COOPERATIVE RESEARCH REPORT

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REPORT OF THE ICES ADVISORY COMMITTEE ON MARINE POLLUTION, 1988

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The Advisory Committee on Marine Pollution (ACMP) was established by the International Council for the Exploration of the Sea with the task of formulating, on behalf of the Council, scientific advice on marine pollution and its effects on living resources to the Member Governments and to Regulatory Commissions. In its work, the ACMP considers, among other things, the results of work carried out in relevant ICES Working Groups (which also report to their respective Standing Committees during the annual Statutory Meetings). It is a firm procedure within the Council that reports of other subsidiary bodies concerned with pollution pass the ACMP.

The ACMP consists of a number of scientists acting - when they work as Committee members - in their personal capacity as scientists, responsible only to the Council. The membership of the Committee is such that it covers a wide range of expertise related to studies of marine pollution. The members do not act as national representatives. The 1988 membership of the Committee is found on page 1.

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REPORT OF THE ADVISORY COMMITTEE ON MARINE POLLUTION

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Dr R.R. Dickson - Chairman of the Hydrography Committee

Dr H. Rosenthal - Chairman of the Mariculture Committee

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Dr (Ms) Janet F. Pawlak, ICES Environment Officer
Secretary to the Advisory Committee on Marine Pollution

OVERVIEW OF THE 1988 ACMP REPORT

This report commences with a summary of the progress made in respect to work requested by the Oslo and Paris Commissions and the Helsinki Commission. It then contains an examination of monitoring strategies, starting with a review of the reasons for and categories of monitoring and thereafter making proposals for the development of future monitoring programmes. This is followed by an account of the progress being made in the monitoring of temporal trends in contaminant concentrations in biota and in sediments. The next section of the report provides guidelines for the use of benthos studies in monitoring programmes.

The next sections of the report concern biological issues. The first reviews the position on fish diseases, based on national reports and the results of a second sea-going workshop devoted to developing common methodologies for fish disease surveys and disease identification. The next section of the report addresses the question of medication used in mariculture and this leads on to a review of the problems faced by the mariculture industry in relation to environmental quality issues. This is followed by a review of the problems caused by algal blooms, including the major Crysochromulina bloom which caused problems in Scandinavian waters in the spring and early summer of 1988. Also included in this section is a summary of the findings of an intercomparison exercise for the measurement of primary productivity.

The next group of sections deals with matters that broadly fall into the category of marine chemistry or chemical oceanography. The first section in this group examines the available information on nutrient trends in the marine environment and the problems of collating data known to exist but not yet supplied to data centres. Then follow sections of the report describing the findings of several completed analytical intercomparison exercises and proposals for new intercomparison exercises. These lead to a section on procedures to be followed in analytical quality assurance. The next section outlines plans for the assessment of the results of the 1985-1987 Baseline Study of Trace Metals in Coastal and Shelf Sea Waters. This is followed by sections briefly describing current procedures used by marine laboratories for measuring suspended particulate matter and plans for improving comparability of data on this determinand and the production of a detailed description of normalisation procedures for use in sediment monitoring programmes. The next section deals briefly with sediment storage procedures and the final section in this group provides advice on the value and limitations of methods for the measurement of the total organochlorine content of effluents or environmental samples.

The next sections of the report address the question of how to quantify inputs of contaminants to the marine environment. The first provides the ACMP's comments on the Paris Commission's plans for assessing gross riverine inputs. This is followed by advice on how to derive net inputs from estuaries to the coastal environment and the open sea. The Paris Commission's and Helsinki Commission's respective plans for assessing atmospheric inputs are noted to be broadly in accord with ACMP's earlier comments. This is followed by comments on the final report of the ICES

Study Group on the Effects of Acid Rain on salmon habitats and on the need for urgent assessment of the possible impact on the water balance of the Baltic Sea of several major civil engineering developments currently being considered in and around the Baltic Sea Area.

The last major section of the report provides revised guidelines for the conduct of regional assessments. This is followed by a short statement on ACMP's plans for an overall statement on regulatory approaches to environmental management. The report concludes with a section on automatic data processing and the procedural arrangements that should govern data input and exchange.

EXECUTIVE SUMMARY

This Executive Summary provides a brief outline of progress in respect to work requested by the regulatory commissions, separate from the body of the report.

The work requested from ICES by the Commissions comprises some items that can be completed in a single year, some that require a number of years to prepare an in-depth and authoritative response, and others that require continuing review in the light of improvement in scientific understanding. An annual work programme, therefore, contains a mix of items, some carried over from previous years and others that are new. The ACMP Report contains both completed responses to individual questions and progress reports on issues receiving longer-term study. Where appropriate, these latter issues are amplified in detailed technical annexes to the Report.

At its 1988 meeting, the ACMP considered, inter alia, the most recent reports of the following ICES groups:

Marine Chemistry Working Group (MCWG)

Working Group on the Baltic Marine Environment (WGBME)

Working Group on Marine Sediments in Relation to Pollution (WGMS)

Working Group on the Statistical Aspects of Trend Monitoring (WGSATM)

Working Group on Biological Effects of Contaminants (WGBEC)

Working Group on Pathology and Diseases of Marine Organisms (WGPDMO)

Working Group on Environmental Assessments and Monitoring Strategies (WGEAMS)

Benthos Ecology Working Group (BEWG)

Working Group on Shelf Seas Oceanography

Working Group on the Effects of Extraction of Marine Sediments

Working Group on Environmental Impacts of Mariculture

Working Group on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries

Working Group on Primary Production

Study Group on the Ecology of Algal Blooms

Study Group on Acid Rain

Study Group on Patchiness Investigations in the Baltic

Report of Second Sea-Going Workshop on the Methodology of Fish Disease Surveys

Work Requests from the Oslo and Paris Commissions

Brief summaries of the progress made in response to questions raised by the Commissions are presented, under the topic headings assigned by the Commissions, in Section 2 of this Report. For the benefit of readers not wishing to study the detailed report, a brief summary of the main topics of interest to these two Commissions is presented below under three headings: "General Monitoring Issues", "Specific Issues", and "Continuing Responsibilities".

General Monitoring Issues

Since the last report of ACMP, considerable progress has been made both in the examination of existing data sets and in the development of new approaches to the assessment of temporal trends in concentrations of contaminants in biota. The latter include approaches to the analysis of data on contaminants in fish liver and for the treatment of data on pooled samples. Information about the advances made and the importance of recording certain data about the samples, particularly total liver weight, is emphasized in the report. An account on the analysis of the available data sets thus far has been produced and is expected to be published separately in the Cooperative Research Report series. Work was started on estimating the degree of change in concentrations of individual trace metals in sediments that may be detected using current methods of analysis, as a first step in considering whether sediments may be useful in monitoring temporal trends in contaminants.

Further information is provided on the use of sediments in monitoring studies, with an account of the sensitivity of sediments in a pollution monitoring context in one particular, but not atypical, sediment accumulation area included as an Annex. Brief details of the procedures to be followed for storage of sediments prior to analysis are provided in response to a particular question raised by the Commissions. Progress has been made towards the development of a definitive statement on normalization procedures which will allow more effective use of data on contaminants in sediments; a complete statement on this issue can be expected in the 1989 report.

Further details are provided on approaches that can now be recommended for assessing the net transport of contaminants from land-based sources to the coastal environment and to the deep sea. These extend the applicability of data on gross riverine inputs, which the Paris Commission is proposing to reassess. Some comments are provided on the procedures intended to be used in these studies with a view to improving the quality of the data the studies will produce.

Work has continued on the assessment of data on nutrients in the marine environment. This is currently being inhibited, partly by deficiencies in the quality of the data, but much more seriously by the limited accessibility of data known to exist but not reported to data centres. Nevertheless, preliminary assessments have been carried out on data sets for French coastal waters and for English coastal waters and the southern North Sea. The results of both studies, which used slightly different procedures, suggest temporal variations that are dissimilar to the apparently rising trends that have been identified in the inner waters of the German Bight. A brief report on the findings is included, together with an outline of the plans for extension of the approach to other sea areas. Due to the present inaccessibility of data, it is not expected that this task can be completed before 1990 and even then, if any trend is identified, it will be extremely difficult to attribute cause (natural or anthropogenic) without similar time series data on net riverine inputs.

Progress on biological effects studies continues, but at a fairly slow pace. The full report on the outcome of the IOC Workshop on the Biological Effects of Pollutants (Oslo, 1986) was not available prior to the ACMP meeting. Consequently, the results could not be assessed by either ACMP or the appropriate working groups. Plans are, however, in hand for a joint ICES/IOC sea-going workshop with a shore-based component. This is expected to take place early in 1990 and is intended to concentrate on studies of effects of contaminants on biota in the sea surface microlayer and on the sea bed. The selection of methods to be tested will take full account of the results of the Oslo Workshop.

Finally, on the general subject of monitoring, detailed advice is provided in this report on the usefulness of benthos studies in monitoring the impact of point sources of contaminants. This includes details on the procedures to be followed for sampling, processing the samples, and analysis of the data on species numbers and composition, etc. It is intended to supplement this advice in the 1989 report with one or two examples of how the procedures have been used in actual monitoring studies.

Continuing Responsibilities

In the last few years a number of intercalibration exercises have been conducted by ICES. This report provides details of the outcome of the more recent ones. Reports are soon to be published in the ICES Cooperative Research Report series on intercomparison exercises on analyses of PCBs in herring oil and on analyses of methyl mercury in biological tissue. The latter was conducted during 1987 and was restricted to laboratories regularly conducting this type of analysis. The results serve to illustrate that good comparability can be achieved by experienced laboratories.

This report also contains an overview in which a comparison is made of the results obtained in the course of three separate intercalibration exercises for trace metals in marine sediments. The findings point towards the need to use digestion procedures involving HF if consistent and comparable results are to be obtained among laboratories and when reference materials are to be used for standardization purposes. The report also contains an outline of the progress being made on the conduct of an exercise on determinations of PAHs, and the plans for the conduct of exercises on CBs in sediments and seal tissue, which will start with a common first stage. On the basis of replies obtained from two questionnaire surveys, it is being recommended that exercises should be conducted for the measurement of trace metals in suspended particulate matter (SPM) and nutrients in sea water. A description is given of the preparatory work undertaken and the likely format of these exercises.

Two new publications in the Techniques in Marine Environmental Sciences series are announced in the report. One addresses the determination of the SPM content of sea water and the other the use of hydrofluoric acid and Teflon "bombs" in the analysis of whole sediment samples.

Work continues on the assessment of the prevalence of fish diseases and their possible association with contamination. An outline is given of the results of surveys reported by six countries and advice is provided on the abnormalities/diseases that seem most likely to prove fruitful in this context, together with the species and sample numbers necessary to obtain reliable and interpretable results. This advice is based on the findings of a second sea-going workshop on fish disease survey methodology and updates earlier advice by ACMP on this topic.

Following the publication during 1988 of a detailed report on the environmental impact of mariculture operations, work on the topic has continued via a new working group. An outline of the problems being addressed is included in this report and issues of particular concern appear to be the increasing scale of mariculture operations, the use of chemicals in mariculture production, and the importance of limiting local nutrient loadings from mariculture operations.

Survey work in connection with the 1985 to 1987 Baseline Study of Trace Metals in Sea Water is now complete and an outline of the procedures that will be followed in assessing the data is provided in this report. It is hoped to complete this work in 1989, but delays in some countries in completing the analysis of samples and processing of the data may delay the final assessment to 1990. This may mean that plans for a second survey are somewhat premature as it will be difficult to decide on the details of a cost-effective survey in the absence of the report on the results of the first survey.

The ACMP duly noted the responses to its activities on approaches to environmental management and decided to refrain from making any further stage-by-stage publication of its views. Only a brief outline of the programme plan is included in this report, basically recording the ACMP's unanimous reaffirmation of its belief in the importance of the subject and its intent to complete the task.

Specific Issues

The report contains detailed information on three specific topics of interest to the Oslo and Paris Commissions: (1) monitoring strategies, (2) regional assessments, and (3) the measurement of primary productivity and problems of algal blooms.

The section on monitoring strategies examines the purpose of monitoring and the procedures currently adopted in most monitoring programmes, including those of ICES itself and the Commissions. It concludes that, in the light of experience gained over a number of years and improvements in scientific understanding, greater reliance can now be placed on single matrices and monitoring effort can be reduced in certain areas releasing effort for new studies and research in support of environmental effects studies.

New guidelines are provided on the conduct of regional environmental assessments. These take account of the experience gained in four such assessments conducted to date and the extent to which earlier ICES guidelines were used. The original guidelines are largely still applicable but the new ones expand them in some respects and, in particular, advocate an overall assessment chapter which can be used as a basis for decisions on further research work and, if appropriate, environmental protection measures.

The section on primary production measurements is based on the results of an intercomparison workshop that involved 24 laboratories from 14 countries. It is expected that the results will lead to a revision of the currently recommended procedures with a view to minimising the extent to which one is free to apply variations to the technique. This should, in turn, lead to better standardisation in results.

The ACMP continues to be concerned over the problems associated with some algal blooms and the questions of whether blooms of troublesome algae are now more common and what causes them. To this end, the ACMP examined several reports on these topics and has included an assessment of their conclusionsin this report. At the time of its 1988 meeting, the Chrysochromulina incident was still in progress, but a brief outline of the facts as they appeared at that time is included in the report. A further, more detailed assessment of these questions can be expected in future reports.

Work Requests from the Helsinki Commission

Brief summaries of the progress in response to questions raised by the Helsinki Commission are presented in Section 3 of this report. Several of the questions raised by the Oslo and Paris Commissions are also of interest to the Helsinki Commission, for example, the report on methods for determining suspended particulate matter in sea water, the advice on the use of benthos studies in monitoring, the planned intercalibration exercise for trace metals in suspended particulate matter and those for nutrients in sea water and CBs in seal blubber. In addition to these questions, the ACMP addressed three topics specifically raised by the Helsinki Commission.

The Helsinki Commission had asked, given that many of the rivers entering the Baltic are relatively small, to what extent the recommendations ICES has made in the past (1984 ACMP Report, Coop. Res. Rep. No. 132) for assessing gross riverine inputs of contaminants are applicable to the Baltic Sea. This question arises because that advice was based on experience with much larger rivers. The ACMP recognises that this presents a source of confusion, but in this report advises that the basic principles are the same for smaller rivers as for larger ones. Thus, the important aspects are that concentration and flow variability across the river and with time must both be adequately addressed.

The second issue was a request for advice on the methods for and value of measuring such parameters as total organochlorine content of effluents or environmental samples. Having duly considered the question, the ACMP suggests in its report that any one of the several published methods will suffice, but that there are severe limitations on the amount of information provided by the data, e.g., there is no indication of the mix or nature of the compounds present, either instantaneously or with time, or of the persistence, toxicity or bioaccumulation potential of the materials actually present.

The other main specific issue on which advice was requested was in relation to seal populations in the Baltic. In fact, some advice on this topic was provided in last year's ACMP report and, accordingly, no discussions were held on the subject at the 1988 meeting. Although at the time of that meeting the occurrence of unusual mortalities in seals in European waters had been reported, investigations as to the cause were only starting and no attempt was made to formulate a statement. This issue will be addressed in the 1989 report.

The ACMP noted that in the Baltic area a number of proposals have been made for major civil engineering projects, some of which might alter the Baltic water balance. Since the Baltic environment is unusually sensitive to changes in the rate and frequency of water exchange, such projects could have a substantial environmental impact. The ACMP, therefore, strongly recommends that these questions be carefully examined by the countries around the Baltic Sea.

1 INTRODUCTION

In dealing with requests put to it by Member Governments of ICES and by the Regulatory Commissions, the ACMP draws on the expertise of its own members and also on the work of various expert ICES Working Groups. The ACMP considers the reports of these Working Groups and calls upon them to carry out specific activities.

The ACMP Report is structured in terms of the ACMP's overall deliberations on subjects related to contamination and pollution of the marine environment, but specific features relevant to the various Commissions' requests are brought together in an Executive Summary, which is at the beginning of the Report, and are further detailed in Sections 2 and 3, where the individual work items from each Commission are listed and related to relevant sections of the main text.

2. REQUESTS FROM THE OSLO AND PARIS COMMISSIONS

A summary of the progress in the 1988 programme of work requested by the Oslo and Paris Commissions is given below, along with a reference to the relevant paragraphs and annexes of the report or an indication of the status of the work.

