Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

IOC Group of Experts on Effects of Pollutants

Third Session

Tomte, Oslo, Norway, 31 August - 2 September 1986

Unesco

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In this Series

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984, the reports of the following meetings have already been issued:

- Third Meeting of the Central Editorial Board for the Geological/ Geophysical Atlases of the Atlantic and Pacific Oceans
- Fourth Meeting of the Central Editorial Board for the Geological/ Geophysical Atlases of the Atlantic and Pacific Oceans
- Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of «El Niño»
- First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in relation to Living Resources
- First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-Living Resources
- First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
- First Session of the Joint CCOP (SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
- First Session of the IODE Group of Experts on Marine Information Management
- Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Testonics and Resources
- Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
- First Session of the IOC Consultative Group on Ocean Mapping
- Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
- Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
- Third Session of the Group of Experts on Format Development of the Working Committee on International Oceanographic Data Exchange
- Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
- Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
- Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
- Second Session of the IOC Group of Experts on Effects of Pollutants
- Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica
- Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
- Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
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- First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific Second
- Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-Living Resources (OSNLR)

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1. OPENING OF THE SESSION

The Third Session ofthe Group of Experts on Effects of Pollutants was convened at the kind invitation of the Norwegian Academy of Sciences at the premises of the Academy at Tomte, Hamre, Norway, following directly after the IOC Workshop on Biological Effects Measurements in Oslo.

The Chairman, Dr. B. Bayne, opened the Session at 09.00 hours on 31 August 1986. He welcomed all the participants (see Annex III) and expressed his appreciation to the Norwegian Academy of Sciences and to Dr J. Gray for arranging for the meeting to be held in such a beautiful location.

The Technical Secretary for the Session, Dr G. Kullenberg, welcomed the participants on behalf of IOC and also expressed his appreciation to Dr J. Gray and the Norwegian Academy of Sciences for the arrangements.

The Chairman declared the Session open.

2. ADMINISTRATIVE MATTERS

2.1 ADOPTION OF THE AGENDA

The Provisional Agenda was adopted (Annex I).

2.2 DESIGNATION OF RAPPORTEUR

The Group of Experts decided that participants would contribute to different Items for the Report and that Dr J. Gray would act as Rapporteur.

3. INTERSESSIONAL ACTIVITIES

Reports on intersessional activities since GEEP II were reviewed. Three topics were considered later on the Agenda: viz. the IOC Workshop on Biological Effects Measurements, Oslo, 11-29 August 1986, and its follow-up, Vulnerable Areas, and Bioassay Techniques.

3.1 PESTICIDE RESIDUES IN MARINE MAMMALS

Following discussions between IOC and ICES, and within ICES, it had been agreed that Dr John Harwood would co-ordinate a review of the effects of pesticide residues in marine mammals. Dr R. Addison would represent the Group in this activity. Dr Addison would be holding discussions with Dr Harwood immediately following GEEP III and would soon thereafter be writing a review which would serve as his contribution to the ICES-led initiative. This review would be made available to the participants for comment and Dr Addison was requested to represent the Group's view in any further discussions and in the final report of the Group. The Session welcomed the possibility that this final report would also include a discussion of the chemical measurements appropriate to the assessment of pesticide residues.

3.2 EUTROPHICATION

The Technical Secretary reported on the formation of a group, under GESAMP, to study the nutrient enrichment problem; several GEEP members would be invited to contribute to this study. The Group of Experts welcomed the news and reiterated its readiness to contribute.

The discussion then centered on what aspects of eutrophication and its associated environmental impacts could be advanced by the Group, given our present understanding.

Organic enrichment gradients have been well documented in temperate regions and it is possible, from a knowledge of community structure, to predict the degree of organic input to the sediment communities and to estimate likely oxygen demand and the potential for oxygen deficiency. These considerations are of interest in the context of eutrophication, which leads to increases in primary production and, under certain circumstances, an increased 'rain' of organic materials to the benthos. In particular, eutrophication effects resulting from increased nutrient losses from land to coastal seas, and the use of coastal areas for the disposal of organic wastes, are in conflict with the demands of mariculture in coastal sites.

Knowledge of the expected consequences of increased organic loading to the sediments could be very important, leading to identification of indicators, and possible predictors of organic stress. However, our knowledge of these community consequences does not presently extend to tropical communities, where some of the environmental problems are most acute. The Session therefore considered that an identifiable need exists, namely to examine a known gradient of organic input to sediment communities within a tropical ecosystem, and to apply the 'rules' of response to organic enrichment that have been shown to apply in temperate systems, in order to establish whether such rules may also be relevant in the tropics.

There is a further important dimension to this problem, concerning the effects of organic enrichment and consequent changes in the redox and pH status of the sediments on the flux and the biological availability of metals and other contaminants. The Session was aware of various initiatives amongst marine laboratories in Europe and in North America, to study this problem in the context of biogeochmeical budgets and mass balances of trace metals. Any study of organic enrichment which was mounted in a tropical country would benefit from collaboration between biologists and chemists, in order to link biological changes with consequences for chemical flux. It would be appropriate for such a co-ordinated study to be jointly undertaken between GEEP and GEMSI.

With these considerations in mind, the Session proposed that discussions be initiated within the Scientific Committee for GIPME for a joint biological and chemical study of ecosystem response, in a tropical situation, to organic enrichment to the sediments. The Group of Experts was aware of previous GEMSI activities in Thailand, concerned with evaluating river inputs to coastal regions, and suggested that future discussions might centre on this region for a combined GEEP/GEMSI activity.

4. IOC (OSLO) WORKSHOP ON BIOLOGICAL EFFECTS MEASUREMENTS

Discussions focused on arrangements for reporting the results of the Workshop and decisions regarding the most effective follow-up activities. These discussions were prefaced by a general agreement that the Workshop had been successful in achieving its main aims (see Annex IV); it was, however, too soon to elaborate on the Workshop outcome and a more considered assessment by the Group of Experts would be postponed until April 1987.

