nominated by members of each country's Task Team, with the final selection by the Task Team Chairman and Workshop Co-ordinator.

(iv) **The IOC and WESTPAC should provide funds for the creation and distribution of photographs, slides and preserved samples of harmful bloom species from the WESTPAC region.**

Comment: Many of the photographic materials already exist, so it is just a matter of duplication and distribution. A fixed number of sets of this material (5-10) will be sent to each country, with the distribution of these sets within each country to be determined by Task Team Members. At present, there are not sufficient supplies of preserved plankton materials for distribution. Through the Newsletter, requests will be made for workers to obtain large quantities of bloom organisms and to preserve them with appropriate methods. These samples will be collected in a central location and distributed in vials as reference materials once taxonomic authorities have examined and categorized them.

(v) **As an adjunct to training workshops, the IOC and WESTPAC should provide funds for expert visits to individual countries, and for long-term training fellowships (TEMA) for WESTPAC-country scientists to expert laboratories.**

Comment: Workshops provide important training, but considerable benefit can be obtained from longer, more personal interactions in expert laboratories or by visits of experts to specific WESTPAC country laboratories.

(vi) **Recognizing the need for increased understanding and recognition of the serious threat to coastal marine resources and to public health posed by harmful algal blooms, the IOC and the WESTPAC Secretariat should work closely with Task Team scientists and high level policy-making officials in member countries and regional organizations so that priority is given to obtaining external aid for bloom research and monitoring.**

Comment: Several large international programmes on harmful blooms are under consideration for funding, but the success of these proposals will be a direct function of the specific enthusiasm and support provided by national planning agencies. These agencies are faced with difficult decisions between competing infrastructure development. If the importance of harmful bloom studies can be adequately communicated by Task Team scientists and a high priority established at the national level, external agencies will be responsive to the perceived needs. To achieve this, Task Team members, the IOC and the WESTPAC Secretariat will need to become politicians and "salesmen/women". To start this process some guidelines will be mailed to Task Team members that can be used to build arguments, and eventually to write letters for planning agency use in their contacts with UNDP and other funding sources. Funds will not be provided by these agencies unless they are convinced that harmful bloom programmes are of great national and regional importance. Since most national research and monitoring programmes in the WESTPAC countries are not well-funded at present, it will not be easy to change the perception of these phenomena at the national level.

(vii) **Convene a regional Symposium on the harmful algal blooms, possibly to be held in conjunction with the marine pollution programme in WESTPAC**

Comment: Periodic exchange of scientific information is a necessary component of the WESTPAC harmful algal bloom network. The symposium should focus on harmful blooms, although some presentations from regional pollution studies would be informative.

(viii) **The IOC and the WESTPAC Secretariat should explore ways to supplement on-going or planned multi-lateral programmes on harmful algal blooms (e.g., ASEAN/Canada) so that non-ASEAN WESTPAC countries can participate in the training activities of those programmes.**

Comment: Several major aid programmes are being implemented that provide training in harmful bloom research issues to certain, but not all, WESTPAC countries. Examples are the ASEAN/Canada red tide programme, and bi-lateral agreements between Japan and Thailand or the Philippines. Through negotiations with responsible officials in these programmes and using WESTPAC funds, it may be possible to expand participation in the training aspects of these programmes to include more WESTPAC countries.

ANNEX XI

RECOMMENDATIONS OF THE IOCARIBE *AD HOC* GROUP OF EXPERTS ON MASS MORTALITY OF FISH (of 1982)

The *Ad hoc* Group of Experts appointed by IOCARIBE have submitted a report dealing with emergency plans in case of mass mortality of fish. The *Ad hoc* Group of Experts made the following recommendations:

1. To prepare a **Manual** containing standard instructions, methodologies and emergency measures to be taken in case of mass mortalities outbreaks in the greater Caribbean.

2. To design standard report formats and to establish a data center which could:

   (a) release a bi-monthly list of fish mortalities;
   (b) co-ordinate a rapid alert system for events that involves areas greater than 100 km^2.

3. To organize brief **training courses** for scientists and support personnel to be involved in the recommended activities and procedures.

ANNEX XII

GLOSSARY OF ACRONYMS AND SPECIAL TERMS

CEC	Commission of the European Communities
DANIDA	Danish International Development Agency
EEC	European Economic Community
FAO	Food and Agriculture Organization of the United Nations
GEEP	Group of Experts on the Effects of Pollutants
GEF	Global Environment Facility
GEMSI	Group of Experts on Methods, Standards and Intercalibration
GESAMP	Group of Experts on the Scientific Aspects of Marine Pollution
GESREM	Group of Experts on Standards and Reference Materials
GIPME	Global Investigation of Pollution in the Marine Environment
GOOS	Global Ocean Observing System
IAEA	International Atomic Energy Agency
ICES	International Council for the Exploration of the Sea
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC Sub-Commission for the Caribbean and Adjacent Regions
IST	International Society of Toxicology
IUPAC	International Union of Pure and Applied Chemistry
MARPOLMON	Marine Pollution Monitoring
MAST	Marine, Science and Technology
MEDPOL	Co-ordinated Mediterranean Pollution Monitoring and Research Programme
OSLR	Ocean Science in Relation to Living Resources
PICES	North Pacific Marine Science Organization
SCOR	Scientific Committee on Oceanic Research
TEMA	Training, Education and Mutual Assistance in the Marine Sciences
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
VCP	Voluntary Contribution Programme
WESTPAC	IOC Sub-Commission for the Western Pacific
WHO	World Health Organization