(A) Work which is expected to be undertaken by ICES and reported on in the ACMP Report for 1988;

A1 (a) to report on the experience gained from trend monitoring studies, including the results of studies using organs other than fish muscles and liver, and including cases where fish tissues or shellfish have been pooled prior to analysis;

(b) to extend the report to cover all aspects of trend monitoring related to seawater and sediments; to supply advice on the value and the use of normalization methods for interpreting contaminant levels in sediments, including dredged materials;

Progress in the work on trend monitoring is reported in Section 5 of this report. Considerable progress has been made in defining an appropriate methodology for the statistical analysis of trend data sets on contaminants in fish liver tissue. Full use of this model requires data on the total weight of the liver tissue. Accordingly, the ACMP strongly recommends that future submissions of data for the analysis of temporal trends in fish liver tissue include the reporting of total liver weight.

Information relevant to monitoring temporal trends of contaminants in sediments is contained in Section 5.3, Section 14.6 and Annex 2; the latter two describe the use of a model for evaluating the sensitivity of sediments for the detection of changes in contaminant fluxes. Progress in the development of guidelines on normalization techniques to interpret contaminant concentrations in sediments is reported in Section 14.1.

A2 to provide advice on methods for monitoring dumping grounds and coastal areas affected by land-based discharges by means of studies of the composition of the benthic communities;

Procedures for monitoring benthic communities near point-source discharges and dumping grounds are described in Section 7. The ACMP recommends that, for routine monitoring programmes, benthic macrofauna provide the most suitable target for studies at the community level. The design and implementation of a field sampling programme is outlined in this Section. An example of the application of this scheme will be published in the 1989 ACMP Report.

A3 overview paper on trends in nutrient concentrations in sea-water;

The results of the ACMP consideration of two papers reviewing analyses of trends in nutrient concentrations in the western North Sea and off the coast of France, respectively, are provided in Section 11.1. Work is continuing to provide a more comprehensive review of the nutrient data for the Commissions' area, but the final report may not be available until 1991 or 1992 because the work going on in various countries is unlikely to be completed until then.

A4 to provide information on appropriate procedures for the storage of sediment samples prior to analysis for inorganic and organic contaminants, with a view to enabling laboratories who presently hold archived sediment samples to determine whether analysis may be worthwhile;

The ACMP advice on this topic is contained in Section 14.2.

A5 to provide information on methods for the estimation of net riverine inputs to the marine environment, with particular emphasis on net inputs from the estuary to the sea;

Section 16.2 describes a general strategy for the estimation of net riverine inputs of trace metals. As conditions vary greatly from estuary to estuary, a specific strategy for determining processes and fluxes in individual estuaries will have to be designed for each estuary by scientists who have a good understanding of the physical and geochemical characteristics of that estuary.

(B) Work which is essentially of a continuing nature and on which it is expected that ICES will submit a progress report in the ACMP Report for 1988;

B1 to report routinely on all on-going and planned ICES intercalibration exercises preferably by means of a full report to JMG on the intercalibration exercises carried out;

An overview of the results of an intercomparison exercise on the analysis of methyl mercury in biological tissues is contained in Section 12.4, and a brief statement of progress in the first step of the intercomparison programme on analyses of PAHs is contained in Section 12.1.

Plans for the first step of the intercomparison programme on analyses of individual chlorobiphenyls in marine media are contained in Section 12.2, while in Section 11.3 information is given on a proposed intercalibration exercise on the analysis of nutrients in sea water. The Commissions have agreed to participate in the first of these exercises and will be invited to participate in the second exercise.

The "Report on an Intercomparison Study of the Determination of Polychlorinated Biphenyls (PCBs) Isomerids in Baltic Herring Oil" (6/OC/BT) has been recommended for publication in the Cooperative Research Report series.

B2 to provide copies of relevant descriptions of methods of sampling and analysis as published in "Techniques in Marine Sciences";

The first six volumes in the series Techniques in Marine Environmental Sciences were published in December 1987. The titles are as follows:

No. 1: Cadmium and lead: Determination in organic matrices with electrothermal furnace atomic absorption spectrophotometry

No. 2: Trace metals in sea water: Sampling and storage methods

No. 3: Cadmium in marine sediments: Determination by graphite furnace atomic absorption spectroscopy

No. 4: Lipophilic organic material: An apparatus for extracting solids used for their concentration from sea water

No. 5: Primary production: Guidelines for measurement by ^{14}C incorporation

No. 6: Quality control procedures: good laboratory practice and quality control

The following leaflets are under preparation, with publication expected in Spring 1989. The titles given are working titles only.

No. 7: Determination of some organic compounds in biological material

No. 8: Determination of organic and total tin in sea water by extraction and graphite furnace atomic absorption spectroscopy

No. 9: Collection of suspended particulate matter for gravimetric and trace metal analysis

Other leaflets under preparation include guidelines for temporal trend monitoring of contaminants in marine biota, a method to determine total organic chlorine in wastewater effluents, and procedures for acidic digestion of marine sediments prior to trace metal determination; for the last method a videotape showing the detailed procedures has also been prepared.

B3 to keep under review the experience with the ADP handling of the JMP data and technical problems of access to the JMP data by other computers;

Large quantities of JMP data were submitted after the deadline in 1987, creating considerable difficulty for ICES to meet its obligations in the preparation of output products by the appropriate time. The JMG considered this problem at its 1988 meeting and steps have been taken to ensure a more timely submission of data in the future. Additional information on the ADP handling of data are contained in Section 22 of this report.

B4 to keep under review the question of new contaminants that may be of interest to JMG; this should be regarded as a current awareness exercise and implies an expectation that advice will be provided on those contaminants which ICES considers may give cause for concern in the future;

No new information on this topic is available in this report; however, an updated overview on mercury in the marine environment is under preparation and will be published in the 1989 ACMP Report.

B5 to keep under review and report as appropriate on the results of studies on the relationship between fish diseases and pollution;

Information on the results of recent work on fish diseases is contained in Section 8.1, and an overview of the results of the Second Sea-Going Workshop on Fish Disease Methodology is provided in Section 8.2. This latter section also contains guidelines for the long-term monitoring of fish disease levels for the purpose of trend analysis in relation to pollution.

B6 to keep under review the question of the bioavailability of contaminants in sediments and dredged material and to provide advice on methods for determining the potential bioavailability of contaminants in sediments and dredged material;

Information on this topic was provided in Section 17 of the 1986 ACMP Report; no new information is contained in this report.

(C) Special topics, on which it is expected that ICES will carry out an in-depth study [none proposed at present].

(D) Work already under way, on which it is expected that ICES will report in the ACMP Report for 1987.

D1 to review knowledge on the input of contaminants from the atmosphere to the sea and to advise on the most appropriate methodologies for quantifying inputs from this source;

The ACMP provided advice on this topic in Section 18 of its 1987 report, with a detailed report on the current state of knowledge concerning the input of contaminants from the atmosphere to the sea contained in Annex 3 to that report. The ACMP advised that measurements of the atmospheric deposition of contaminants should be made only by laboratories experienced in these measurements. For trace metals, the sampling strategy should be based on direct measurement of the contaminant concentrations in precipitation according to individual events. In the formulation of its advice, the ACMP prepared a complementary statement about the need for concommitant attention to improving estimates of gross riverine fluxes of contaminants. The ACMP notes that both sets of advice have been acted upon by the Paris Commission and urges that more attention be paid to ensuring data comparability within the studies now being planned or already underway.

D2 to report on the experience with biological effects and biological monitoring and to recommend those techniques which, having been tested, appear useful for general application;

Some information on this topic is contained in Section 6. ICES is planning a workshop in Spring 1990 to test methods that show promise for monitoring the biological effects of contaminants. The Commissions have already reviewed the topic on their own and reached the same conclusions as ACMP.

D3 to report on progress made in studies of sediments and pollution, by providing information on the progress of the various pilot surveys, the outcome of the relevant intercalibration exercises in which ICES is involved and to advise on the detailed methods of sampling and analysis which have been tried and tested and found to give satisfactory results.

In Section 15.1 of its 1987 report, the ACMP provided a summary of information on the results of pilot sediment studies in the German Bight and in the Belt Sea and the Kattegat; detailed information was contained in Annexes 1 and 2 of that report. These pilot sediment studies have now been completed.

An overview of the results of several intercalibration exercises on trace metals in sediments is provided in Section 12.5 of this report. A model relevant to assessing the sensitivity of sediments in pollution monitoring is contained in Section 14.6 and Annex 2.

3. REQUESTS FROM THE HELSINKI COMMISSION

The ACMP took note of the current requests by the Baltic Marine Environment Protection Commission (Helsinki Commission) and reviewed the present status of this work, as follows.

1. **To conduct a specific assessment of contaminants in sediments;**

   Progress is now being made in the conduct of this work, as indicated in Section 19.3.

2. **To continue the work on evaluating the size of seal populations in the Baltic and to assess their condition in relation to contamination;**

   As major work had been done on this topic during 1986 and 1987, ICES did not convene a meeting of its Working Group on Baltic Seals during 1988. However, in the light of the serious incidence of disease in seals in the Baltic, and Northern Europe as a whole, it can be expected that ICES will convene meetings to evaluate the impact on the seal populations. The ACMP will report on the outcome of this work in 1989.

3. **To review the results of the Patchiness Experiment (PEX) in terms of any possible implications on sampling schemes used in the BMP;**

   As noted in Section 19.1, an overall report on the results of PEX is in the process of being drafted by the Study Group on Patchiness Investigations in the Baltic. When available to other groups, this report will be evaluated in terms of possible implications relevant to the BMP and the results will be reported by ACMP.

4. **To provide advice on reliable, intercomparable methods to determine concentrations of suspended particulate matter in sea water;**

   A paper on the "Collection of Suspended Particulate Matter for Gravimetric and Trace Metal Analysis", prepared by Dr P.A. Yeats and Dr L. Brügmann, has been accepted for publication in the series Techniques in Marine Environmental Sciences (see Section 14.5). This paper describes the appropriate methods to determine concentrations of suspended particulate matter (SPM) in sea water. In addition, a proposal has been developed, as provided in Section 14.4 and Annex 1, for an intercalibration exercise on analyses of trace metals in SPM.

5. **To study the problem in the intercomparability of nutrient analyses and coordinate an intercalibration exercise on analyses of nutrients and oxygen;**

   On the basis of work conducted during the past year, a proposal for the conduct of an intercalibration exercise on the analysis of nutrients has been prepared, as given in Section 11.3. Further information on this exercise will be provided in due course.

6. **To review the ICES recommended method for measurement of gross riverine inputs of contaminants with regard to their application to rivers flowing into the Baltic Sea;**

   The ICES recommended method for the measurement of gross riverine inputs of contaminants (contained in Annex 1 of the 1984 ACMP Report (Cooperative Research Report No. 132)) is applicable to both small and large rivers. The basic requirements are the same regardless of the size of the river. For smaller rivers, it remains essential that the flow and concentration variability across the river and in time have been adequately assessed.

7. **To provide information on "new contaminants", particularly those of special concern to the Baltic marine environment;**

   No information on new contaminants has been presented in this report. The ACMP has, however, noted the concern about dioxins and furans in the Baltic Sea area and intends to initiate the preparation of an update of the overview on these classes of contaminants that was presented as Annex 4 to the 1984 ACMP Report.

8. **To provide information on progress in the intercomparison work on the determination of specific hydrocarbons in marine samples;**

   The progress in this intercomparison programme is reported in Section 12.1.

9. **To provide information on the environmental impact of aquaculture, including nutrients and organic load impacts.**

   Some information on the environmental impact of aquaculture is provided in Section 9 of this report. In addition, the "Report of the ad hoc Study Group on Environmental Impacts of Mariculture" has been published as Cooperative Research Report No. 154 (March 1988). This provides a detailed treatment of the subject, along with reports containing relevant information from ICES member countries. In 1987, ICES established a Working Group on Environmental Impacts of Mariculture; the ACMP invites the Helsinki Commission to encourage representatives from member countries to participate in and contribute to the activities of this Working Group. In this way, ICES can ensure that the topics of concern in relation to the Baltic Sea can be discussed in as complete a manner as possible.

Although not part of the formal work requests, the ACMP notes the interest of the Helsinki Commission in the measurement of total organic chlorine in wastewater effluents. Some information on this topic is provided in Section 12.7.

4 MONITORING STRATEGIES

Based on the report of the Working Group on Environmental Assessments and Monitoring Strategies (WGEAMS), the ACMP reviewed guidelines on the Philosophy, Principles, and Strategy of Monitoring, issued as an annex to the WGEAMS report. On the basis of this paper, the ACMP has prepared the following guidance on this topic.

4.1 Philosophy, Principles and Strategy of Monitoring

4.1.1 Introduction

This paper is a revised and extended version of the previous advice on the question of monitoring in relation to the marine environment given by ACMP in its 1978 report (Cooperative Research Report No. 84, Annex 1).

4.1.2 Definition

In the context of assessing and regulating environmental and human health impacts of anthropogenic activities, specifically the introduction of wastes, monitoring is the repeated measurement of an activity or of a contaminant or of its effects, whether direct or indirect, in the marine environment.

4.1.3 Objectives

The ultimate purpose of monitoring is the control of exposure of the organism of interest, most likely to be first affected, to the activity or contaminant in question, whether this target be Man or some specified element of the marine resource. Basically, monitoring looks at changes in the marine environment, and in practise, falls into one of the following categories:

- monitoring for compliance purposes,
- monitoring patterns and trends, or
- monitoring for research purposes.

It should be noted that research purpose monitoring is generally the first and major step in establishing appropriate and efficient techniques for monitoring patterns and trends, and that in many cases the latter provides information that will be useful in the interpretation of compliance monitoring results.

4.1.4 Strategies

All too often monitoring programmes continue unchanged long after they have ceased to produce useful data in the context of the original objective.

It is essential that monitoring should have a clearly defined objective, that the measurements made are designed so as to be usable in meeting that objective, and that the results be reviewed at regular intervals in relation to that objective. The monitoring scheme should then be continued, revised or even terminated, as appropriate.

Then, before any programme is drawn up and any measurements are made, the following questions should be addressed:

1) What exactly do we wish to measure?

2) Why do we wish to monitor a particular variable, contaminant or biological effect?

3) How can that measurement be achieved and is monitoring the most appropriate approach?

4) In what compartment or at which locations can measurements most effectively be made?

5) For how long do we need to continue measurements in order to meet the orignally defined aim?

Although much is now known about the marine environment, there is still a lack of basic knowledge and adequate description of the marine ecosystem as a whole. In order to be able to assess the quality and health of the environment, there is a need to be able to determine natural variability and corresponding induced effects. This can only be achieved through monitoring programmes that include biological effects or produce data that can be compared to known and agreed effects levels, i.e., environmental quality standards.

Since the environment is subject to natural changes, e.g., climatic, it is important that an understanding is established of these natural changes and the way they might affect either contaminant levels or biological characteristics. This implies long-term data sets on parameters which establish the basic characteristics of the marine media, e.g., water temperature and salinity, transparency, chlorophyll levels, and nutrient concentrations.

There is also a fundamental need to recognise the requirements of decision-makers. It is especially necessary to recognise that they will require the results on finite time scales and that they will expect the results to be presented in a readily interpretable form. Thus, in common with the formulation of a regional assessment, part of which will be based on monitoring data, a basic requirement of monitoring is that it yields accurate data. These data, in turn, will provide the basis of sound, reliable advice to administrators on the need for environmental protection measures or the effectiveness of protection measures already introduced.

It is apparent that the responsibility to undertake monitoring programmes rests with organisations having interests in the nature and scale of particular areas and problems. From the single effluent outfall or river, to estuaries and shelf seas, through to the open ocean, there is a gradation of responsibility from local authorities to international organisations. However, with respect to the protection of the environment, global considerations are of primary importance and, as far as possible, they should be taken into account in developing standards and scientifically based quality criteria.

With these strategic considerations as background, the following illustrates a practical approach to the planning of monitoring programmes.

It is first essential to identify the resource at risk and then the substances or activities most likely to threaten the resource it is desired to protect. This obviously requires, at an early stage, a fairly thorough assessment of what activities are already in progress and which substances are likely to enter the area in question and via which routes. Alternatively, information on inputs can be used to focus environmental monitoring effort on those substances or effects which are most likely to be encountered at levels considered to be significant. An understanding of input fluxes to the marine environment will frequently permit even sharper focussing of the monitoring effort.