4.1 REPORTING THE RESULTS OF THE WORKSHOP

Three levels of reporting were agreed: (i) oral reports to the Scientific Committee for GIPME, Session in September 1986, the ICES Statutory Meeting in October 1986, the IMO/LDC Meeting in October 1986 and the International Symposium on Pollution Responses in Marine Animals (Woods Hole) in April 1987; (ii) a written report in the IOC Workshop Series; (iii)a commercial publication, already discussed with the publishers Inter-Science. A programme for time-tabling activities (ii) and (iii), with some indication of content follows:

The following timetable for publication of the main report is:

Action	Date
Submission of MS by authors to Group Convenors (see below)	30 November 1986
Circulation of draft Introductions and Summaries for each section, by Convenors, to all participants	31 January 1987
Circulation of complete texts among all Convenors	15 March 1987
Meeting of GEEP ad hoc Group to write synthesis	26-28 April 1987
Dispatch of final text to publisher	Spring 1987
Publication	Autumn 1987

The Convenors are as follows: Biochemistry - R. Addison; Physiology - J. McDowell Capuzzo; Pathology - M. Moore; Community Ecology - R. Warwick. The editors of the publication are: B.L. Bayne, J.S. Gray and R.K. Clarke.

Bearing in mind discussions held during the Oslo Workshop, the Group of Experts agreed that commercial publication would comprise three sections. Section 1 would introduce the Workshop, its basic rational and aims and the statistical considerations underlying its design. Section 2

would be comprised of contributions from all participants (including chemistry and statistical analysis) describing procedures and results obtained at the Workshop; these contributions would be grouped according to subject matter and each sub-section would start with an introduction and finish with a summary. Section 3 would contain conclusions and recommendations.

The Report to IOC of the Workshop would comprise an Introduction and Rationale, the Group Summaries from Convenors, and a section drawing Conclusions and Recommendations. This Report would be prepared in parallel with the book and be ready for submission to IOC in the Spring/Summer of 1987.

4.2 FOLLOW-UP TO THE WORKSHOP

It has always been the intention of the Group of Experts to follow the Oslo Workshop with other, similar activities associated with IOC's regional programmes; two areas, in particular, have been identified, viz. the WESTPAC and IOCARIBE regions. Discussions on these two regions were prefaced by a discussion of the framework within which these activities could best be set.

4.2.1 Training

The Group of Experts agreed that Workshops were a useful means of communicating the utility of certain biological effects techniques and from training other scientists in these techniques. However, such training Workshops should not be organized in isolation. It was necessary to set such training in the context of on-going and committed environmental programmes, where the techniques, once demonstrated as effective, could be built-in for regular use. It was also felt to be important that trainees should be given more time than the three of four weeks of a typical Workshop, to assimilate the background to the subject and to be instructed in the interpretation of data. A further points was made: many of the techniques currently available for biological effects measurements have been developed within well-equipped laboratories and demand the use of sophisticated equipment. If such techniques are to be applied in areas not so fortunate in the availability of equipment, they need to be adapted to the appropriate conditions. The meeting agreed that trainees, working in particular laboratories, could participate in this process of adaptation of the procedures for wider application.

The Group of Experts supported the concept of rapid exchange of successful biological effects techniques between countries and regions and wishes to effect training in the techniques demonstrated to be useful in the Oslo Workshop and in subsequent activities. The Group would wish to see carefully chosen trainees given the opportunity to spend periods of three to six months in particular laboratories selected for their excellence in certain areas of effects measurements. Such periods could bracket or be arranged to include a training workshop, also attended by the trainees; and the trainees would be invited to participate in the development of biological effects techniques for wider use in tropical areas and elsewhere.

4.2.2 Proposed practical Workshop in Venezuela

The Group of Experts discussed the assessment of 'vulnerable areas' and the role in this activity of certain biological effects techniques (see later Agenda Item). It was felt that the next step in these developments should be to hold a practical Workshop in which various approaches were brought together. The Group's involvement in the Venezuelan programme on the Morrocoy National Park suggests that this would be one possible venue. The approaches considered appropriate are as follows:

(i) the application of effects techniques (of the type evaluated at the Workshop in Oslo) to bivalve molluscs living within the mangrove system of the Park, to fish species living within the mangrove system of the Park, to fish species living in the coral reef area, and to benthic communities of organisms living in both these areas and within the soft sediment areas of the Park. This study would be designed to evaluate the current "condition" of these various components within the Park ecosystem and to assess the value of these techniques in a tropical setting.

(ii) the use of bioassay to evaluate the "quality" of local environments within the Park. Two types of bioassay (see below) are considered most appropriate viz. a sediment bioassay to rank the various habitats within the Park in terms of pollution impact, and bivalve larval development bioassay as a measure of water quality;

(iii) the application of 'expert systems' methodology to the management of the Park, as a means of integrating information on the economic pressures on the Park, the knowledge base available within Venezuela on the ecology of the Park, and the results of activities described in (i) and (ii), above and (iv) below. The rationale for the use of expert systems in this way is discussed under Agenda Item 5;

(iv) chemical analyses of water, sediments and biota, including polyaromatic hydrocarbons and trace metals. It may be appropriate to consider such analyses in the light of discussions proposed to be held between GEEP and GEMSI during the coming year (see below);

(v) in all of these main elements, to include training of Venezuelan scientists and to make available the opportunity of training other scientists from the region.

Such a Workshop will require four weeks, organized as follows: a week in which the various techniques are described in detail to all participants; a week in which laboratory exposure experiments are carried out, in order to apply the various experimental procedures in a simplified setting; a week in which material sampled from the field situations is utilized; and a fourth week for synthesis and interpretation. Appropriate numbers might be 8-10 instructors and 20-22 trainees. The Group of Experts would wish to see some of these trainees be given the opportunity to spend some time after the Workshop in the laboratories of the instructors, so that training could be consolidated. GEEP considers that such a Workshop should be held during 1988.

In designing and planning this activity, the Group would wish to co-operate with, and work within the overall plans of the Regional Marine Pollution Monitoring component part of MARPOLMON of IOC/IOCARIBE, (CARIPOL). In order to initiate this co-operation, the Group would welcome the opportunity to have a representative reporting on the IOC (Oslo) Workshop and the follow-up plans to the forthcoming Expert Meeting of the CARIPOL Steering Committee. The Group also proposed to send representatives to the National Symposium convened in Venezuela in December 1986, in order to initiate detailed discussion with Venezuelan scientists.

4.2.3 Training Workshop in China

In discussing possible future activities associated with the WESTPAC regional programme, the Chairman reported that he had been in contact with the East China Seas Fisheries Research Institute in Shanghai. The Institute had expressed an interest in hosting a training workshop in biological effects measurement. The WESTPAC Task Teak on Marine Pollution Research and Monitoring, at its meeting in Townsville, Australia (April 1985), expressed interest in such training in this region and, at that meeting, China reiterated its willingness to host such a workshop.

The Group of Experts therefore agreed that appropriate discussions should be initiated in order to develop plans for a training workshop in China, to be held, if possible, in 1989. The Group agreed that:

(i) discussions with the appropriate authorities within IOC would be initiated which would express GEEP's interest in sending a representative to China as soon as possible to consider, with Chinese scientists, possible venues and the content for the Workshop;

(ii) the Chairman of GEEP would continue his correspondence with the East China Seas Fisheries Research Institute, maintaining the Group's interest in Shanghai as a possible venue;

(iii) the GEEP ad hoc Workshop Group, which would be meeting in Woods Hole, USA in April 1987, would review the situation then and consider all the available options.

5. VULNERABLE AREAS

The Group of Experts has given further thought to the important question of how the vulnerability of an area to impact by man's activities may be assessed. The Group takes a biological perspective on this problem, i.e., vulnerability is viewed as a property of the biological components of the system. The problem is then one of describing the sensitivity of key system components and attributes to disturbance, and of developing such a 'sensitivity analysis' to the point of prediction, where possible. The first step in such an analysis will be to map the various structural properties of the system, including the major sources of potential disturbance (industrial activity, tourism, etc); this might be followed by the selection of key species and/or processes, which are considered to be

suitable sentinels of response to disturbance. Measurements made on these species/processes can be used to advance from a static mapping stage to a more dynamic appreciation of the current "health" of the system. Finally, such information, together with information on the economic pressures on the area might be brought together into a modelling framework which can be used by the manager in decision making.

There are two important aspects of this scenario that GEEP considers are amenable to further development through practical evaluation, viz., the role of biological effects techniques in providing the measures of response to disturbance, and the use of 'expert systems' methodology to provide a framework for decision making that draws on all available information and expertise, including both quantitative and semi-quantitative data. The first of these aspects represents a main aim of the IOC (Oslo) Workshop on Biological Effects Measurements and the Group's continuing practical evaluation of various biological effects procedures. For example, in an area potentially subject to hydrocarbon pollution, and representing, for example, a composite of mangrove and coral reef environments (such as are found in the Morrocoy National Park in Venezuela), it may be appropriate to monitor potential biochemical responses in key fish species in order to provide early warning of any increase in hydrocarbons in the environment; to measure the physiological status of mangrove oysters (as, for example, the scope for growth), as a sentinel species of reflecting general environmental stress; and to assess benthic community structure as providing the most integrated measure of environmental change. The Group of Experts agreed to further develop these ideas in its evaluation of the results from the IOC (Oslo) Workshop and in its plans for follow-up activities.

The application of expert systems (i.e. structured computer-based diagnostic and management tools) to environmental problems is a relatively new development and one viewed by the Group as having great potential. The Group of Experts decided that this topic merited the setting up of an ad hoc intersessional group which would report to the Fourth Meeting of the IOC Group of Effects of Pollutants on the role of expert systems in assessing ecosystem vulnerability, with particular reference to a practical evaluation of these methods during the planned Workshop in Venezuela in 1988. The membership of this group is:

B. Bayne (Chairman); R.K. Clarke (United Kingdom);
J. Rabinovitch (Venezuela); and K.L. Seip (Norway)

The Terms of Reference of the ad hoc Intersessional Group are to report to GEEP-IV concerning: (a) the application of expert systems to problems of assessing the vulnerability of marine systems to disturbance by man, and ; (b) how best the planned GEEP Workshop in Venezuela in 1988 may be used to provide a practical demonstration and evaluation of expert systems methods, applied specifically to the Morrocoy National Park project.

6. BIOASSAY TECHNIQUES IN BIOLOGICAL EFFECTS MONITORING

The Group of Experts considered a report on bioassay submitted by Drs. J. McDowell Capuzzo and A. Stebbing (Annex V). This report identifies certain strengths and weaknesses in the current development and application of bioassays for measuring environmental quality. In particular, bioassays are increasingly being used to set environmental standards although the relationships between assay results, the form and the bio-availability of the contaminants, and the relationship between various types of biological response are incompletely understood. For example, sediment bioassays are being used as indicators of contaminant levels within sediments, but can only be interpreted fully if details of chemical (contaminant) speciation within the sediments is known and can, together with the bioassay data, be related to changes in community structure and/or function.

The Group of Experts identified where it might best contribute, in practical terms, to furthering the development of bioassay procedures for application in biological effects studies. The Group of Experts agreed on the following actions:

(i) The Group would seek to include both a sediment and a water-quality bioassay in the design of the Venezuela Workshop (referred to above), in order to explore their sensitivity in comparison with other measures of 'biological effects', such as community change.

(ii) Discussions would be initiated with GEMSI to review the various features of chemical behaviour and dynamics within sediments (e.g., the relationships between pore-water chemistry, the chemistry of the sediment surface, and physico-chemical features such as redox balance and pH that are likely to affect the bio-availability of contaminants and therefore control the biological responses as determined in sediment bioassays.

(iii) Subsequent to these discussions, the Group would incorporate such bioassays in experiments planned for a tropical region in which the community responses to increasing organic inputs are measured and related to such features as oxygen demand and consequent geochemical flux of metal and organic contaminants.