The next step assumes the existence of maximum acceptable levels of inputs or effects in order to protect the resource in question. This requires an understanding of the working relationship between rates of input and environmental concentrations, ideally via a model of exposure pathways, and the effects it is desired to avoid. It also assumes that a maximum acceptable level has been set or can be derived. Standards do not always exist and it is often argued that they cannot be defined. However, the use of simple data, even data from acute toxicity tests, can be used to derive preliminary quality objectives which will, if they incorporate appropriate safety factors, suffice pending the derivation of more accurate standards from more thorough biological testing.

4.1.5 Guidelines

The following general guidelines should provide some assistance in selecting the most appropriate monitoring techniques for the problem in question. Detailed guidelines on monitoring using marine organisms, sediments and sea water have been provided in past ACMP reports and are currently under review; details will be published separately as soon as the reviews are complete. If the following guidelines are followed, it is hoped that some of the effort currently devoted to routine monitoring can be deployed to research programmes designed to establish a better understanding of the marine environment and what constitutes a pollution problem.

4.1.5.1 Contaminants

In the past, the selection of contaminants has been based largely on the black and grey lists of the various pollution prevention conventions. It is now apparent that some of those originally listed substances do not present serious pollution risks in a marine context, whereas other substances not identified in the lists probably do. This illustrates the need to review monitoring activities from time to time in order to assess the need for their continuation.

It is, therefore, recommended that the choice of which contaminants need to be monitored should depend primarily upon the perceived aim, i.e., why there may be concern, and secondly, on whether there is real reason for concern in the area in question, i.e., is there an input of sufficient scale and is there a target likely to be affected. One certainly should not have to monitor regularly for all contaminants at all sites and it should not be necessary to use more than one substrate or effect to meet each aim. Thus, for example, if it is possible to analyse samples of fish liver for a range of metals and establish trends over time, it is not necessary also to measure any of these same contaminants in sea water for the same purpose. Matrix tables could be provided to cover the various options available and indicate the most appropriate choice.

The following table is given as an illustration.

Table 1

Marine matrix selection for contaminant monitoring in relation to the protection of human health.

Matrix	Contaminant									
	PCB	Lindane	Hg	Cd	Cu	Zn	As	Cr	Ni	Pb
Water										
Sediments										
Shellfish	+	+	+	+			[4]			+
Fish muscle			+				[4]			
Fish liver	x[2]	x[2]		x[1]	[3]	[3]		[3]	[3]	

+ = primary matrix
x = secondary matrix

Notes and Qualifications:

[1] If fish liver is not a consumed fisheries product, ignore entry.

[2] If fish liver is not a consumed fisheries product and there remain human health concerns, transfer attention to fish muscle.

[3] These contaminants are not normally of concern in respect to the consumption of fisheries products.

[4] While arsenic exists in significant amounts, e.g., in plaice muscle and crustaceans, its chemical form makes it of little concern in respect to fish consumption and human health.

4.1.5.2 Biological Effects

At present, there is a wide variety of techniques available that are capable of demonstrating whether or not an effect occurs. Some are simple to conduct, others more complex, and not all are readily amenable to use in the field. A difficulty in many cases is that although an effect is clearly detectable, its significance is unclear in terms of the well-being of the organism or species in question. Such techniques are not suitable for routine application to monitoring programmes and are probably best regarded at present as research techniques. From the standpoint of monitoring as defined in this document, the most useful biological effects are those that can be interpreted as being likely to affect adversely the ability of the species to survive, grow normally or reproduce. Ideally, the effect should be linked to a particular contaminant or source of contamination, but the fundamental requirement is that the effect is liable to have harmful consequences. Experience suggests that no one technique is likely to suit all situations.

4.1.5.3 Data Quality

Whilst it is obvious that good quality data are necessary at all times, attention should be paid to the level of accuracy and precision required. This can only be judged in relation to the aim. For example, if one is looking for trends at the $\pm$ 20% level, a high degree of precision will be called for (accuracy of data will also be important, in particular where several laboratories are to be used and data are referred to an agreed standard). However, if, on the other hand, one is demonstrating compliance with a standard which is several times higher than the concentrations actually being encountered, the level of precision (and accuracy) required is lower. There may be occasions when it is extremely difficult to measure accurately the parameter of interest, e.g., river inputs. In such situations, the limitations of the data must be clearly stated and, if comparisons are made between data from different sources, it is essential that the data compared be collected according to a common pattern, so as to eliminate differences related to procedures. Equally important is the statistical reliability of the original sampling design and the interpretation of the results.

In cooperative programmes involving several laboratories, it will of course be necessary to ensure that all participants are producing comparable data. For new contaminants this may not initially be possible and it may, therefore, be appropriate to allow a single laboratory with proven capability to conduct preliminary measurements in order to demonstrate the scale of a problem. If further measurements are considered necessary on a wider basis, it is almost certain that national authorities would wish to assure themselves of access to the data at the earliest possible opportunity. This would necessitate measures to assure the comparability of data produced by the different organizations in the different countries but the principle of having lead laboratories for particular contaminants, at least one per country, would facilitate achieving this end. The use of quality assurance procedures is strongly recommended.

4.1.5.4 Reporting Data

Once the monitoring programme is underway, it will be necessary from time to time to report the data to some coordinating centre so that they can be reviewed and assessed relative to the originally stated aim and/or established standards or criteria. It is essential that the data be reported in adequate detail to meet this requirement. In this context, however, it should be noted that although it is now relatively easy to transmit data from centre to centre by tape, diskette or electronically, collecting and recording data involves effort and costs money. What is collected and transmitted should, therefore, be tailored to the need and be the minimum necessary to meet that need.

4.2 Future of ICES Monitoring Programmes

The ACMP discussed the future of monitoring programmes coordinated by ICES, on the basis of a review of this topic in the WGEAMS report and the monitoring strategy guidelines agreed in Section 4.1, above. The ACMP agreed to keep this topic under review in the light of impending developments, particularly those regarding the North Sea.

5 MONITORING TEMPORAL TRENDS OF CONTAMINANTS

The ACMP reviewed the 1988 Report of the Working Group on the Statistical Aspects of Trend Monitoring (WGSATM) and agreed to the information and advice contained in the following paragraphs.

5.1 Report on the Analysis of the CMP Trend Data for Fish Muscle Tissue

The ACMP took note of a draft report on the statistical analyses of the Cooperative ICES Monitoring Studies Programme (CMP) data, up to 1985, on contaminants in fish muscle tissue for the determination of temporal trends, that had been prepared by the Working Group. This report details the results of a total of 62 statistical analyses of contaminant levels (53 for metals and 9 for PCBs). Twenty-five sets of samples were considered, each comprising the data for a given species of fish sampled annually from a given area. The data series were submitted by six countries (Belgium, Denmark, Federal Republic of Germany, Norway, Sweden, and the United Kingdom); they concerned six species (cod, flounder, herring, plaice, sole and whiting) and covered eighteen defined areas (based on ICES statistical rectangles). It was clear from this report that considerable manual intervention in the analysis of the data had been required. This was necessitated by the poor structure of the data sets, especially with respect to missing information and a lack of consistency in following the guidelines. The most serious problem was that often the annual samples had not covered a sufficiently wide, annually consistent, length range. This adversely affected the regression analysis applied, for example, by giving different slopes for the relationship between log contaminant concentrations and length in different years. Identification of this type of problem required close inspection of the data, and extended statistical analysis led to the conclusion that it was not possible to clearly identify a length effect for all contaminants considered or for certain contaminants in all species considered. In these cases, only the annual geometric means, uncorrected for length, were used to assess trends in contaminant levels.

The ACMP agreed that this report should, in principle, be adopted for publication as an ICES Cooperative Research Report, subject to review of a final version of the report by individual members of ACMP prior to the 1988 Statutory Meeting. The ACMP further agreed that this report will only include the results of the statistical analyses of these data; the interpretation of these results in association with environmental conditions in the areas sampled should be conducted as a separate activity.

5.2 Further Development of Techniques for Statistical Analysis of Trend Data

5.2.1 Univariate versus multivariate analyses

The WGSATM had discussed in considerable detail the relative merits of univariate and multivariate analyses in respect to trend analysis. It was pointed out that a trend for a contaminant identified by univariate analyses might be a consequence of interaction between the contaminants. Conversely, it was noted that, in the example of multivariate analysis presented to WGSATM, a vector trend (three contaminants) had been identified and that further work on the multivariate approach would be required to investigate how the trends for an individual contaminant could be resolved from such a combination vector, and also to ensure that this multivariate trend did not 'mask' trends in less significant contributors. This supports the view that there is a role for both techniques of analysis in trend elucidation.

5.2.2 Statistical implications of pooling organisms

The ACMP noted that the WGSATM had continued to pursue the question of the statistical implications of the pooling of organisms prior to chemical analysis. In this connection, it had considered a report on an investigation of Cooperative Monitoring Studies Programme (CMP) data on contaminants in individually analyzed mussels which had been 'artificially' pooled for different levels of pooling (i.e., by computing contaminant concentration values for pools consisting of different numbers of individuals) to observe the effect of pooling on the detection of trends. In addition, an approach for considering the relationship between the losses associated with pooling (statistical aspects) and the economic 'costs' of obtaining data (sampling and analytical costs) was outlined. A paper on this latter subject will be considered by the Working Group at its next meeting.

5.2.3 Contaminants in fish liver tissue

In respect to the effects of tissue fat content on trend analysis of data on contaminants in fish liver tissue, the ACMP noted that WGSATM had made considerable progress in defining an appropriate methodology for the statistical analysis of the trend data sets on contaminants in fish liver tissue. The methodology provides a generalized model for analysing these data and also provides a rationale for the treatment of data reported on a variety of different bases (e.g., wet weight, dry weight or fat weight). On the issue of the role of tissue fat content, the model allows for the investigation of the importance of fat as a covariate for a given contaminant. Fat content information is generally included in the data as the percentage fat in the liver. Whilst it is possible to include fat content as described by this measure using the model derived, it is important that data on the total weight of the liver tissue are also available to check the validity of the model in any given case. In a large proportion of the data currently available, this latter item of information is not reported and the ACMP strongly recommended that future submissions of data for the analysis of temporal trends in fish liver tissue include the reporting of the total organ weight. It is also important that the WGSATM receives data that allow the statistical utility to be assessed of the various means of measuring 'fat' currently being used.

5.3 Temporal Trends of Contaminants in Sediments

The WGSATM had been requested by the Working Group on Marine Sediments in Relation to Pollution (WGMS) to examine the extent to which trends in contaminants in surface sediments might be detectable using currently employed sampling and analytical techniques. In this connection, the WGSATM had asked Dr J. van der Meer to review the results of the First Intercalibration for Trace Metals in Marine Sediments (1/TM/MS) (ICES Coop. Res. Report No. 143). On the basis of an analysis of the results for cadmium, chromium, and copper (total concentrations using the hydrofluoric acid (HF) extraction method), Dr van der Meer had made an assessment of levels of changes in sedimentary metal concentrations which might be detectable, taking cadmium as an example. The results of this work will be considered by the WGMS at its 1989 meeting. The ACMP recognized this piece of work as a valuable contribution for evaluating the requirements for detecting trends in cadmium concentrations in sediments at a single site and encouraged the WGMS to extend this work, using the approach employed by Dr van der Meer, to other contaminants. However, it is apparent that considerably more investigative and developmental work will be needed before it would be possible to provide more specific advice on this topic.

6 BIOLOGICAL EFFECTS OF CONTAMINANTS

The ACMP discussed at some length the draft report from the Working Group on the Biological Effects of Contaminants (WGBEC). It was generally agreed that the report would have profited from a general appraisal of the methods deployed during the IOC/GEEP Oslo Workshop along the lines of the paper "Biological Effects Monitoring" by A. McIntyre, J. Davis and J.G. McHenery, which had been prepared for the Oslo and Paris Commissions and which would be published by them as an Annex to their 1988 Reports. The ACMP considered that paper to be a very useful review of the present situation regarding the application of biological effects studies in monitoring programmes. However, it noted that, since the initial production of the text, a summary table had been added indicating the state of development and usefulness of the various methods referred to in the text. The ACMP regarded this table as giving a rather more optimistic picture than was justified by the text and it therefore strongly endorsed the reservation expressed in the table caption that the table should not be used without reference to the text.

The ACMP noted the initial plans for an ICES/IOC Biological Effects Techniques Workshop in the North Sea. These indicated that studies will be concentrated on two areas: the benthic layer and the sea surface microlayer. The ACMP generally agreed that the deployment of techniques using flatfish and benthic organisms could give valuable results, however, the scarcity of detailed information on the sea surface microlayer work, e.g., what was hoped to be achieved, what was to be measured and by what specific methodology, made this part of the programme difficult to appraise. It was also somewhat unclear how the results would be interpreted. The microlayer work seemed to be directed at both a general appraisal of environmental quality as well as at toxicological effects on specific organisms, both organisms resident in this layer and under experimental conditions using test organisms (bioassays). In this context, the ACMP considered that the concentrations of contaminants in the sea surface microlayer and the extent and thickness of the microlayer might be greatly affected by wind-induced turbulence.

The ACMP also stressed the need both for detailed general background information about the sites to be visited and for information on the chemistry of the sediments, biota, water, and surface microlayer being studied. In this respect, it was noted that chemical and statistical support will be required but that it was not yet clear how, or to what extent, this would be made available by the organisers or by the host Institute.

The ACMP will review the more detailed plans for this workshop when they become available and will provide comments on them in its 1989 Report.

7 BENTHOS ISSUES

The Oslo and Paris Commissions have requested that ICES provide advice on methods of monitoring dumping grounds and coastal areas affected by land-based discharges by means of the composition of the benthic communities. The Benthos Ecology Working Group (BEWG) considered this issue at its 1987 meeting and prepared an extensive draft report which was subsequently reviewed by ACMP. The ACMP concluded in 1987 that the final report will be a valuable contribution and should be published in the Cooperative Research Report series. The ACMP further requested that a shorter text be drafted that outlined specific methods to be used for routine monitoring. The BEWG completed this latter task during 1988. The BEWG also made substantial progress in the analysis of the results of the North Sea benthos survey. This survey will provide a baseline for future monitoring programmes as well as an input to regional assessments.

The ACMP discussed the new shorter report on procedures and concluded that it should be included, with some minor amendments, in the ACMP report as it provides a good basis for defining a benthos monitoring programme. However, in order to make it more useful, specific case studies will be developed as concrete working examples, both by the BEWG and the Working Group on Biological Effects of Contaminants (WGBEC). It is hoped to include these examples in the 1989 report of ACMP. The text, as amended, follows below.

7.1 Procedures for the Monitoring of Benthic Commmunities Around Point-Source Discharges

7.1.1 Introduction

It is recommended that, at this stage in the development of methods, the core of most routine monitoring programmes involving the benthos should be based on the description of structural properties of macrobenthic communities, in parallel with relevant physical and chemical measurements of the receiving environment. Gray *et al*. (1980) reviewed the attributes of various components of the marine biota in the context of the field monitoring of pollution effects. The ACMP concurred that the benthic macrofauna, i.e., animals living within or in close association with the sea bed, and which are retained by 1 mm (or 0.5 mm) mesh sizes, continue to offer the most suitable target in routine monitoring at the community level. Definitions of size classes of benthos are given below from McIntyre (1978):

Category	Size	Biological features	Sampling techniques	Taxonomic position
Micro-benthos	Pass finest sieves	High rates of respiration and reproduction	Plating and culturing. Cores of <2 cm diam.	Bacteria, viruses yeasts, fungi actinomycetes blue-greens Most protozoa Some algae
Meio-benthos	Pass 0.5-1 mm sieves	Medium respiration rates. Two or more generations per year	Cores of 2-10 cm diam.	Large protozoa Small metazoa
Macro-benthos	Retained on 0.5-1 mm sieves	Low respiration rates. Two or fewer generations per year. Mostly infauna	Grabs sampling at least about 0.1 sq.m.	Medium-sized metazoa
Mega-benthos	Hand picked from samples	As above, mostly epifauna	Towed gear, trawls, dredge	Large metazoa

The reasons why the macrobenthos are amenable for routine monitoring include:

1) sea bed sediments represent the ultimate sink for most contaminants discharged to the sea;

2) most macrofauna species are relatively long-lived (>1 yr) and sedentary, and so can provide an indication of the integrated effects of discharges over time;

3) they are relatively easy to sample quantitatively;

4) they are well-studied scientifically, compared with other O sediment-dwelling components (e.g., meio- and micro-fauna) and taxonomic keys are available for most groups;

5) there may be direct links with valued resources, e.g., fish (via feeding) and edible molluscs; and

6) macrofauna community structure has been shown to respond to pollutants in a predictable manner (thus, the results of changes can be interpreted with some degree of confidence).