In addition, the Group of Experts is aware of the interest shown by ICES and by IMO in the application of bioassays to problems associated with the dumping of wastes at sea. It may be appropriate to arrange an intercalibration exercise in which the various bioassays are evaluated together at a single site, applying the same logic as used in the Oslo Workshop. Such an exercise could be held, for example, in the North Sea, and GEEP would be prepared, with support from other organizations, to co-ordinate such an activity.

7. BIOLOGICAL EFFECTS STUDIES IN MUSSELWATCH PROGRAMMES

The results of the GEMSI-GEEP questionnaire were not yet available and it was therefore felt that full discussion of the status and potential for biological elements within musselwatch programmes should be considered an intersessional activity, to report to GEEP IV in 1987. There are two aspects to this question. Firstly, as biologists, the Group is in a position to offer advice on biological considerations that are likely to affect the quality and the interpretation of chemical data from such programmes. Secondly, the Group was now in a position to describe various biological techniques that could be included in musselwatch programmes in order to help interpret the contaminant data in terms of pollution impact.

The Group of Experts therefore recommended that an intersessional GEEP ad hoc Group be asked to consider these problems, by correspondence. This Group consists of, among others:

J. McDowell Capuzzo (Chairperson); J. Widdows (Plymouth) N. Kautsky (Stockholm); A. Viarengo (Genoa); A. Bremner (Melbourne); N. Menon (Cochin).

The Terms of Reference for this Group are:

To prepare a report for GEEP IV on:

(a) What further biological processes should be incorporated into Musselwatch programmes in order to facilitate the interpretation of chemical data.

(b) What further biological processes could be included into Musselwatch programmes in order to measure the biological impact of the observed contaminant levels;

(c) What are the appropriate "costs and benefits" associated with the inclusion of biological effects studies in these programmes, such costs and benefits not to be interpreted in strictly financial terms, but rather in terms of information gain set against the different levels of effort that could be involved.

In discussing GEEP's action plan for the next three years, the Group was aware that, once this intersessional activity was complete, and the results made known, the Group may expect to be asked to participate in various regional programmes, perhaps to initiate biological effects studies within musselwatch programmes, perhaps to co-ordinate training. The Group would welcome such participation wherever appropriate.

8. THE INTEGRATED GLOBAL OCEAN MONITORING (IGOM) CONCEPT

The Technical Secretary reported on recent developments concerning IGOM and a discussion followed on the question of the Group's possible involvement.

The Group of Experts expressed interest in the discussions that have taken place and in the scale and content of a possible IGOM pilot project. Current activities of the Group are directed at consolidating suites of biological techniques for application in coastal and in-shore areas where contaminant levels are high. These activities are designed to integrate with the GIPME Action Plan and eventually to facilitate comparable monitoring of the biological effects of pollutants within the world's coastal seas. When such techniques have developed to the stage where global application is feasible and advisable, it may be appropriate for the Group to offer procedures and insights to a pilot project structured on the scale of IGOM. In the meantime the Group would maintain an interest in the further development of IGOM.

9. INTERACTION WITH OTHER GROUPS

Presently, the emphasis of the Group of Experts is to initiate and to participate in practical studies designed to further the development and the application of biological effects measurements in marine pollution programmes. It is in this light that the Group discussed relationships with other organizations. The Group welcomed collaboration with other Groups who share an interest in biological effects studies. Discussions concerned four such organizations in particular:

(i) Discussions are continuing between IOC and IMO; IMO has expressed a strong interest in the activities of the Group and a wish to become more closely involved in the work.

The Technical Secretary will be reporting to IMO in due course on the results of the IOC (Oslo) Workshop and on the intentions of the Group regarding follow-up activities. It was felt, in particular that the planned Workshop in Venezuela, in which procedures appropriate to the evaluation of vulnerable areas will be explored, represents a particular interest of the IMO and the Group would welcome IMO support and involvement. Furthermore, in the future, intercalibration studies on various bioassay techniques might also benefit from collaboration with IMO.

(ii) The ICES Observer expressed ICES' interest in the activities of the Group and the positive way that GEEP had rapidly undertaken practical studies. He suggested that ICES would wish to maintain close links with the group in the immediate future. The Chairman welcomed these remarks and expressed pleasure at the participation in the Oslo Workshop of an ICES representative, who had been fully involved in the practical work. It was agreed that the Technical secretary would report on the activities of the Group to the Statutory Meeting of ICES in October 1986.

(iii) The Technical Secretary, referring to correspondence with the Chairman, brought to the Group's notice GESAMP's activities on the Report on the State of the Marine Environment (GESAMP WG.26). It was agreed that the Group could make a positive contribution to this initiative, particularly in the section on biological effects; the Chairman would contact the Chairman

of WG.26 to discuss how best such a contribution could be effected. The meeting also took note with interest of the activities of WG.27 on The Effects of Long-Term Low Level Contamination in the Marine Environment, and would welcome the opportunity to contribute to these discussions.

(iv) The National Oceanographic and Atmospheric Administration (NOAA) of the US, who were part sponsors of the Oslo Workshop had expressed an interest in collaborating with the Group in a Workshop on Biological Effects Measurements in the US Gulf Coast/Caribbean area. The Group welcomes this interest. The primary objective of the Group in the Caribbean area at the present time is the assessment of the effect of man's activities on vulnerable areas and the Group has selected the Morrocoy National Park in Venezuela as a possible convenient test site. The meeting considered that these objectives and NOAA's interests were complementary. The Group would be prepared to co-ordinate the scientific planning and the execution of a workshop, as suggested by NOAA, but would wish to see this interphased with planned activities in Venezuela.

The Group of Experts agreed that the Chairman, in consultation with the Technical Secretary, should develop discussions with NOAA along these lines, with a view to furthering the aims of both organizations within the Caribbean area.

In addition, the Group of Experts considered various aspects of its relationship with GEMSI. The Oslo Workshop had benefitted considerably from the efforts of Professor Palmork's laboratory in providing organic analyses, and the Chairman expressed his thanks to Professor Palmork and to GEMSI for this collaboration. It was clear to all at the Workshop that any similar activity in the future would equally depend on the provision of good analytical data from a laboratory known to meet GEMSI standards.

In turning to wider issues of collaboration with GEMSI, the Group of Experts agreed that there were many topics that would benefit from joint discussion between GEEP and GEMSI at this stage. In particular, discussions could aim to identify the aspects of current research into the behaviour of contaminants in the sea which are relevant to chemical monitoring and likely to increase our understanding of the interactions between chemical compounds and organisms. Such factors might include:

(i) the importance of analyzing specific individual compounds rather than sums of classes of compounds (for example, individual PCBs instead of total PCBs) and in assessing their impact on biological systems;

(ii) the various routes of introduction of chemicals to the sea and the consequences for biological impact;

(iii) the partitioning of chemical compounds between dissolved and particulate phases in sediments and in the water column;

(iv) the predictive value for biological effects studies of such parameters as the octanol/water partition coefficient;

(v) the effects of redox change and of the organic content of sediments and particulate matter, on chemical speciation and bio-accumulation;

(vi) metabolic and depuration processes within biota.

The emphasis of such discussions would be to assess the impact of the environment on the chemical and its speciation and so complement GEEP's emphasis on the impact of the chemical on the biota.

The Group agreed of Experts agreed that the Chairman should contact the Chairman of GEMSI to initiate such discussions. A possible focus for dialogue would be the interactions between contaminants and suspension-feeders, such as bivalve molluscs, since musselwatch projects are of interest to both GEEP and GEMSI.

10 FUTURE ACTIVITIES

Discussions centred on formulating an Action Plan for GEEP to cover the next three years, the main features of which are as follows:

1986

September: Three reports will be presented by GEEP at the GIPME Symposium in Paris: (1) on the IOC (Oslo) Workshop on Biological Effects, by B.L. Bayne; (2) on Statistical Properties and Developments in Effects Monitoring, by K.R. Clarke and R. Green; and (3) on GEEP Vulnerable Areas Activities by J. Gray and B.L. Bayne.

November J. McDowell Capuzzo to attend the planned CARIPOL Steering Group meeting to report on GEEP activities.

December Possibly R. Addison, J. McDowell Capuzzo and J. Gray to attend the National Symposium on Biological effects of Petroleum Hydrocarbons (Caracas, Venezuela, 8-12 December) to contribute to the discussions and to meet with appropriate Venezuelan scientists (14-16 December) to contribute to the discussions and discuss various aspects of the planned practical Workshop in Venezuela in 1988.

1987

April The GEEP ad hoc Group on the Workshop on Biological Effects Measurements to meet in Woods Hole with the following Terms of Reference:

(a) To co-ordinate and to prepare a report on the IOC (Oslo) Workshop on Biological Effects Measurements, for publication in the IOC Workshop Report series, and to finalize the Conclusions and Recommendations section of the related commercial publication;

(b) To plan further follow-up activities resulting from the Workshop.

October/November GEEP IV Session in Paris.

Dates unknown:

Chairman of GEEP to visit China to investigate possibilities of holding a training workshop there in 1989.

Consultation regarding the Effects of Organic Residues in Marine Mammals.

1988

April/May Practical Biological Effects/Vulnerable Areas Workshop in Venezuela.

Various training activities; ad hoc activities associated with musselwatch and vulnerable areas.

Discussions initiated on Intercalibration of Bioassays; on an Experiment to Assess the Effects of Organic Enrichment in Tropical Benthic Communities; and on a regional Biological Effects Survey in the Caribbean.

1989

Training Workshop in China, in association with WESTPAC.

11. OTHER MATTERS

Three topics were discussed:

(1) The Group of Experts agreed that preparation for future Training Workshops would necessarily involve detailed manuals of techniques which could subsequently be published. The publication of the Oslo Workshop Report will provide the basis for such manuals, since each participant had been asked to describe the procedure used in Oslo in some detail.

(2) Due to the increasing involvement of GEEP in a wide variety of activities associated with the biological effects of pollutants, IOC had approved an increase in the number of participants present at any one session of the Group of Experts on Effects of Pollutants.

The Group agreed that early preparation of an agenda, well in advance of a GEEP meeting, should permit the appropriate expertise to be invited to the meeting.

(3) Most GEEP members are now in direct contact with each other via Telemail or other networks. The Group agreed that a list of access numbers and codes should be lodged with the Technical Secretary.

12. ELECTION OF OFFICERS

Pursuant to the Rules of Procedure governing Groups of Experts of IOC, the Group was required to elect its Officers for the next intersessional period and the Fourth Session. In order to elect the Chairman, the Session was referred to the Technical Secretary. Dr B.L. Bayne was nominated and unanimously elected Chairman for the next intersessional period and the Fourth Session. The Chair was returned to Dr Bayne.

Due to the increasing interests of GEEP, and an increase in the membership, it was thought appropriate to elect a Vice-Chairman, and the Chairman invited nominations. Dr J. McDowell Capuzzo was nominated and unanimously elected.

13. ADOPTION OF THE SUMMARY REPORT

The Summary Report was adopted. The Session was closed by the Chairman at 20.00 hours on 2 September 1986.