Though similar principles apply in the planning of discharge studies both intertidally and subtidally, attention is focussed on the latter, where more sophisticated (and costly) remote sampling methods are usually required. Emphasis is also placed on soft-sediment communities, which are those most commonly encountered in pollution studies. However, alternatives are also considered.

Notable among a number of existing works on sampling methods are those of Holme and McIntyre (1984) and Baker and Wolff (1987). These cover the full range of habitats likely to be encountered in monitoring programmes.

It should be noted that there is increasing interest in the use of meiofauna as a monitoring tool. This group, conventionally separated from the macrofauna at a mesh size of 0.5 mm, has the advantage of having no pelagic larval stage, and individuals are in intimate contact with the pore water by virtue of their small size. Less field sampling effort is required than for the macrofauna, but their main disadvantage lies in the need for a high level of taxonomic expertise. A state-of-the-art review of meiofauna research results will be included as part of the more extensive report by the BEWG to be published in the Cooperative Research Report series.

As further research is done on meiofauna, it is to be expected that additional cost-effective options will become available for routine monitoring. Microfaunal analysis, however, is not sufficiently developed at this stage to provide standard procedures.

7.1.2 Design and Implementation of Field Sampling Programmes

In the case of new waste arisings, it is essential that benthic monitoring programmes commence before the onset of discharges, to allow the identification of any effects by direct comparisons of pre- and post-disposal data. However, it is recognised (see below) that a modified strategy will be required in cases where discharges pre-date impact assessments.

STAGE 1: Desk study

The starting point in any benthic survey must involve an appraisal of the environment at and around the (proposed) receiving area, entailing:

1) a review of the literature on the biology, physiography and hydrography;

2) a review of human impacts - past and present - including port/harbour construction, offshore structures, dredging/dredgings disposal, other point-source or diffuse waste inputs (e.g., nutrients: possible eutrophication), fishing practices;

3) a review of uses - present and predicted - including waste disposal, commercial fishing, shipping, recreation; and

4) an assessment of potential impact (scale and intensity) of the discharge in the water column and/or at the sea bed.

The outcome of this review will determine the degree of monitoring effort, if any, which will be required to meet the objectives of waste disposal management. In the event of any uncertainty regarding the predicted outcome of waste discharge, a programme of biological monitoring is advocated. In stages 2-6, below, it is assumed that there are grounds for anticipating some interaction between discharge products and the sea bed biota.

On average, a macrofauna sample will take 1-2 days to analyse by an experienced individual, but there may be considerable variation outside this range (see Laboratory Processing of Samples, pp. 27-28, below). Without prior knowledge of the sampling area, it will be difficult at this stage to assign costs to samples; this will depend on the outcome of stage 2, below. Other important cost considerations include site accessibility and, therefore, ship-time and size of ship required, and time allocated to data processing/reporting.

STAGE 2: Planning a sampling programme

If existing local information on benthic biota and supporting habitat is adequate, then the programme may proceed to stage 4, below. If not, then systematic sampling over an appropriate spatial scale is required, using a grid of stations.

The area covered will depend on tidal and residual movements, as well as the nature and quantity of the waste. As a general rule, the minimum area covered should enclose the zone of initial sea-bed impact, if known, or alternatively an area defined by at least one tidal excursion from the discharge point. Sampling should also encompass nearby depositional areas, if any, within which there may be a possibility of accumulation of any persistent contaminants in the longer term.

The nature of the sea bed will determine the most effective type of sampling gear. In hitherto unworked areas, a pilot survey using a range of devices will be required in order to resolve any uncertainty regarding the nature of the substrates. This will have the additional benefit of allowing an assessment to be made of the relative importance of the biota living within, on, or just above the sea bed. Deployment of still and video cameras, either remotely or by divers, can provide useful data during this phase of sampling (see, e.g., Holme, 1984; and George et al., 1985; also, Rhoads and Germano, 1986, for application of a remotely operated sediment profile camera).

In areas of rough ground which are unsuitable for grabs, samples of the biota within or on the sea bed may be obtained by dredging, but usually at the cost of accurate quantification. Alternative methods, such as the use of video or still photography, may be necessary for routine monitoring of such areas (see Field Sampling Procedures, p. 26, below).

For soft substrates, a grab of standard design conforming with the Day or Van Veen type can be used (see Eleftheriou and Holme, 1984; and Rumohr, 1989, for description; also Field Sampling Procedures, p. 26, below). These should sample a standard area of 0.1 sq.m., should allow access, on retrieval, to the surface sediment to permit sub-sampling and should have stainless steel buckets to minimise the risk of trace metal contamination, if such determinations are to be made. An estimate of the retained sediment volume should routinely be made; volumes of less than 5 litres would normally be discarded.

A sieve mesh of 1 mm can be recommended for field extraction of samples of the benthos from sediments in this type of survey, prior to fixation and return to the laboratory, though local circumstances may occasionally dictate the use of coarser or finer meshes. The implications of mesh size for sample processing and interpretation are dealt with by Eleftheriou and Holme (1984), Hartley et al. (1987), and in stage 4, below.

The primary aim of this initial survey is to describe the distribution of the benthos and to relate this, as far as possible, to habitat type. It should also be possible to identify any major impacts of existing discharges. For soft substrates, samples of the benthic biota should be accompanied by sediment sub-samples for analysis of particle size and a range of physical or chemical contaminant tracers appropriate to the outfall(s) under consideration.

The importance of integrating physical, chemical and biological approaches to sampling must be strongly emphasised, since changes in the biota near to waste discharges invariably provide only circumstantial evidence for effects. Such evidence can be considerably strengthened by a knowledge of waste transport pathways and the distribution of contaminants, as well as natural environmental variability, though absolute proof will rarely be attainable without recourse to follow-up laboratory investigation.

Because of this descriptive emphasis, and the need for adequate spatial coverage, the information content of such surveys can be maximised - relative to the resources available - by sampling singly at several stations, rather than repetitively at a reduced number.

STAGE 3: Analysis and interpretation of data

At this stage, analysis will be required in order to identify patterns in the spatial survey data, and to allow selection of stations for regular follow-up monitoring (see below). A variety of methods may be employed, either for the analysis of spatial or temporal trends, and these are given in Procedures for Measuring Community Responses, pp. 29-32, below.

STAGE 4: Rationalisation of sampling design for regular monitoring

The number of sampling stations will be largely governed by spatial heterogeneity at the sea bed, predicted dispersal pathways, and cost considerations. Replicate sampling at a minimum frequency of three per site or stratum may be recommended to allow statistical comparisons between stations in space and/or time. Additionally, the choice of mesh size will have a considerable bearing on sampling accuracy. Since the costs of benthos surveys are usually a function of laboratory processing time, the decisions taken concerning numbers of stations and replicates, along with the timing and frequency of sampling (stage 5, below), will be critical to cost-effectiveness.

Local circumstances and, especially, the nature of the waste will dictate the sampling effort required. The simplest case which can be envisaged is the disposal of an inert solid waste with minimum dispersion, the immediate effect of which is the elimination of all biota; clearly the sampling effort required in order to delineate such an effect will be minimal. This is very different from the case of a complex effluent of uncertain composition, where the early onset of any adverse change may be of interest. Here, for example, it may be necessary to use finer sieve meshes (0.5 mm) for extraction of the benthos, along with increased replication, to facilitate the detection of subtle effects.

Important considerations at this stage are the efficiency with which taxa and individuals are sampled, and the proportion of animals retained on different mesh sizes. Upon these will depend the number of samples required to achieve a particular level of precision, which will in turn depend on the survey objectives. These can be investigated during a pilot survey, or at selected sites on the first occasion at which this sampling stage is implemented. It should be remembered that the cost of collecting additional samples in the field is usually small in comparison to that of laboratory processing, so that samples which eventually turn out to be surplus to requirements can be discarded.

A detailed account of these aspects of sampling design is given in McIntyre et al. (1984) and Hartley and Dicks (1987). Other relevant sources of information include Andrew and Mapstone (1987), Bros and Cowell (1987), Caswell and Weinberg (1986), and Cuff and Coleman (1979); (see also Green, 1980; Cuff, 1980; Green, 1979, 1984; Millard and Lettenmaier, 1986; Saila et al., 1976; Skalski and McKenzie, 1982; and Walker et al., 1979).

In the case of new or existing discharges, a judgement is required as to the degree and spatial extent of degradation of the habitat, if any, which can be accepted. This represents a logical progression from stages 1 to 3, above. Subsequent monitoring will then have as its primary aim the establishment that there is no worsening trend in intensity or increasing extent of impact with time. Clearly, the facility to detect and quantify such changes will be determined by both the adopted sampling strategy and the chosen measure(s) of biological response (see Procedures for Measuring Community Responses, pp. 29-32, below).

It will be noted that, while the emphasis is on the monitoring of temporal trends, the incorporation of a spatial element is necessary. In its simplest form, a stage 4 strategy will involve sampling at two sites which are comparable in all respects except the influence of the discharge. However, in practice, local heterogeneity will invariably demand a greater sampling effort.

The objective at this stage can, therefore, be met by selecting a limited suite of stations which represent those areas of interest for regular follow-up monitoring. These may include zones of waste impact identified from the physical, chemical, and/or biological data generated from stage 2 (above), or locations deemed to be potentially at risk.

It should be remembered that the sensitivity of different analytical measures of contamination may vary widely. The presence of detectable levels of contamination does not necessarily imply a biological effect and vice versa. Such factors must be considered in weighting the contribution of contaminant data to sampling design.

The sampling design should aim to minimise the influence of extraneous environmental variability; this may be relatively straightforward if, for example, the main dispersal pathway is aligned with depth contours, and environmental conditions along this line are similar. More complicated situations may arise, e.g., where dispersal is across depth contours; in shallow waters, this is often accompanied by gradients of substrate type caused by the natural sorting processes of wave and tidal action.

A further complication near to urban or industrial areas is the potentially confounding influence of other discharges in the vicinity. In both these cases, sampling should be designed so as to adequately represent the major strata identified from the descriptive survey.

As a general rule, the frequency of sampling will be greater at the onset of a discharge, in order to allow for: 1) any uncertainty in predicted impact, and 2) stabilisation of impact (intensity and extent) with time. However, many studies of the responses of benthic communities to discharges suggest that only exceptionally will there be a need to sample at a frequency of more than once per year.

Initially, annual sampling at the same time each year is adequate. Ideally, sampling should be done within a period (often Spring) which will avoid seasonal maxima in larval recruitment, since the transient presence of many of the latter may obscure quantitative trends in adult populations which have been exposed to discharges for longer periods. This can have an additional benefit, since identification of juvenile stages is often problematic and can add significantly to processing time. The frequency of sampling may subsequently be reduced if there is evidence of stability in the response to the contaminant.

The choice of mesh size, as well as timing, will in many cases affect the proportion of juveniles and adults in samples (e.g., Rees, 1984). At one extreme, it may be noted that small size at settling and slow growth of some macrofauna species may result in failure to recruit to even the finest (0.5 mm) sieve mesh commonly in use within the one- to two-year period that might elapse between surveys (see Buchanan et al., 1986).

STAGE 5: Establishment of routine

This will involve adherence to standard protocols for sampling and analysis, and these must include continued monitoring of the relevant physical and chemical parameters. However, some flexibility must be allowed for, e.g., in response to changes in quantity of waste discharged. The continued validity of the rationalised sampling design should be checked by periodically repeated stage 2 grid surveys.

FIELD SAMPLING PROCEDURES

Box-core samplers (such as the Reineck box-core; see Eleftheriou and Holme, 1984) have the potential advantage over grabs of digging deeper into bottom substrates as a result of a frontal pressure wave which has been associated with the latter (see Eleftheriou and Holme, 1984; and Hartley and Dicks, 1987). However, because of their size and weight, they require larger vessels - and relatively calm conditions - for their efficient deployment, and so are less versatile than grabs.

Remote grab samplers of the Day or Van Veen type are recommended for routine monitoring of soft sediments. Non-standard equipment should not be deployed. If comparisons are to be made between data sets obtained by different gear, then calibration of performance against recommended designs will be necessary (Rumohr, 1988).

Regarding vertical distribution within sediments, most studies show that the majority of benthic organisms occur in the surface 5-10 cm, and will be adequately sampled by grab. However, the distribution of biomass may be different, in that older individuals, especially of bivalves, may live atdepths considerably greater than this. Such occurrences, and their significance to the outcome of monitoring programmes, can only be tested by comparisons of the results of grab and deeper-penetrating core samplers.

Protocols for field sampling, including extraction of the benthos on sieves, and preservation, are given in Eleftheriou and Holme (1984), Hartley and Dicks (1987), Hartley et al. (1987), and Rumohr (1988).

Areas of hard ground (e.g., rocks, coarse gravel) present particular problems for quantitative sampling at the community level, as there may be considerable uncertainty as to the sampling efficiency of dredging devices. However, this can be overcome in areas accessible to divers. For example, non-destructive quantitative assessment of the fauna and flora of rock faces has been carried out over several years using stereo photography (Lundalv and Christie, 1986).

Also in shallow sub-tidal rocky areas, the fauna inhabiting kelp (seaweed) holdfasts, collected by divers, has been used as a monitoring tool (see Moore, 1973). Recent reviews of survey approaches for both inter- and sub-tidal rocky habitats are given by Gamble (1984), Baker and Crothers (1987), and Hiscock (1987).

Monitoring strategies in such localities may benefit from a consideration of the role of individual species (e.g., sedentary bivalves) as indicators of biological effects and/or contaminant bioaccumulation at the population level.

LABORATORY PROCESSING OF SAMPLES

The laboratory undertaking will depend on the objectives of data analysis (see below), but typically will require the identification and enumeration of all taxa encountered in preserved samples. In most cases, identification to the level of species can be achieved by reference to standard taxonomic keys. The time - and therefore cost - required to achieve this will vary considerably according to:

i) the expertise and continuity of staff;

ii) previous knowledge of the area. Familiarity gained from initial surveys, and/or access to historical reference collections of taxa encountered, can considerably enhance the speed and efficiency of processing;

iii) mesh size. In general, the larger the mesh size used in sampling, the easier and faster will be the rate of processing, since juvenile stages and a range of adult species of small size will tend to be omitted. Identification of the former, in particular, can be problematic;

iv) nature of samples. Samples containing large quantities of residual material in addition to the benthic fauna can create special problems at the sorting stage. For example, fine organic detritus, often found in association with muddy depositional areas, may extend the sorting time to several days, in contrast to a fine sandy sediment, where separation of sediment from the fauna may be virtually complete at the field sampling stage.

Extraction of the biota in the presence of quantities of inorganic material such as coarse sand or gravel can be speeded up by simple decantation or the use of more sophisticated procedures, such as Barnett's fluidised sand bath (see Eleftheriou and Holme, 1984; also Pauly, 1973), provided that thorough checks are made on the efficiency of the procedures.

If sub-sampling is considered to be necessary, it should be remembered that while this may be acceptable for species counts, only exceptionally will this account for the full range of taxa present. Thus, sorting of the entire sample is required, unless this deficiency can be tolerated in subsequent comparisons of the data. Such a comparison can impose severe limitations, especially when making comparisons with studies conducted elsewhere, and if possible should be avoided.

Details of laboratory procedures are given in Eleftheriou and Holme (1984), Hartley et al. (1987), and Rumohr (1988). Regarding biomass determinations, they should be expressed as ash-free dry weight using appropriate conversion factors (Rumohr et al., 1987) or following the procedures outlined in the report of a recent ICES intercalibration exercise (Duineveld and Witte, 1987; see also Rumohr, 1988).

It will be appreciated from the above that a major proportion of the resources committed to benthic monitoring programmes will be taken up at the laboratory processing stage. Model sampling strategies must be translated into the reality of local routines, and some compromises are invariably necessary. It is, therefore, imperative that this aspect is taken into account at the survey planning stage, and adequate resources allocated.