ANNEX I

AGENDA

1. OPENING OF THE SESSION

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   2.3 CONDUCT OF THE SESSION

3. INTERSESSIONAL ACTIVITIES

4. IOC (OSLO) WORKSHOP ON BIOLOGICAL EFFECTS MEASUREMENTS

   4.1 REPORTING OF THE RESULTS OF THE WORKSHOP
   4.2 FOLLOW-UP OF THE WORKSHOP
      4.2.1 Training
      4.2.2 Proposed practical workshop in Venezuela
      4.2.3 Training Workshop in China

5. VULNERABLE AREAS

6. BIOASSAY TECHNIQUES IN BIOLOGICAL EFFECTS MONITORING

7. BIOLOGICAL EFFECTS STUDIES IN MUSSELWATCH PROGRAMMES

8. THE INTEGRATED GLOBAL OCEAN MONITORING (IGOM) CONCEPT

9. INTERACTIONS WITH OTHER GROUPS

10. FUTURE ACTIVITIES

11. OTHER MATTERS

12. ELECTION OF OFFICERS

13. ADOPTION OF SUMMARY REPORT

14. CLOSURE OF THE SESSION

ANNEX II

RECOMMENDATIONS

Recommendation number	Title
GEEP-III.1	Ad hoc Group on the Workshop on Biological Effects Measurements, Woods Hole, April 1987
GEEP-III.2	Vulnerable Areas
GEEP-III.3	Regional Co-operation
GEEP-III.4	Convening of the Fourth Session of the IOC Group of Experts on Effects of Pollutants

Recommendation GEEP-III.1

THE WORKSHOP ON BIOLOGICAL EFFECTS MEASUREMENTS

The GIPME Group of Experts on Effects of Pollutants:

Noting that the field phase of the IOC (Oslo) Workshop on Biological Effects Measurements has been successfully implemented and

Mindful that the completion of the report, the publication and the follow-up proposals need to be completed in a consolidated form,

Recommends that the GEEP ad hoc Group on the Workshop on Biological Effects Measurements meets in Woods Hole in April 1987 for 3-4 days to:

(i) co-ordinate and prepare a report to IOC on the IOC (Oslo) Workshop, for publication in the IOC Workshop Report Series;

(ii) write a Conclusions and Recommendations section for the commercial publication of the Workshop;

(iii) plan the follow-up activities resulting from the Workshop.

Recommendation GEEP-III.2

VULNERABLE AREAS

Noting that the IOC (Oslo) Workshop on Biological Effects Measurements has given results relevant for application to the problem of identifying vulnerable areas,

Noting further the recent initiatives in Venezuela,

Recommends that the activities of GEEP regarding vulnerable areas be advanced by:

(i) participation of up to three members of GEEP in the national symposium "Biological Effects of Petroleum Hydrocarbons" to be held in Caracas, Venezuela in December 1986, and

(ii) discussions with the appropriate Venezuelan authorities and scientists on the practicalities of holding a training workshop in Venezuela in 1988 covering aspects of the assessment of vulnerable areas and associated biological effects measurements.

Recommendation GEEP-III.3

REGIONAL CO-OPERATION

Noting the possibility of developing a biological effects monitoring programme on a pilot project basis in co-operation with the appropriate Regional Bodies and the Regional component of MARPOLMON in the Caribbean and Adjacent Regions,

Noting further that considerable interest has been expressed in establishing biological effects measurements in various parts of the WESTPAC Region,

Recommends

(i) that a dialogue be established with the Regional Pollution Monitoring Programme in the Caribbean (CARIPOL) through attendance by a GEEP member at the next CARIPOL Steering Committee meeting planned for November in Puerto Rico;

(ii) that plans be developed, in co-operation with the WESTPAC Task Team on Marine Pollution Research and Monitoring as appropriate, to hold a practical regional training workshop on biological effects measurements in the WESTPAC region, possibly in China in 1989 and that, in order to facilitate this, the Chairman of GEEP visits relevant institutions in China at the earliest possible opportunity.

Recommendation GEEP-III.4

CONVENING OF THE FOURTH SESSION OF THE IOC GROUP OF EXPERTS ON EFFECTS OF POLLUTANTS

Noting that intersessional activities need to be developed over the coming year,

Recommends that the next session of the Group of Experts on Effects of Pollutants (GEEP-IV) be held in Paris in October/November 1987, with the participation of up to ten experts.

ANNEX III

LIST OF PARTICIPANTS

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ANNEX IV

PRELIMINARY REPORT ON IOC WORKSHOP ON BIOLOGICAL EFFECTS MEASUREMENTS (Oslo, 11-19 August 1986)

The Workshop was held at the University of Oslo from 11 August to 29 August 1986 inclusive. It was attended by 31 scientists from 12 countries and the aim of this practical workshop was to evaluate various techniques for measuring the effects of pollutants in the sea, by applying these procedures to material collected along a contamination gradient in Frierfjord and from experimental exposures to different levels of a contaminant "cocktail" within the mesocosm facilities at Solbergstrand on Oslofjord.

Participating scientists were invited to represent biochemical, cellular (pathological) and physiological techniques, and techniques appropriate to the analyses of structure within benthic faunal communities. Benthic samples were collected, both from the field and the mesocosm, prior to the workshop and subjected to faunal analysis by appropriate experts; these data (essentially counts of the fauna expressed per unit area of sediment bottom) were made available from computer analysis in Oslo. Flounders, crabs, periwinkles and mussels were collected at each of four sites within the Frierfjord during the first week of the WS and transported to Oslo for experimental analysis. The Solbergstrand mesocosm was set up four months prior to the workshop; three basins were dosed at low, medium and high concentrations of a mixture of the water-accommodated fraction of diesel oil and soluble copper, with a fourth basin kept free of contamination as a control. Intact box-core samples of the local soft-bottom faunal community were placed in each basin, as were numbers of crabs, mussels, winkles and flounders. Each basin was sampled once daily in the second week of the workshop, and material transported to Oslo for analysis. In addition to a suite of biological measurements (briefly described below), samples of sediment and of mussels, crabs and flounders were analyzed for polyaromatic hydrocarbons and polychlorinated biphenyls (by the Institute of Marine Research at Bergen) and for heavy metals (by the Department of Marine Chemistry in Oslo).

An important aspect of the workshop was the careful consideration given to the statistical demands of the sampling strategy, to rigorous statistical analysis of the results and to the fact that all samples were analyzed "blind", i.e., the biologists were unaware of the source of their material until after all analyses were completed. To date, not all results are available for discussion, although approximately 60 per cent of the studies were completed during the workshop itself. This brief and preliminary report identifies some of the main findings and draws some conclusions. A more comprehensive report will be made available to IOC during 1987.

(a) Biochemical procedures

In accordance with the latest developments in the biochemical evaluation of the effects of pollution, emphasis was given to responses specific to certain classes of contaminant, by measuring aspects of two systems of biotransformation, viz., metallothione in production, which responds specifically to heavy metals, and components of enzyme systems involved in the

metabolism of foreign compounds (xenobiotics), namely the microsomal mono-oxygenase or MFO system. Data on metallothioneins cannot yet be assessed.

Of all the indices measured, MFO in flounder liver, as assayed by the activity of the enzyme known as EROD, showed the most sensitive response to the expected pollution gradient in the field, with a x15 increase in activity from the reference to the most contaminated site. Since a concise mechanistic framework exists within which to interpret induction of activity in EROD, in terms of body-burdens of either PCB's or PAH's, this measurement can be recommended as an indicator of environmental contamination by such compounds, with reservations which will be discussed elsewhere.

Measurements of xenobiotic metabolising systems in marine invertebrates also showed responses related to pollutant distribution. However, the magnitude of these responses was less than was seen in the fish and, because we still lack detailed information on the biochemistry of these systems within mussels and crabs, for example, such measures should be regarded as having potential, rather than immediate application, for use in monitoring.

(b) Physiological Responses

Physiological approaches included: the measurement of the scope for growth in mussels, which is an analysis of energy intake and energy losses by individual animals, set in an equation which considers the resultant energy balance; determination of the respiration rates of isolated gills of crabs and mussels; and an assessment of the balance within the tissues of the major classes of biochemical component (protein, carbohydrate and lipid).

There was a marked decline in the scope for growth in mussels with increasing contaminant body burden, both in the field and in the mesocosm; this technique clearly discriminated between stations and between contaminant loadings within the experimental basins. It was concluded that, with certain reservations concerning the type of animal under investigation, this index may successfully be used to assess the biological effect of pollution at the organismic or 'whole animal' level.

Measurement of tissue (gill) respiration rate showed mixed success; crab tissues from the field situation were responsive to the contamination gradient but neither mussels in the field or in the mesocosm, nor crabs in the mesocosm, showed significant responses. These techniques are concluded to have limited application. Biochemical compositions of the digestive glands of both crabs and mussels showed significant changes in response to contaminant levels and provide a physiological expression of changes noted also at the cellular level (see below).

(c) Cellular and Histopathology

Both quantitative and more classical descriptive approaches to cellular and tissue pathology were evaluated at the Workshop. Cytochemical analysis of the functional state of sub-cellular organelles, such as the lysomes, proved responsive to the contamination gradients, although interpretation of some of this material is complicated by variability in the reproductive state of the animals. The accumulation of lipid residues within some cell

types (lipidosis) was confirmed as a sensitive measure of cellular condition and these results are borne out by both physiological and biochemical data. Quantitative stereological tests were also useful in discriminating cell damage in mussels from the different sites. The more descriptive approaches of tissue histopathology did not prove sensitive to the contaminant levels encountered in the Workshop.

(d) Analysis of Benthic Communities

In such analyses, at least two separate aims must be recognized; firstly, to discriminate amongst sampling stations, irrespective of the causes of any differences recorded; secondly, to link differences to pollution, bearing in mind the many confounding variables that may be present in any natural system such as a fjord. Advanced statistical analyses employed at the Workshop succeeded in the first aim, but until more chemical data are available success or failure in the second aim will be unclear.

This difficulty was best illustrated in the results of applying Multi-Dimensional Scaling to numbers or biomass distributions of fauna in the field. Such plots clearly discriminated the reference (control) station from others along the contaminant gradient, and also identified differences amongst the contaminated sites. However, it was not possible to entirely reject the hypothesis that these differences are due, at least in part, to depth differences between sites; benthic community structure is known to be sensitive to depth, in fjordic systems and elsewhere.

The application of multi-variate statistical tests to the benthic faunal data led to two important insights. Firstly, distinction between stations proved possible at various levels of taxonomic discrimination (species, orders, families, etc), suggesting that in some situations full and time-consuming, taxonomic analysis to the species level may not be necessary to identify within-station differences. Secondly, in certain circumstances the copepods proved more sensitive, in their species distributions, than other components of the fauna, to differences in environmental contamination.

(e) Conclusions

A full appreciation of the success or otherwise of the Workshop must await more thorough analysis of the results. Nevertheless, it is already clear that the results will prove of considerable (and possibly unique) utility in guiding the further development of techniques for application in programmes of biological effects monitoring. It was unanimously agreed that the Workshop provided an unique opportunity for interested experts to compare the different procedures currently available, and that this has resulted in a consolidation of the scientific base and an increased enthusiasm for the application of appropriate techniques in other systems.

ANNEX V

PRELIMINARY CONSIDERATIONS ON THE ROLE OF BIOASSAYS IN BIOLOGICAL EFFECTS MONITORING

Bioassays have been designed to assess the comparative responses of organisms to contaminants and have been used to both make regulatory decisions concerning discharges and predict the environmental consequences of contaminant inputs. Although the conceptual framework of the bioassay has changed little since bioassays were first used in assessing water quality, modifications in design have been developed to expand the utility of toxicity tests in biomonitoring. Further development has occurred recently for the application of such methods for meeting specific management goals - such as ocean dumping, disposal of dredged materials, and characterization of complex industrial mixtures. Bioassays can be used to:

(i) identify sublethal responses and define modes of toxic action;

(ii) compare sensitivity of various phylogenetic groups;

(iii) compare sensitivity of various stages in the life cycle;

(iv) determine the influence of various environmental parameters on toxicity.

Bioassay approaches can be classified by the relative ranking of system complexity - single species tests, multiple species including species interactions and experimental communities, microcosms, or mesocosms - or by specific professes - determination of developmental or reproductive changes. In combination with data on environmental concentrations of specific contaminant, bioassays can be used to predict potential for environmental concentrations of specific contaminants, bioassays can be used to predict potential for environmental hazard associated with contaminant discharge.