PROCEDURES FOR MEASURING COMMUNITY RESPONSES

Numerical Analysis of Primary and Derived Variables

Primary variables

Following quantitative sampling, determinations of species composition, densities, weight, and preferably size fulfil a basic requirement of most routine benthic monitoring programmes. Any subsequent rationalisation, e.g., selection of target organisms for single-species studies, or identification to the level of higher taxa only, should proceed only after the establishment of a sound baseline of knowledge of the biota in the receiving area.

The variables of total abundance, number of species and biomass can be surprisingly robust indicators of environmental changes, and have been shown to respond predictably along organic enrichment gradients (see Pearson and Rosenberg, 1978). Moreover, these are explicable in terms of functional responses of the biota to alterations in the benthic habitat. They may be expressed graphically or by simple mapping techniques, depending on the sampling design.

Derived variables

The ability to detect gradients or trends using the primary variables is often limited. The application of classical univariate or bivariate statistical techniques may even be misleading. A variety of summary statistics and ordering techniques have been developed which may be used for the further elucidation of structure in the data, and to aid the formulation of hypotheses concerning effects of discharges. They may also provide an objective basis for rationalising subsequent sampling programmes (Clarke and Green, 1988).

It should be remembered that a number of these methods employ sophisticated mathematical techniques, a sound appreciation of which is required for the correct interpretation of output.

These take three main forms:

a) Graphical displays of species-area or species-abundance relationships

   Many different methods exist which are variants of ranked species abundance (RSA) curves and k-dominance curves in which species are ranked according to abundance. Species abundance distributions are frequency distributions with a logarithmic or linear ordinate. When geometric abundance classes are used, a log-normal distribution is often found.

   These graphs and distributions are useful tools for presenting the data, but since these are empirical relationships, it is difficult to detect causality when changes occur. Statistical comparison between curves is not at the moment possible (Heip *et al.*, in press).

b) Diversity

Two aspects are recognised: species richness, i.e., the number of species, and equitability, i.e., the distribution of individuals among the species.

Many different indices have been proposed. A coherent system may be found in the diversity numbers of Hill (1973), which includes S (the number of species), H' (the Shannon-Wiener index), and Simpson's index, among others. Diversity indices are useful and may be compared statistically. The different diversity numbers in the Hill series cover different structural aspects and thus more adequately represent overall community structure. However, full species-abundance plots contain more information (Heip et al., in press).

c) Classification and ordination

These are techniques capable of synthesis and ordering of the data. Classification involves arranging the sites or species into groups (clusters), setting them apart from the members of other groups. Ordination attempts to place sites or species in a space defined by one or more axes in such a way that knowledge of their position relative to the axes conveys the maximum information about them.

Classification and ordination should be standard practice to analyse abundance or biomass data obtained in surveys involving many species and stations. The definition of a standard protocol of data analysis is still awaited (but see Gray et al., 1988; Clarke and Green, 1988). However, the general availability of personal computers and software packages brings these methods within easy reach.

Conclusions

Many options are available within each of the above categories of data analysis, and no single measure can be recommended as suitable in all cases. Rather, there is merit in the application of a variety of different measures of community structure, a procedure which is facilitated by the wide availability of statistical packages.

Other Measures of Community Properties

Trophic groups

For most species, the predominant feeding mode can be deduced from the literature, and such information may be used as a measure of the response of the benthic fauna to waste discharges. For example, a shift in dominance from suspension- to surface deposit-feeding may indicate excessive turbidity, or increased accumulation of organic matter at the sea-bed (e.g., Pearson, 1971).

One limitation which should be borne in mind is that some species have the ability to switch from one feeding mode to another.

Vertical distribution of fauna

Soft sediments present an array of habitats suitable for faunal colonisation both within and on the substrate, including, for smaller-sized species, the interstices between particles. Effects of discharges may be manifested through a reduction in their suitability, e.g., due to sediment accretion, or the development of anoxic conditions at depth as a result of excessive organic matter accumulation.

Periodic examination of the vertical distribution of the fauna (e.g., from undisturbed sediment cores), along with measures such as redox potentials, may, therefore, be useful in assessing the progress of any degradative processes within sediments (e.g., Pearson, 1987).

Size spectra

The response of benthic communities to pollution may be expressed in terms of changes in the frequency distribution of body size, e.g., for the macrofauna, smaller 'opportunistic' species are commonly found to predominate near to discharges, at the expense of larger, slow-growing species (Pearson and Rosenberg, 1978; Pearson, 1987; see also Warwick *et al.*, 1986). This approach requires exhaustive treatment of samples if carried out over the full size range of the benthic biota (e.g., Schwinghamer, 1983), and - though a promising area of research - could not be advocated for routine monitoring.

Recently, Warwick (1986) and Warwick *et al.* (1987) have proposed a method of pollution detection based on the relation between ranked abundance and biomass curves of the macrofauna at individual sites. The technique may prove to be useful, but presently requires further empirical testing.

Community metabolism

Impairment of community function in response to waste inputs may have consequences for the supply of energy (as food) to higher trophic levels, and may be expressed through changes in, e.g., oxygen uptake, ETS (electron transport activity), ATP concentrations, and heat production.

These may be measured *in situ* or from sediment sub-samples and can be converted into units of carbon or energy flow. As rate functions, they can contribute to models of ecosystem energy flow, and thus have potential application in assessments of assimilative capacity or vulnerability to contaminant effects (e.g., Pamatmat *et al.*, 1981; Graf *et al.*, 1984; de Wilde *et al.*, 1986).

Presently, methodological problems and uncertainty regarding the accuracy of some of the measured responses preclude their routine application. However, the general approach is considered to have potential value as a monitoring tool, for use in conjunction with traditional studies of community structure.

Annual production calculated from growth and mortality rates

This entails separate examination of the dominant species using methodology outlined by Crisp (1984), followed by summation to obtain an estimate of community production. The approach has the advantage of providing data on: (1) the performance (e.g., growth rates) of individual species in proximity to discharges; (2) the 'carrying capacity' of the receiving environment, in energetic terms; and (3) the nature and quantity of biomass available as food for fish.

The main disadvantage is that the sampling and initial analytical effort can be time-consuming; at least seasonal sampling is required. It may be possible to overcome this using annual P:B ratios for species studied elsewhere, but this may not always be valid, since the ratios may vary substantially from one region to another. The approach cannot, presently, be advocated for routine monitoring programmes, but the potential for future application should improve as the data-base expands (see Brey, 1989).

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8 FISH DISEASE ISSUES

8.1 Results of Disease Surveys

Four items from the draft report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) were noted of interest to the ACMP: the disease survey portions of the national reports, the planned Dutch long-term disease/pollution experiment conducted in large basins, the impact of medication on the mariculture environment, and the review on immune systems in crustaceans.

Most of the work reported on disease problems referred to mariculture; only six countries reported results of disease surveys on wild fish stocks.

From the Danish report, it was noted that, whereas disease rates in dab increased in areas presently showing oxygen deficiency, the disease rates decreased in an area that has recovered from an oxygen deficiency that had occurred in the early 1980s.

The report from the Federal Republic of Germany presented the results of seven years of surveys on prevalences of lymphocystis, epidermal papilloma/hyperplasia and ulcerations in dab in the German Bight and the southern North Sea. Disease frequencies were found to be elevated within the centre of the German Bight, off parts of the British coast, on the Dogger Bank and off some parts of the Danish coast. Long-term data did not reveal any clear overall up- or downwards trends in disease prevalence. Only spring/early summer data on lymphocystis and epidermal papilloma indicated increasing frequencies during the last seven years on the Dogger Bank and in the vicinity of the dumping area for titanium dioxide wastes within the German Bight.

From the Federal Republic of Germany report, it was also noted that during a study on the biology of two microsporidian parasite species in smelt, it had been found that an infection of the skeletal muscle was associated with a lowered condition factor in the host fish. Together with previous reports on lowered condition factors in cod, flounder, and smelt due to infections with other parasites, there are now several examples from the Elbe estuary that suggest that fish hosts are not adapted to, but suffer seriously from, their parasites. It is assumed that some parasite species have strong effects on the natural mortality of their hosts.

The report from Finland stated that the high prevalence of lymphocystis in Baltic herring, reported the previous year, has continued to persist; the infection occurs in the muscle and all visceral organs of this fish. High prevalences (11%) of fin erosion, apparently originating during an early developmental stage of the fish, have been recorded in pike-perch from the Helsinki area. A new five-year study of diseases in coastal fish, particularly flounder, was initiated by Finland in 1987.

The Dutch baseline study recorded diseases of dab, flounder and cod caught during standard stock assessment surveys. In another Dutch study on the flatfish species flounder, dab and plaice, it was also noted that the results support those of previous field studies in the 1983-1986 period. The WGPDMO agreed that this study seems to suggest that a relationship exists between several diseases of flounder (lymphocystis, ulcers, fin erosion and liver tumours) and contamination, whereas disease levels in dab and plaice did not show such a trend. In relation to this study, and because of the difficulty of establishing a conclusive cause-and-effect relationship between contamination and disease, a large-scale experiment has been started at the Research Centre on Texel. The experiment is being carried out in basins 40 x 40 x 3.5 m using one species of fish, flounder, which will be exposed (1) to contaminants in sediments from Rotterdam harbour sludge, (2) to relatively clean sediments with highly eutrophic water, and (3) to relatively uncontaminated sediments from the Wadden Sea area. A pilot study is being carried out initially from April 1988-1989 using about 200 flounder per basin. This will be followed by the main study from 1989-1992 with about 1,000 fish per basin. Fish will be screened monthly for evidence of external diseases, and fifty fish will be sacrificed every 3 months for detailed histological, bacteriological and immunological examination. Food for the fish will consist of live organisms.

A report from Sweden drew attention to a previously unexplained increase in verteberal compression (Platyspondyli). This condition occurs in the Ringhals-Värø area, an area affected by thermal discharges from the Ringhals nuclear power plant and by effluents from the Värø pulp mill, and was found in cod. 7.6% of cod showed the condition in the Ringhals-Värø area, whereas only 1.6% prevalence was found 15 km offshore. During surveys in 1982-1985, only 0.1% of cod were found with the same condition.

In connection with the discussion on dedicated disease cruises <u>versus</u> disease work included in stock assessment surveys, the ACMP noted the report of a UK disease specialist taking part in an annual North Sea groundfish stock assessment survey. In this survey, 77 stations spread over the entire North Sea up to 62°N were trawled for fish. Statistically viable numbers of diseases were recorded only in dab, which was by far the most common fish of the 57 species caught. Epidermal diseases, especially ulcers, were recorded at the highest prevalences in the Firth of Forth, Humber and on the Dogger Bank, where total catches of this species were also the highest. Many of these skin diseases showed evidence of healing, thus demonstrating their transient nature. Histology of dab livers revealed low numbers of pathological changes. These included responses to nematode infestations, ichthyophonus and necrosis. In addition, the overall combined prevalence of hepatic hyperplasia, pre-neoplastic lesions and hepatoma was less than 5%. Diseases in other fish species were not recorded quantitatively because of their low prevalence rate. The majority of fish appeared to be generally healthy.

The strategies and methodologies used in fish disease surveys are largely directed toward obtaining information about the status and fate of commercially important fish stocks. Fish disease surveys thus give data of limited usefulness to an assessment of the biological effects of pollution. They do, however, provide useful information regarding the incidence of diseases in natural stocks that may assist in baseline specification.

A more epidemiological approach, with strategies and methodologies directed more at the etiology and spread of diseases, might yield data of greater use for the assessment of the possible role of contamination as a cause for fish disease, especially if they include biological criteria (e.g., morphological, physiological) that demonstrate the pattern of events that occur before the disease manifests itself in a form that can be diagnosed in a finite form (e.g., nodules, papillomas, etc.).

It was further noted that the results of a Scottish survey on two pairs of sewage sludge dump sites/reference sites gave rather unexpected results, as relatively lower disease prevalences were found in dab from both dump sites compared to dab from the reference sites. Such results re-emphasize a general problem in interpreting the results of fish disease surveys, namely, that there is currently insufficient information on the spatial variability of disease prevalence to attribute significance to inter-area differences, even if the areas concerned are in close proximity, as in this case.

The ACMP reviewed the status on identification leaflets on diseases of marine organisms and noted that, with the 10 new leaflets published in 1987, the total number of leaflets published by ICES in this series is now 40. Nine new leaflets have been cleared for publication; the tenth leaflet for this group will be ready before the end of May 1988. Almost 20 further new titles and authors have been suggested for subsequent leaflets.

8.2 Second Sea-Going Workshop on Methodology of Fish Disease Surveys

The ACMP examined the report from the Second Sea-Going Workshop on Methodology of Fish Disease Surveys and highlighted some of the topics.

The second ICES Sea-Going Workshop on Methodology of Fish Disease Surveys took place on board R/V "Argos" from 16-23 April 1988. Twelve scientists from seven countries, most of whom have worked on national fish disease surveys on a regular basis, participated in the Workshop.

The aim of the Workshop was to revise ICES Cooperative Research Report No. 140, "Methodology of Fish Disease Surveys: Report of the 1984 Workshop", in the light of field experience gained over the last four years and to update the recommendations for such surveys. It is hoped that the report of this second Workshop will encourage and facilitate new investigators to initiate regular work in this field. A final goal of the Workshop was also to construct a simple diagnostic and reporting system so that future survey data can be computerised by ICES.

The format of the Workshop had allowed the Group to participate in practical exercises, discussions, and presentations working around catches from 11 hauls in the Kattegat. As a basis for programme activities, summary presentations were given of the first Workshop's results and a critical assessment was made of shortcomings identified by four years of practical experience.

The uncoordinated way in which ICES member countries have up to now conducted studies on the prevalence rates of fish diseases and reported the results to ICES has been recognised as a major problem in assessing the significance of fish diseases in relation to pollution. The Workshop participants therefore discussed and suggested a coordinated long-term programme of fish disease monitoring, drawing up guidelines which would allow the detection of any possible trends.

Whereas the first (1984) Workshop report had shown that suitable fish species for disease monitoring for the North Sea was the dab (Limanda limanda), and possibly the cod (Gadus morhua), recent experiences confirmed the dab as a suitable species in the North Sea, but for inshore and estuarine waters the flounder (Platich thys flesus) now also appears to be a suitable species. Because of its mobility, cod is no longer considered to be suitable as a species for long-term monitoring of fish diseases in the North Sea in relation to pollution; however, it can still be considered a suitable species for the Baltic Sea in conjunction with the flounder. The diseases which were proposed for inclusion in ICES international monitoring in dab were lymphocystis, skin hyperplasia/papilloma, skin ulcers and x-cell gill lesions. For internal diseases, the liver should be the target organ of choice.

Experiences on the effectiveness of disease monitoring on different types of vessels were presented. The conclusion is that research vessels in which the cruise is dedicated solely to fish disease work are to be preferred, although a major disadvantage is cost utilisation. To reduce costs, it may be better to participate in cruises with multiple aims, e.g., benthos sampling, stock assessment, etc. There are advantages in using routine fish stock assessment cruises because a wide sea area can be covered, giving an overall impression of background levels of disease. Furthermore, a great deal of other biological and physical data are collected and can be made available for correlations. However, disadvantages were related to the priorities of cruise aims, etc. During the Workshop, the participants identified the need for fish disease studies to be correlated with other biological, chemical and physiological studies. The Workshop also identified a need for illustrated guides to fish diseases, both for identification and general training purposes.

The 1984 Workshop had identified a series of factors that can contribute to variability in the results of fish disease surveys. Although considerable improvements have resulted from the recommendations made, subsequent practical experience has shown that significant problems still exist in the following areas:

1) The collection of data from wide-ranging extensive studies (e.g., in cooperation with stock assessment cruises) has considerable value in indicating the range of diseases present, their breadth of distribution and the variability present, but it is recognised that such data have limited value in trend analysis.

2) The comparison of fish disease levels in different areas has proved difficult because of the marked spatial variability found for all fish diseases being studied. Consequently, there have been problems in finding true reference areas to compare with test (i.e., polluted) areas of interest.

3) There are difficulties in determining from field data whether diseases are lethal or non-lethal and, therefore, whether the prevalence data obtained on fish diseases accurately reflects the incidence levels.

4) There have been insufficient long-term studies at limited area sites on an international level to allow adequate trend analysis of fish disease levels in the North Sea. In addition, the restricted extent to which fish disease studies have been integrated with studies on the chemical, physical and biotic components of the environment makes interpretation of data difficult in relation to pollution. There is a lack of information as to what data are required.

5) There is a lack of knowledge of fish population delineation, migration, physiology, and behaviour in relation to fish diseases and to what extent fish sub-populations may show different disease prevalences.

6) Individual national requirements and constraints present significant problems in closely integrating sampling programmes on fish diseases internationally. This is compounded by the current lack of a reliable method of providing information to relevant specialists on national disease sampling programmes which are proposed. The reporting of such proposals through the Chairman of WGPDMO should be encouraged.

7) The serious lack of compatability in fish disease diagnoses and recording and presentation of data is the major factor preventing international comparison and pooling of data. Standardised methods appropriate for international use are required and suitable instruction (including training aids suitable for use on board ships) must be provided to improve the quality and the amount of compatible data.

Recognising that the solution of some of the major problems identified lay outside the possibility of immediate practical feasibility, the 1988 Workshop had set itself some broadly based objectives, namely:

1) The establishment of guidelines for an integrated international programme to determine long-term trends in fish disease prevalence levels in the North Sea. The realisation of this objective would be dependent on the formulation of agreed minimum sampling requirements in terms of fish disease using standardised methods of diagnosis and reporting. Intensive sampling should be conducted in a limited number of areas throughout the North Sea (and more extensively, if possible) with due regard to contaminated and reference sites; and

2) The establishment of internationally agreed cut-off points for the principal disease conditions currently being considered in pollution monitoring studies below which data would be excluded from international reporting.

Stemming from the results of the Workshop, the following guidelines are recommended as minimum requirements for the long-term monitoring of fish disease levels for the purpose of trend analysis in relation to pollution. Investigators should endeavour to meet these requirements and, if possible, exceed them in terms of numbers of fish and sites examined. Data submitted from studies in which all these requirements have not been fully met should be accompanied by an appropriate note.

The fish species selected as suitable for examination in the North Sea are dab in offshore areas and flounder in inshore and estuarine waters; in the Baltic Sea, flounder and possibly cod should be used.

For each host species, the following disease symptoms were selected as appropriate for study on the basis of:

i) their possible responsiveness expressed as changes in prevalence levels to surrounding environmental conditions as indicated by current published and unpublished data; and

ii) the ease and reliability of diagnosis.

For some cases, clear "cut-off" points above the lower limits of visual detection are recommended for international reporting to increase the reliability of diagnosis and allow international comparability of results, but it should be noted that data outside these limits may be useful for other purposes.

Host	Disease	Minimum requirement for international reporting
Common dab	Lymphocystis	More than one surface nodule
	Epidermal papilloma	Lesions larger than 2 mm
	Skin ulcers (acute and healing)	Open lesion
	x-cell gill lesion	Secondary filaments affected
	Liver nodule/tumours	Larger than 2 mm diameter
Flounder	Lymphocystis	One or more nodules
	Skin ulcers	Open lesion
	Liver nodule/tumours	Larger than 2 mm diameter
Cod	Skin ulcers	Open lesion
	Skeletal deformities	Grossly or by filleting
	Pseudobranchial swelling	Grossly observable
	Cryptocotyle	Parasites present

Each country should select and report, either jointly or in collaboration with another country, on at least two stations which are known for their differences in contamination levels to ensure a sufficiently broad spread of positions covering the areas of interest. The final choice of the fixed positions to be used for long-term monitoring should be made carefully with particular attention being paid to areas of national and international interest (e.g., dump sites), areas removed from pollution input as reference areas, fish species availability, disease occurrence and the presence of existing knowledge on pollution, fish stock movements and disease.

Sampling for the purpose of this international study should be conducted as follows:

a) Sampling should be accurately positioned on a nominated latitude and longitude with all repeat haul tracks being within clearly defined limits of the position, e.g., a two nautical mile radius.

   ICES Statistical Rectangles may be inappropriate for reporting many fish disease prevalences, as some diseases are extremely localised. Therefore, additional information, including station code and accurate sampling position in latitude and longitude, should be included in reports to ICES.

b) Sampling should be conducted on a long-term basis once a year within the same time window (month) or, if possible, at two periods to provide data from summer and winter periods (which should not be combined).

c) Catches should be stratified by length into groups and a minimum number of fish per length group examined for disease. The minimum sampling requirements considered appropriate for dab and flounder are as follows:

Minimum numbers of fish required for the purposes of identifying the percentage of fish affected by disease

Dab	Disease examination	
Size group (cm)	External	Internal
15-20	100	
20-25	100	(50)
25+	50	50*

Flounder	Disease examination	
Size group (cm)	External	Internal
20-25	100	
25-30	100	(50)
30+	50	50*

For cod, the numbers will be specified after further study.

*If 50 fish of the largest size group of dab and flounder are not available for internal examination on the sampling station, ad-ditional specimens to make up the total should be taken from the upper range of the middle size group. This is the reason for the parenthetic entry in the middle size range.

d) The average length and sex ratio of fish within each length group should be recorded.

Other data from sampling stations

To facilitate interpretation of long-term disease data and to characterise sampling stations, additional investigations of biotic and abiotic characteristics are required. The complete list of appropriate complementary investigations should be compiled through consultation with relevant ICES working groups, but the initial framework should be based on the following points:

a) Host characteristics

Age/length relationship (based on 10 fish per cm)

Condition factor (gutted)

GSI (Gonadal Somatic Index)

Stomach food composition (based on 25 fish of 20-25 cm)

Contamination of liver (based on pooled samples of fish of 20-25 cm)

MFO (Mixed Function Oxidase activity)

Catch per unit effort as an index of population density

b) Biotic

Benthos characteristics

Fish fauna - catch composition of other species

c) Abiotic

Sediment composition

Sediment contamination (heavy metals, organochlorines, PAHs)

Having discussed the report of the Sea-Going Workshop in detail, the ACMP endorsed the proposed plans for future data reporting on fish diseases to ICES.

8.3 Environmental Impact of Medication used in Mariculture

Concerning the problem of the impact of medication used in fish farms on the environment, the ACMP noted that although antibiotics and chemicals have been used for many years without much attention, research in this field has now been established in several countries. It has been shown that the degradation of Neguvon and Nuvan in sea water is affected by temperature and pH and that degradation is slower in shellfish than in finfish. Reference was also made to Norwegian studies on the degradation of rotenone and its possible effects on oysters, even at low temperatures.

Because of the oral administration of antibacterial compounds to farmed fish, residual concentrations in fish flesh and in the environment give cause for concern. Withdrawal periods after the use of antibacterial compounds and before fish sale are regulated and strongly enforced in most countries. Nevertheless, there have been reports of cases in the Norwegian salmon industry in which residues of oxytetracycline remained high for a much more extended period than normal (up to 5-6 months).

Results of assays of sediments under fish farms, reference areas well away from farms, and in laboratory experiments indicate that antibacterial compounds degrade rapidly if present on the surface of sediments but only slowly when embedded within the sediments. 18-20% of the total sediment bacterial load under a fish farm showed resistance to oxytetracycline compared with 0.8-1% in a reference area. This picture persists for a considerable period of time, for at least 9 months according to measurements available to date. The question of whether the extended resistance is associated with the persistence of the antibiotic in the sediments is being studied and possible changes in the bacterial species composition in the sediments are being assessed.

9 ENVIRONMENTAL IMPACT OF MARICULTURE

Considering the environmental issues that are emerging as being associated with the mariculture industry, the ACMP had noted at its 1987 mid-term meeting the proposals of the ad hoc Study Group on Environmental Impacts of Mariculture (a) to publish the Study Group report as a Cooperative Research Report, and (b) to establish an ICES Working Group on Environmental Impacts of Mariculture. The Council approved these proposals at the 75th Statutory Meeting in October 1987.

As a result, the report of the ad hoc Study Group on Environmental Impacts of Mariculture was published in March 1988 as Cooperative Research Report No. 154, and the newly established Working Group met for the first time in Hamburg, Federal Republic of Germany, in April 1988. The ACMP considered the report of this Working Group and concluded that the most important issues addressed are those outlined below:

a) a discussion of on-going and recently initiated research programmes on environmental issues related to mariculture, to facilitate transfer of information and to avoid duplication of efforts in member countries;

b) an evaluation of techniques and monitoring strategies with the aim of beginning preparation of a technical report on them;

c) the identification of criteria for site selection which minimize environmental impacts; and

d) the compilation of a directory of chemicals and their properties currently used in mariculture, with a view to providing advice to member countries.

To facilitate an appropriate discussion of these issues, the Working Group had considered the following topics on the basis of national reports presented at the meeting and from information gathered by participants:

(1) production trends, (2) farm siting, (3) the use of chemicals (including antifoulants), (4) human health aspects, (5) interactions between wild and cultured fish, (6) nutrient loadings, and (7) attempts to quantify a water body's carrying capacity for shellfish or holding capacity for finfish.

Mariculture production continues to show an upward trend in most of the ICES member countries. While early growth of the salmon cage industry has taken place in sheltered inshore sites, water and sediment quality problems encountered in poorly flushed areas have caused the industry to consider the potential for development of offshore areas. In general, this trend is encouraging from the viewpoint of minimizing environmental impacts, although site-specific evaluations must still be made on a case-by-case basis.

General concern was expressed about the wider use of chemicals. Shellfish cultivated and/or harvested in the vicinity of fish farms have a potential to accumulate chemicals. While there are government mandated holding times for cultured fish treated with antibiotics, no similar protection exists for products derived from fish or shellfish caught in the vicinity of farms. The only study on this topic for which there are data failed to find evidence that shellfish in the vicinity of finfish farms accumulate antibiotics, although additional studies are in progress. There is also evidence that antibiotics can persist in marine sediments beneath net cages for quite some time. In some cases, antibiotic resistance has complicated disease treatment for farmers, but the greater ecological effects of antibiotic resistance in bacteria remain unknown. Scientists from several ICES member countries have indicated that studies are being initiated to evaluate the effects of antibiotic use in mariculture on benthic microbial communities.

In several countries concern is being expressed as to the potential interactions between mariculture and wildlife; these concerns mainly relate to issues such as the consequences of salmon farms on nearby natural spawning streams. At the present time, there are very few studies on the effects of farming practice or location of wild stocks and research projects in this area should be encouraged.

Progress has been made in studying the nutrient loadings originating from fish farming activities and in several countries attempts are underway to reduce the input of dissolved inorganic nitrogen and phosphorus. The success these efforts can have is well illustrated in Finland, where improved feed composition has resulted in a total phosphorus loading that has remained essentially the same, despite the impressive growth of the industry over the past years.

In relation to appropriate site selection criteria, it was noted that expansion of the mariculture industry often comes into conflict with other users of coastal waters. In addition, poor site selection prior to the establishment of a farm can lead to ecological changes which may, in the long run, affect farm production. In many countries there is a need to provide guidance to the mariculture industry and to planning authorities on site selection. On-going programmes from three ICES member countries (Canada, Norway, Sweden) contain various planning elements which might be used to derive appropriate site selection criteria. The first stage of the site selection procedure may examine broad geographical regions and identify, in the form of a coastal resource interest survey, areas unsuitable for mariculture, either because of conflicting water use (e.g., fishing, recreation, conservation, industrial use) or unsuitable environmental conditions. The resolution of this process is typically in the order of 1 to 100 km^2, although the resolution may vary depending on the requirements of an individual country.

A second phase of the site selection process would employ techniques to identify specific sites. This is often the responsibility of the prospective farmer and in some countries may involve local authorities. Several criteria which the Working Group considered important for the selection of specific sites are outlined in Cooperative Research Report No. 154. The only development since publication of this report has been the completion and testing of a site sedimentation model. This model can be used for three purposes: (1) determining the suitability of a site for salmonid culture in terms of the probability of benthic impacts, (2) predicting the dispersal of organic wastes from fish farms, and (3) optimizing the development of cage units. As it has been formulated, the model does not take into account a number of factors which might limit its applicability in some areas (e.g., effects of turbulence in the water on the dispersal of waste particles, re-suspension of sedimented material, variability in settling rates of fish faeces).

In respect of the possible negative influences of mariculture on the environment, a number of options and practical methods to reduce or avoid these effects through improved management and site selection were evaluated. These included (a) recovery of waters used in the treatment of fish, (b) site rotation, (c) site capping, (d) improved husbandry, and (e) removal of organic sediments.

Site rotation is a farm management tool which allows the farmer to exploit marginal environments, however as a matter of principle, this cannot be recommended because it simply means that farmers contaminate one site to the point that it becomes unusable, and then move on. Site rotation, however, might be a method of minimizing environmental effects, provided that the strategy does not use each site at a higher level than would be possible if it were used continuously and provided that the alternative site is not connected to the same water system.

The Working Group recognised that there are a number of important factors which need to be addressed in devising a monitoring programme for water-based aquaculture units. First, it is necessary to define the aim of a monitoring programme and to distinguish between monitoring for regulatory purposes, monitoring to detect changes which might affect the farm productivity, and monitoring for research.

From the discussion of the various topics considered in the Working Group report, the ACMP noted that there are many more aspects which should be addressed by the Working Group and for which other problem-solving strategies might be suggested. While it is possible to formulate unifying concepts about the practice of cultivating aquatic or marine organisms, aquaculture is carried out under widely differing geographic, climatic and sociological (cultural) conditions and many important concerns may thus have their validity limited to the specific conditions under which they arise.

The ACMP noted that the Working Group intended to address the following items in its future work: (a) to review ongoing research programmes on environmental issues related to mariculture; (b) to collate information on the use of chemicals for the preparation of a technical report to include (1) a directory of chemicals used within the various forms of mariculture, (2) quantities used within member countries, and (3) a synthesis of information on the environmental effects of these chemicals; and (c) to evaluate techniques and monitoring strategies and begin the preparation of a technical report on them.

The ACMP noted the request from the Helsinki Commission for advice on issues related to excessive nutrient inputs from fish farms and considered that, at the present time, the position is adequately covered by Cooperative Research Report No. 154, which clearly outlines the activities relevant to mariculture in which the recently established Working Group on Environmental Impacts of Mariculture is involved. In order to facilitate an adequate coverage of the specific questions asked by the Commission, the Helsinki Commission is invited to encourage representatives from member countries to participate in and contribute to the activities of the ICES Working Group at its 1989 meeting, since it is largely on the basis of the report of this Working Group that ACMP will be formulating its advice to the Commission. The presence of scientists from countries around the Baltic will ensure that the discussion on these topics is properly focussed.

10 ALGAL BLOOMS AND RELATED ISSUES

10.1 Report of the Working Group on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries

The draft report of the Working Group on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries was briefly considered by the ACMP.

For the purpose of timely exchange of information, the Working Group again encouraged ICES member countries to designate an appropriate national coordinating centre for information exchange on exceptional blooms, as requested by Council in C.Res.1985/4:22(a). The ACMP endorsed this proposal, noting the diverse interests of various groups in such information. Past experience shows that it is very important that only carefully balanced factual information is given, as the fish and shellfish trades are easily damaged by distorted "scare-stories". In addition, individual countries will need to demonstrate that they can protect their producers and customers. The Working Group had also stressed the need for an international data filing and information exchange centre, since the annual record of incidents of exceptional blooms in the archival journal Annales Biologiques has been discontinued with the demise of that journal.

The Working Group reported on improvements in various methods for the analysis of algal toxins in shellfish and finfish in the light of five basic criteria: reliability, acceptable costs, precision, sensitivity, and specificity.

For PSP (paralytic shellfish poisoning), further standardisation requirements for the mouse test were outlined and mention was made of the housefly bioassay. The latter procedure involves the injection of acidified tissue extract into the thorax of a housefly and subsequent observation of decreased mobility. This test is extremely fast, simple and requires only very small volumes of test media.

Uncertainties and sources of error in fluorometric methods for PSP analysis were also discussed. Regarding the available high pressure liquid chromatography (HPLC) methods, the Sullivan method appears to offer probably the greatest potential in a high-volume PSP regulatory programme (reasons: column specifically selected for longevity and tolerance to relatively impure shellfish samples; the separation of significant shellfish toxins is effected in a single injection; the mouse bioassay/HPLC comparisons have been successfully carried out).