Acute bioassays are designed to assess the toxicity of concentrations of specific contaminants to single species during controlled laboratory exposures generally for short periods of time. The standard measure of toxicity is the LC50 value which represents the concentration at which 50% of the test organisms die during a designated exposure period or an EC50 where some other biological parameter is used for impact assessment (growth, behaviour, etc.). Contaminant bioavailability may be influenced by chemical speciation as in the case of trace metals or the octanol-water partition coefficients of organic contaminants, yet few acute bioassays have considered chemical bioavailability in governing toxic responses. Exceptions to this are the work by Sunda et al (1986 and earlier studies) for trace metals and the work by Veith et al (1986) relating structure-activity relationships to acute toxic responses.

Sediment bioassays using sensitive infaunal species have recently been developed for the characterization of sediment quality and development of sediment criteria. Schwartz et al (1985) found good agreement between LC50 measurements for cadmium determined in sediment bioassays with the infaunal amphipod Rhepoxynius abronius and those measured in seawater bioassays

and concluded that acute sediment toxicity was associated with the concentration of admium in interstitial waters. Long-term toxicity of cadmium contaminated sediments, as well as that of other trace metals, cannot be defined without a better appreciation for the geochemical processes altering contaminant bioavailability. Similar concerns are relevant for organic contaminants (PAHs chlorinated hydrocarbons, petroleum hydrocarbons) and contaminant bioavailability is associated with the solubility of specific components in interstitial waters. Sediment bioassays, if they are to be useful in predicting toxic responses in the field, must be designed with geochemical processes in mind.

Bioassays for assessing complex industrial mixtures have been described by Walsh and Garnas (1983) and include techniques for fractionating wastes into inorganic and organic subfractions. Such an approach provides an advantage over the assessment of either individual contaminants or the entire waste as it may differentiate the potential synergistic, antagonistic and additive effects of substances within a complex mixture. The organic subfraction may be subfractionated into acid-, base-, and neutral extractable components, and the inorganic fraction may be separated into anion and cation components. In their studies of a suite of complex industrial mixtures Walsh and Garnas (1983) found that toxicity was generally limited to one or two subfractions. Such a approach could be useful in selecting the most appropriate waste management technologies for minimizing environmental hazard.

Chronic bioassays are designed to assess long-term ecological consequences of contaminant exposure and include evaluations of reproductive impairment, developmental abnormalities, and genetic change. Life cycle bioassays and bioassays with early developmental stages contribute to basic information on the effects of contaminants on life history characteristics of individual species. Parameters generally measured include effects of specific contaminants on intrinsic rates of development, incidence of developmental abnormalities, and genetic change. Life cycle bioassays and bioassays with early developmental stages contribute to basic information on the effects of contaminants on life history characteristics of individual species. Parameters generally measured include effects of specific contaminants on intrinsic rates of development, incidence of developmental abnormalities, other demographic parameters, and the determination of maximum acceptable toxic concentrations (MATC). MATC is defined as that concentration of a contaminant which induces no significant harm. Because MATC is difficult to determine experimentally, it is approximated by the ratio of the geometric mean of the lowest concentration having an effect and the highest concentration having no effect. A "safety" factor or application factor can be defined from the ratio of the MATC to LC50. Such an approach has been used for determining "safe" application rates of pesticides to coastal environments as well as determining effluent guidelines. The relationship of chronic effects, however, to uptake and accumulation of contaminants has not been carefully evaluated.

Sublethal responses may also be evaluated during chronic bioassays and may shed light on mechanisms of toxic action. Sublethal responses of contaminants that may be measured during chronic bioassays include estimates of changes in feeding, growth, reproduction energetics and development. Linking sublethal responses with uptake, accumulation and disposition of specific contaminants is also important if we are to expand our predictive

capabilities of environmental hazard. Bioassay approaches and sublethal response evaluation have been coupled with measurements of the distribution of chemical contaminants to model predictions of environmental hazard and for use in field verification programmes. Gentile et al (1986) combined such a multiple evaluation approach to assess the toxicity associated with the disposal of dredged materials in Long Island Sound, USA. Laboratory assessment through sediment bioassays and sublethal responses combined with sediment chemistry were used to classify disposal options for contaminated dredged sediments. Understanding the fluxes of chemical contaminants from contaminated sediments, partitioning of contaminants to interstitial waters, and the sediment characteristics that influence bioavailability would advance the utility of sediment bioassays in predicting environmental hazards. Multiple species biota assays offer the potential to evaluate species interactions as a result of contaminant exposure, assess contaminant transfer through trophic level interactions and evaluate the interactions of biological and chemical processes in altering contaminant bioavailability. Multiple species tests can be grouped into food chain bioassays generally conducted in microcosms, simple community assemblages or assessing the settlement and colonization of azoic sediments maintained in contaminant gradients, and mesocosm experiments (Hansen, 1985; Cairns and Buikema, 1985). The latter offer the greatest potential for simulating the interaction of chemical and biological processes and for evaluating the interactive effects of contaminants on community structure and function.

If bioassays are to be utilized effectively, they must go beyond the level of categorizing toxic responses and become more predictive in assessing ecological consequences of contaminant discharges. Gentile and Schimmel (1985) argue that in order for bioassays to be used effectively in regulatory decisions, they must: (1) couple laboratory derived evaluations of toxicity with environmentally realistic estimates of contaminant exposure; (2) be designed in such a way that predictions of consequences in the field can be made; and (3) combine with monitoring approaches as a feedback procedure to verify or compare field observations with predictions. Cairns (1983), however, questioned the value of single species bioassays in predicting environmental hazard because of our inability at the present time to link effects at the organismal level with higher levels of biological organization - i.e., population, community and ecological levels. Cairns and Buikema (1985) further questioned how best single species tests and tests on more complex systems could be better integrated as predictors of environmental hazard.

What role can GEEP, in conjunction with GEMSI, play in bridging the gap between laboratory bioassays and predictions of environmental hazards? Major advancements in our understanding of fluxes of contaminants from sediments and the sedimentary processes that govern bioavailability is an important first step in bridging this gap. Consideration of chemical speciation of trace metalsand structure-activity relationships of organic contaminants and their pharmacological/toxicological properties warrants further evaluation.