With regard to DSP (diarrhetic shellfish poisoning), the techniques for determining total DSP toxicity and for detection and quantification of diarrhetic effects were briefly outlined. Details were provided on analytical methods and biological tests for the recently discovered toxin domoic acid, which caused a human health impact from farmed mussels of Prince Edward Island, east coast of Canada. Efforts are under way to develop screening and detection methods which will be specific and quantitative enough to be used by regulatory agencies.

The major current problems related to toxin and toxicity monitoring appear to be in the following areas: (1) sample handling, (2) bioassay procedures, and (3) chemical methods. Representative sampling (by weight or volume) and proper storage are important. It should also be noted that only highly skilled and experienced technicians can operate bioassay units with a precision sufficient enough to detect the effects of all toxins present.

A number of aspects relevant to the analytical techniques indicate particular constraints to a widespread application of the HPLC methods for PSP monitoring, the main problems being attributed to the limited availability of PSP standard toxins for calibration and a capital outlay on equipment that is beyond the capacity of many regulatory laboratories.

There is a need for intercalibration between the mouse bioassay and the analysis of PSP using the Sullivan HPLC method. It should also be noted that at present there are no immunological test kits in general usage in regulatory programmes, although several have reached the stage of prototype. Immunological methods are advantageous since they could be applied by field technicians and even shellfish producers themselves, at least as a preliminary screening procedure.

In the light of the report by the Working Group, the ACMP concluded that although fairly reliable HPLC methods for PSP and DSP are available, further reference materials for the commonly occurring PSP and DSP components are needed and it is hoped that they will become commercially available within a year. Hardware requirements in HPLC, however, are capital demanding and HPLC procedures are unlikely to be generally used for monitoring, but rather will serve as back-up confirmatory tools. Thus, bioassays will most likely continue to be the general methodological principle in monitoring and regulatory analytical operations. However, the routine use of experimental animals, especially mammals, in bioassays is likely to be drastically reduced by law enforcement in a number of countries within a few years. This dilemma may be solved by the introduction of immunoassays, for which further research is still required. Thus, ELISA immunoassay procedures for PSP and DSP (okadaic acid) have been developed and are at present being evaluated for reliability and specificity. If these methods prove reliable, this type of test would be the method of choice in monitoring for regulatory purposes, because the tests are easy to perform and large numbers of samples can be analysed at low cost.

With regard to management strategies for reducing the effects of harmful algal blooms on mariculture, emphasis should be placed on appropriate site selection (pre-siting management); on the importance of nutrients and light conditions on culture grounds; on the existence of shelf sea fronts (frontal boundaries could act as a source of harmful species); and on the flushing time of estuaries, water column stability and transport mechanisms. Post-siting management strategies depend mainly on a design of farm structures that would allow the movement of culture units away from the affected area.

The ACMP noted that several technical aspects on mitigating effects during the presence of a harmful plankton population had been evaluated by the Working Group. These included (a) pre-emptive harvesting, (b) movement of cultured stocks, and (c) in situ shielding of culture units. The first method will only be reasonably applicable if fish have reached a marketable size. The second suggested strategy is only applicable if the extent of the bloom is restricted in area so that waters free of the harmful species can be reached within a reasonable amount of time. A number of shielding techniques have been tried with varying degrees of success, including non-porous barriers (for example polythene sheets), bubble curtains (effectiveness doubtful), or injection of water free of the harmful species.

The Working Group identified a number of research priorities that were considered to be of major importance in understanding the problems associated with harmful effects on finfish and shellfish caused by phytoplankton. These relate to (1) effects of harmful phytoplankton species, (2) mitigating techniques, (3) predictability improvement, (4) toxicology and toxin analysis, and (5) general biology and ecophysiology of harmful phytoplankton species. Several multidisciplinary studies were identified which would involve the additional participation of meteorologists, hydrographers, and analytical chemists.

10.2 Report of the Intercomparison Exercise on Primary Production Measurements

Following Council Resolution 1986/2:34, an Intercomparison Exercise for the ^{14}C Incorporation Method of measuring Primary Production was carried out during 1987. The exercise was coordinated and organized by the Danish members of the Working Group on Primary Production (WGPP) (Dr K. Richardson, Danish Institute for Fisheries and Marine Research, Dr G. Ærtebjerg Nielsen, Marine Pollution Laboratory, and Dr L.M. Jensen, International Agency for ^{14}C Determination) and was divided into two parts.

In the first part, two types of filters, onto which a known concentration of ^{14}C-containing phytoplankton had been filtered, were distributed to 24 laboratories from 14 countries with instructions to determine the amount of ^{14}C associated with the filters using the normal procedures employed by each laboratory. At the same time, data from a "typical" North Sea station were circulated and the participants were asked to calculate primary production using their own calculation procedures. In this manner, it was possible to compare the counting and calculation procedures specific to the individual laboratories prior to the comparison of experimental procedures, which was carried out during the field exercises (Part II) of the intercomparison. These field exercises were conducted from 1-6 June 1987 onboard the R/V "Dana" (Danish Fisheries Ministry) and in the North Sea Centre Laboratories of the Danish Institute for Fisheries and Marine Research in Hirtshals, Denmark.

A number of different experiments were carried out both in Hirtshals and onboard the R/V "Dana". At the 1988 meeting of the Working Group on Primary Production, these experiments were grouped according to the type of information they yielded. The final statistical treatment of the data recommended by the Working Group had not yet been completed. However, the preliminary conclusions arrived at by the Working Group concerning the results were discussed by ACMP following a presentation by Dr K. Richardson, Chairman of the Working Group.

The results of the exercise show that coefficients of variation were as high as 50% for some of the intercomparison experiments carried out. This is not surprising, however, given the number of steps in the procedure and the lack of a standard method used by the participants. Formal recommendations for a standard method, as well as guidelines for archiving data, will be forthcoming from the WGPP. The recommendations will specify the preferred procedures to be followed, rather than providing a number of options, which is the case for the present ICES method for measuring primary production (published in ICES Techniques in Marine Environmental Sciences No.5).

The findings of this intercalibration tend to suggest that there are two main stages at which variability can be introduced in the calculation of productivity. These are the various steps of the actual measurement procedure and the subsequent assumptions and algorithms used to produce an answer in g C/m^2/day. Pending agreement on standard procedures to be used by all workers, this conclusion, if confirmed, tends to suggest that any central banking should be of the basic results obtained. This would allow individual workers to calculate their own g C/m^2/day values according to their own assumptions and eliminate this source of variability in data to be held in data storage centres.

It is planned that the full report of the intercomparison exercise will be published in the Cooperative Research Report series. In addition, selected aspects of the study will be published in the primary literature. The ACMP commended the WGPP, and its Chairman, K. Richardson, on the excellent work done in carrying out this study and the timeliness with which the results are being made available to the ICES community.

Clearly, there is a need for considerable further work on this topic. The results of this intercomparison exercise have shown a perhaps hitherto unexpected need for a standard method. Until such a method has been agreed upon and is in general use, it will not be possible to utilise results collected by different laboratories, or perhaps even by the same laboratory at different times, to assess whether there have been changes in primary productivity in either spatial or temporal terms. Since it is known that the Helsinki, Oslo and Paris Commissions are considering the relationship between nutrient inputs and algal production in estuaries and coastal waters, the ACMP particularly wishes to draw to their attention the findings of this report on the intercomparison exercise on primary production measurements.

10.3 Chrysochromulina polylepis Incident

Short presentations were made to ACMP about the reactions in Scandinavia to the bloom of *Chrysochromulina polylepis* in spring 1988 and some immediate indications as to how to improve responses to similar future incidents. This event was still underway when discussed by the ACMP.

It was noted that in Norway, a single official expert group had been made responsible for gathering information and processing it prior to disseminating it to the aquaculture industry, authorities, and the media. This group had direct contacts to obtain meteorological information, remote sensing information, reports from international fisheries and pollution control authorities, and reports about algal numbers from research vessels and shore-based laboratories. The group also was able to direct monitoring activities by the research vessels on the basis of previously developed models for the hydrography of the Norwegian coastal current.

The proper taxonomic identification of the algae in question was crucial to obtaining proper quantification where the Chrysochro mulina polylepis algal blooms coexisted with large numbers of other algae. In this context, a very important limiting resource was the number of persons able to identify and count the algae in question.

A large number of fortunate coincidences had made a rapid and effective response possible. However, it is clear that some mechanisms need to be put into place to reduce reliance on luck in future occasions. These include:

1) the development of mechanisms for assembling an official expert group and making research vessels from various agencies available;

2) establishing routine communication lines for the gathering and dissemination of information by the official expert group;

3) establishing kits of needed materials and instruments (microscopes, filtering and counting apparatus); and

4) establishing a roster of scientists able and willing to be mobilized.

In Denmark, although the press carried headlines about the plague of "killer algae", only small areas in the Western Kattegat (where the water is shallow) were adversely affected by the bloom. The alga, however, was shown to be present in large concentrations at the pycnocline over the entire Kattegat and parts of the Skagerrak. The presence of the organism, which is not unusual in the southern Kattegat, was first observed in mid-April 1988. Aquaculture operations along the Swedish coast (and thereafter the Norwegian coast) were first affected in mid-May. It is believed that the organism "bloomed" first at the pycnocline and was, via hydrographic processes, later mixed into coastal waters near Sweden and Norway and into the shallow waters of the Western Kattegat. This alga had an apparently noxious effect on many marine organisms. In areas where the algae became mixed into the water column so that other organisms could not avoid contact with it, "kills" resulted. Danish scientists believe that there are parallels in the pattern of the Crysochromulina bloom development and previous blooms of Gyrodinium aureolum and stress the importance of international efforts to elucidate the interaction between hydrography and plankton development in the Skagerrak/Kattegat in order to obtain better understanding of the bloom phenomenon.

The ACMP agreed that, in future, research should be directed at elucidation of the autecology of important bloom algae and an increased interest in algal taxonomy should be stimulated. The ecological principles behind algal blooms, both noxious and productive, should be given increased attention. Methods for mathematical modelling of biological systems and handling of multivariate data seem to have advanced to the point where they can contribute to the understanding of algal blooms and real advances may be possible.

The ACMP noted that the topic of the research to be conducted to understand the ecology of algal blooms and the ICES mechanisms to promote such research will be discussed at the 1988 Statutory Meeting.

10.4 GESAMP Working Group on Nutrients and Eutrophication in the Marine Environment

The ACMP noted that the report of the GESAMP Working Group on Nutrients and Eutrophication in the Marine Environment covered many examples from the ICES area. These examples were discussed together with the parts of the text which form the general discussion and conclusions. The ACMP found that the report was in general thorough, well-balanced, objective, and thus an extremely useful account of the subject. The ACMP felt that it goes a long way to meeting the need expressed in Recommendation 1 of the report of the Study Group on Ecology of Algal Blooms, i.e., "that an International Working Group be established with the specific tasks (a) to identify, collect, and re-examine available long-term data series in order to judge their usefulness and (b) to determine what is needed . . . for long-term . . . monitoring efforts".

It was also noted that the conclusions did not support many of the wilder statements that have been made by both scientists and the popular press in relation to algal blooms and that a considerable amount of careful work was still necessary before definitive statements can be substantiated. There is no doubt that algal blooms are a natural event, it is their scale and the effects sometimes associated with them that give cause for concern. The extent to which they are apparently more frequent and of greater scale is unclear. Environmental conditions, which may or may not be changing, and which in turn play a role in addition to nutrient inputs alone are, however, likely to be important in triggering the initial bloom. It is also worth noting that, in some instances, blooms of certain species, e.g., nitrogen-fixing, can occur under conditions with abnormally low concentrations of nitrogen. Nevertheless, recognizing the concerns and interests that exist in both the Paris and Helsinki Commissions in relation to nutrients, the ACMP recommends that these organizations take account of the GESAMP Working Group findings.

11 ISSUES RELATED TO THE MEASUREMENT OF NUTRIENTS

11.1 Report on Nutrient Trends in the Oslo and Paris Commissions Area

The ACMP reviewed progress in nutrient trend analyses from two main sources: first, a preliminary analysis of winter nitrate data from the Western North Sea since 1960 (Dickson *et al.*, 1988) and second, a French report entitled "Monitoring of Nutrients: Interpretation of Ten Years' Monitoring and Changes in Sampling Procedures".

The analysis in the first paper began by stressing the two main obstacles to nutrient trend analysis: (i) the continuing uncertainty surrounding the general quality of nutrient data available in data centres, particularly those data that were not specifically collected for the purpose of trend analysis, and (ii) the fact that only a very small percentage (~ 9%) of the data collected in the North Sea have ever been returned to regional data centres such as the Service Hydrographique. Thus, the first point raised by this report and endorsed by ACMP concerned the need to support current initiatives within the Marine Chemistry Working Group and the Hydrography Committee to assess the quality of nutrient data via the conduct of intercalibration exercises (see Section 11.3, below) and to encourage a fuller return of historical data by a range of direct and indirect means.

The ACMP also supported the view in the analysis of the Western North Sea data that, in seeking to identify an anthropogenic contribution to North Sea nutrient concentrations, the presence or absence of a correlation between the trend of nitrate in rivers and in offshore waters is not likely to be very decisive. The nitrate concentrations in rivers represent only the gross amounts, whereas the sea only receives the net input after denitrification processes in estuaries have been at work. We know little of the rate of denitrification in the individual estuaries other than the fact that its effect can be very large. Up to 70% of the nitrogen load of the Scheldt, for example, is removed in the estuary and, since the denitrification rate is a function of organic loading and degree of anoxia, it is paradoxical that efforts to clean up the Scheldt would, in all probability, lead to an increased nitrogen transfer to the North Sea.

Despite the undoubted deficiencies in the available data set, the analysis of the Western North Sea data does provide a first indication that a common trend of nitrate variation with time appears to characterize the waters of the Western North Sea since 1960, and this trend does not appear to resemble either the trends in nitrate loadings of UK rivers, or the trend reported for the coastal zone of the German Bight by Radach and Berg (1986).

The ACMP endorsed the value of extending this type of analysis to other areas of the European shelf, especially if the present data deficiencies can be overcome, since it recognized that the extent of any regional trend might usefully shed light on whether the cause was likely to be "natural" or anthropogenic.

The French report provided an analysis of the seasonal and interannual variations of nutrient concentrations at five sites around the coast of France from the Gironde to Dunkirk over the period 1975-1984. Although the 10-year monitoring programme had measured a range of nutrients, the aspects of the report which dealt with trend analysis were once again restricted to the temporal variations in winter nitrate concentrations. Though the trends described were similar at all five sites and bore a qualitative resemblance to the trends described for the Western North Sea, the different definition of "winter" and the different techniques employed to normalize the data for geographical and temporal variations in salinity in the two studies prevented any meaningful comparison of results.

It was noted that the type of analysis presented in the French report is identical to that employed in the ICES Secretariat as part of its procedures for quality control of nutrient data, including those data collected during the February International Young Fish Survey. The Secretariat has found this technique to be useful for detecting small differences in nutrient levels due either to analytical differences or to temporal/spatial variations. The technique is most useful for data sets containing mainly data obtained at various stations, i.e., on cruises, rather than data sets comprising mainly data from fixed monitoring positions.

For reasons outlined above, the ACMP recommended that the data from the two studies should be re-analysed on a common basis so that the results of the trend analyses could be more directly compared.

The ICES Hydrographer, Dr H. Dooley, also reported on the discussion on nutrient trend analyses that had recently taken place at the meeting of the Working Group on Shelf Seas Oceanography. That discussion had centered on the question of whether nutrient data quality in the complex hydrographic region of the Southern North Sea was adequate to permit a precise identification of the appropriate nitrate vs. salinity regression (and hence the nitrate trend analysis) that applied in those waters. In view of these uncertainties, the Shelf Seas Oceanography Working Group had commended the Norwegian coastal zone as the site that was likely to provide the least ambiguous indication of nutrient trends, since nitrate concentrations there appear to be independent of salinity over a wide salinity range.

While the ACMP accepted this viewpoint as valid, it pointed out that the potential problems regarding the anthropogenic input of nutrients lay in the Southern North Sea, where the river inputs were large and the receiving volumes were small. Even if nutrient trends could be identified less ambiguously off the Norwegian coast, it would be impossible to identify any remote source of the trend since waters of the Norwegian coastal zone might come from any part of the North Sea or, indeed, the Baltic Sea. The ACMP, therefore, reiterated its support for extending trend analysis for nutrients as widely as practicable on the shelf while seeking to maximize the data set on which these analyses would be based.

Noting the various activities in progress and the problems that need to be resolved, the ACMP concluded that, while the present interim status of trend analysis should be reported, as requested, to the Oslo and Paris Commissions in June 1988, a final report should not be expected before 1991 or 1992.

11.2 Consideration of Nutrient Data Quality

The ACMP noted that the current international debate on hypernutrification and eutrophication issues has meant that questions of nutrient data quality retain their importance.

The ACMP strongly supported the nutrient intercalibration exercise being planned by the Marine Chemistry Working Group (MCWG) (Section 11.3, below). However, it also recognised that data quality and data quantity were to some extent inter-related, since it is from the comparison of data sets returned to him that the Hydrographer obtains his most direct insight as to their general quality, and at present the data return has often been inadequate to make this assessment. Thus, any and all measures that would improve the present poor return of data would meet with ACMP support.

The ACMP noted the Hydrographer's view that the nutrient data set arising from the International Young Fish Surveys of the North Sea was potentially the most valuable sub-set of data for many purposes since it covered the entire North Sea each year and at a time of the year (February) when production would not have made serious inroads into the winter nutrient maximum. Thus, present attempts to intercalibrate these data, assess the effects of sample storage, and encourage a full exchange and return of data from these surveys are especially to be encouraged.

11.3 Intercalibration of Nutrient Measurements

The ACMP was informed that, on the basis of (1) the results of the questionnaire distributed by MCWG in 1986/1987 to assess the need for an intercalibration exercise for nutrient measurements, (2) the outcome of the nutrient intercalibrations in the Joint International Multi-Ship Investigation of Patchiness in the Baltic Sea (PEX) exercise, and (3) the results from the intersessional work by UK and Norwegian laboratories, which included an informal workshop at Aberdeen in November 1987, the MCWG had drawn up plans for a broad-based ICES intercalibration exercise on nutrient measurements.

The ACMP was informed that intersessional work by members of the MCWG had addressed stability of seawater samples for the proposed intercalibration exercise. Sea water had been collected off Greenland during a MAFF cruise on R/V "Cirolana" in June 1987 and, following analysis on board (for nitrate and phosphate), the samples had been stored for later analyses by a number of laboratories (see Tables 1-4). This mini-intercomparison exercise had involved three ICES laboratories who had examined the samples after 3-4 months of storage and had obtained comparable results to those obtained at sea. This success had persuaded the MCWG that it could conduct an intercalibration exercise for a greater number of laboratories.

Details of the proposed exercise are as follows:

a) The exercise will be coordinated by D. Kirkwood, assisted by M. Perttilä and A. Aminot.

b) The anticipated determinands, assuming that stability is confirmed, should include nitrate, nitrite, phosphate, silicate, ammonia, total P and total N.

c) The samples to be used would be based on sea water collected off Greenland at a depth of 1200 m and, subject to stability tests, estuarine and coastal water samples covering an appropriate concentration range.

d) Some laboratories have been approached by the coordinators in April-June 1988 to indicate their willingness to participate and to supply details of their analytical methods. To date, 35 laboratories from 18 countries have agreed to participate in this exercise. After approval by Council in October 1988, all ICES member countries will be invited to participate in this intercalibration exercise. In addition, given the interest of the Oslo and Paris Commissions and the Helsinki Commission in this exercise, they will be invited to nominate laboratories to participate.

e) Following the collection of the water samples and a limited distribution to assess their stability, the coordinators are planning to distribute samples to all participants in Spring 1989 with a request for analyses to be completed and reported by Summer 1989.

f) A preliminary report on the results of this exercise will be presented at the 1989 ICES Statutory Meeting and a full report will be available for the 1990 MCWG meeting.

The ACMP noted that an important component of the proposal was the assessment of the stability of samples prior to their distribution in Spring 1989 and assumed that the exercise would only go ahead if this component was successful. In conclusion, the ACMP welcomed the response it had received from the MCWG and looked forward to receiving a progress report at its next meeting.

References

Dickson, R.R., Kirkwood, D.S., Topping, G., van Bennekom, A.J., and Schreurs, W. 1988. A preliminary trend analysis for nitrate in the North Sea west of 3^{0} E. Doc. ICES C.M. 1988/C:4.

Radach, G. and Berg, J. 1986. Trends in den Konzentrationen der nahrstoffe und des Phytophanktons in der Helgolander Bucht (Helgolander Reede Daten). Ber. Biol. Aust. helgoland, 2:1-63.

<u>Table 1</u> Results of routine determinations at $63^0$33.14N, $36^0$24.34W.

Depth	Temperature	Salinity	Oxygen	Phosphate	Nitrate	Nitrite	Silicate
100*	-	34.928	6.96	1.00	13.9	0.34	8.8
400	4.21	34.901	6.80	1.08	16.5	0.02	10.6
600*	-	34.899	6.65	1.10	16.7	<0.02	11.2
800	3.70	34.891	6.54	1.12	16.8	<0.02	11.7
1000*	-	34.874	6.68	1.10	16.9	<0.02	11.7
1200	3.36	34.886	6.67	1.09	16.6	<0.02	11.8
1300	-	34.899	6.62	1.09	16.8	<0.02	12.1
1400*	3.32	34.917	6.44	1.09	16.8	<0.02	12.5
1500	-	34.935	6.41	1.09	16.8	<0.02	13.9
1700	3.03	34.934	6.42	1.09	16.6	<0.02	14.5
1800*	-	34.894	6.76	0.99	15.2	<0.02	11.1

*Identifies samples retained for further studies.
Nutrients in µMol/l.
Salinity in PSS.
Oxygen (ml/l) determined by Winkler method.

<u>Table 2</u> Results of phosphate determinations on retained (*) samples.

Samples	Depth	-----(Six samples	from each	depth)-----				Mean	rsd
25-30	100	0.99	1.00	1.00	1.01	0.99	1.00	0.998	<1.0%
19-24	600	1.08	1.09	1.08	1.09	1.08	1.08	1.083	"
13-18	1000	1.10	1.10	1.10	1.10	1.10	1.09	1.098	"
7-12	1400	1.08	1.09	1.08	1.08	1.09	1.08	1.083	"
1- 6	1800	0.99	0.99	0.98	0.99	0.98	0.99	0.988	"

(Lowestoft Auto-Analyser on R/V "Cirolana", 27 June 1987)

Results of phosphate and nitrate determinations at various times and places

Table 3 Phosphate μMol/l

	27/06 Lo*	10/09 Lo	06/10 LoB	12/10 Be	31/10 Be	18/11 Be*	18/11 Lo**	18/11 Ab	31/12 Lo
25	0.99	1.01	1.05				1.08	1.07	1.02
27	1.00	1.00	1.01	1.05	1.09	!			
29	0.99	1.15	1.14				1.18	1.18	1.09
19	1.08	1.05	1.05				1.12	1.09	1.05
21	1.08	1.05	1.07	1.08	1.08	1.17			
23	1.08	1.05	1.06				1.18	1.09	1.03
13	1.10	1.03	1.04				1.12	1.07	1.05
15	1.10	1.07	1.06	1.10	1.12	!			
17	1.10	1.03	1.04				1.10	1.10	1.04
7	1.08	1.05	1.06				1.12	1.07	1.03
9	1.08	1.03	1.05	1.09	1.08	!			
11	1.09	1.02	1.01				1.08	1.05	1.04
1	0.99	0.93	0.89				0.97	0.98	0.88
3	0.98	0.96	0.92	0.92	0.94	0.81			
5	0.98	0.90	0.90				0.95	0.90	0.88

Table 4 Nitrate μMol/l

	12/10 Be	19/10 Lo	31/10 Be	18/11 Be*	19/11 Ab	30/12 Lo	09/03 Mi	15/04 Mi
25		13.0			13.0	13.7	13.6	13.2
27	14.0		12.7	!				
29		13.0			13.0	13.5	14.3	13.4
19		15.7			16.8	16.5	17.2	16.7
21	n.d		15.3	14.3				
23		15.8			17.6	16.8	17.0	16.2
13		15.6			16.9	16.4	17.2	16.3
15	n.d.		15.7	!				
17		15.7			16.8	16.7	16.8	16.1
7		15.4			16.8	16.2	16.4	15.9
9	16.2		15.3	!				
11		15.4			16.4	16.2	16.6	16.1
1		14.0			14.5	13.8	14.7	14.1
3	14.5		14.3	12.5				
5		13.7			14.0	14.0	15.1	14.7

!These samples were 'lost at sea' sometime between 10 and 18/11.
Lo = Lowestoft, Be = Bergen, Ab = Aberdeen, Mi = Middelburg,
Br = Brest (in own laboratory).
Lo* = in North Atlantic on R/V "Cirolana".
LoB = at Lowestoft with Bergen participation.
Be* = in Aberdeen harbour on R/V "G.O. Sars".
Lo** = Lowestoft Auto-Analyser at Marine Laboratory, Aberdeen.
n.d. = not determined.

12 INTERCALIBRATION AND QUALITY ASSURANCE ISSUES

12.1 Intercomparison of Analyses of Polycyclic Aromatic Hydrocarbons

The ACMP was informed that, due to instrumental problems in the laboratory of the coordinator, Mr R. Law, the first phase of the Intercomparison Programme on the Analysis of Polycyclic Aromatic Hydrocarbons (PAHs) will not commence until July 1988. The exercise will start with the distribution of solutions of selected PAHs, following validation of these samples in the laboratory of the coordinator. Participants will be requested to report the results of their analyses by October 1988 so that a report on the first phase can be prepared for submission to the Marine Chemistry Working Group (MCWG) in February 1989. Assuming that the first phase is successful, the second phase will be planned at that meeting. Eighteen laboratories from ten ICES countries are participating in this exercise. The ACMP noted that the MCWG had discussed the matrices to be considered for the later phases of this exercise and had identified mussels/oysters, suspended particulate matter, and sediments as being of interest. The consensus among MCWG members was that the effort should focus on biological tissue and, in this respect, the second phase should consist of an extract of biological tissue.

The ACMP looked forward to reviewing the results of the first phase of this exercise at its 1989 meeting.

12.2 Intercomparison of Chlorobiphenyl (CB) Measurements and Selection of CBs

The ACMP was informed that the MCWG had produced detailed plans for part I of the Intercomparison Programme on Analyses of Individual Chlorobiphenyls, which will be jointly coordinated by ICES and IOC (Dr J. de Boer and Dr J. Duinker, respectively). This exercise has been intended for laboratories determining PCBs/CBs in marine mammals tissues, but it is equally relevant for laboratories determining CBs in fish and shellfish tissues, and sediments. The exercise as a whole will follow the three-step plan outlined in Section 13 of the 1986 ACMP report (Cooperative Research Report No. 142). The ACMP noted the following details about this exercise.

The coordinators have taken due account of advice on the statistical design of the exercise received from the Working Group on the Statistical Aspects of Trend Monitoring.

The selection of CBs had been based on the following criteria:

a) Toxicity concerns (e.g., to mammals);

b) Environmental occurrence;

c) Analytical capability. Either the CBs yield single, resolvable peaks, or have been specifically chosen to give a test of column resolving power and to resolve controversies on analytical capabilities; and

d) Pure, certified reference CBs are readily available.

The CBs chosen were IUPAC Nos. 28, 31, 52, 101, 105, 118, 138, 153, 180, 189. These can be compared to the list of congeners previously selected by ICES, BCR, IOC, and the U.S. National Oceanic and Atmospheric Administration for the sediment intercalibration exercise (see Table 1). Information on the known toxicity characteristics of some CBs is also given in this Table.

TABLE 1

IUPAC No.	BCR	ICES1	ICES2	IOC	Sediment I/C	Toxicity+	Selection by MCWG
8					X		
18			X	X	X		
26				X			
28	X	X			X		X
31			X				X
44			X	X	X		
49			X	X			
52	X	X		X	X		X
66			X		X		
77					X	X	
95			X				
101	X	X		X	X		X
105					X	X	X
118	X	X		X	X	X	X
126					X	X	
128				X	X	X	
138	X	X		X	X	X	X
149			X	X			
151				X			
153	X	X			X		X
156						X	
169						X	
170				X	X	X	
180	X	X		X	X		X
183				X			
187			X	X	X		
189							X
194				X			
195					X		
206					X		
209					X		

+Affinity for (aryl hydrocarbon) AH-receptor (3-methyl cholanthrene and mixed-type MFO-induction).

ICES 1 - ICES primary list of CBs.
ICES 2 - ICES secondary list of CBs.

In Table 2, possible interferences in the GC-ECD analyses are indicated on the basis of the chromatographic properties of all 209 congeners on an SE-54 column and multidimensional GC-ECD on an SE-54 column.

TABLE 2

List of congeners selected

IUPAC No.	Possible interference
28	31, 50
31	28, 50
52	-
101	90
105	153, 132
118	149, 123
138	163, 160
153	132, 105
180	-
189	-

Individual CBs will be used to prepare standard solutions for circulation to the participants. A synthetic mixture in which the selected CBs are present, as well as some other possibly interfering CBs, will also be distributed.

The use of the stationary phase SE-54 will be mandatory for both the ICES and IOC laboratories; ICES laboratories should also use a second confirmatory column.

At the request of the MCWG, the Working Group on the Statistical Aspects of Trend Monitoring has provided statistical assistance in the planning of the exercise and will assist with the interpretative stage of the exercise.

Although this exercise was originally intended for laboratories analyzing organochlorines in tissues of marine mammals, as a first stage intercomparison exercise to assess analytical capabilities using standard solutions, this is an opportunity to broaden the participation by including laboratories involved in fish and shellfish monitoring programmes, and laboratories carrying out sediment analyses. Depending on the results of the first stage, subsequent stages would probably be conducted separately for each matrix.

The Oslo and Paris Commissions have accepted an invitation to join this first step exercise on a cost-sharing basis. Accordingly, laboratories analyzing for CBs in sediments (including dredged material) and fish and shellfish under the Commissions' programmes will be participating in this exercise.

As this is to be a stepwise collaborative exercise, it will be made clear to laboratories that a firm commitment to the programme must be made and it is unlikely to be possible for other laboratories to join the exercise for the later stages only. Experience from exercises under the European Community's Bureau of Community References (BCR) and other similar exercises will be incorporated; good communications and feed-back to laboratories will be essential.

Following preparatory work by the coordinators and contacts established with potential participants by August 1988, it is expected that the exercise will commence in September 1988 with the distribution of samples to laboratories. The deadline for the receipt of results has been established as December 1988 so that a preliminary report can be submitted to MCWG in February 1989.

The ACMP welcomed and endorsed these proposals of MCWG and looked forward to receiving a progress report on the exercise at its next meeting.

12.3 Intercomparison Study of PCBs in Herring Oil

The ACMP noted that the "Report on an Intercomparison Study of the Determination of Polychlorinated Biphenyls (PCBs) Isomerids in Baltic Herring Oil" (6/OC/BT), by L. Reutergårdh and K. Litzén had been completed some time ago, but had not yet been published. It therefore endorsed the MCWG recommendation that this report be published in the Cooperative Research Report series.

12.4 Intercomparison Exercise on Methyl Mercury in Biological Tissue

The ACMP was informed that a report on the results of the Intercomparison Exercise on Analyses of Methyl Mercury in Biological Tissue (1/CH_3Hg/BT), coordinated by Dr D Cossa, had been presented at the 1988 meeting of MCWG. This exercise had been carried out in 1987; participation had been restricted to laboratories that had prior experience with the analysis of methyl mercury.

The ACMP noted that the exercise had been based on two sample matrices that had been provided by the National Research Council of Canada, out of the remaining stock of the ICES 7/TM/BT exercise. Sample E consisted of dogfish muscle and sample H consisted of the soft tissue of blue mussel. Twenty sets of samples had been distributed in August 1987 and by February 1988 the results from 13 participants had been received.

In addition to reporting results for measurements of methyl mercury (some measured organic mercury), participants reported results for total mercury. The overall means for total mercury for the two samples E and H were 1.99 $\pm$ 0.21 µg/g and 0.18 $\pm$ 0.03 µg/g, respectively; these were very similar to the consensus values reported in 7/TM/BT, i.e., 1.95 $\pm$ 0.38 µg/g and 0.17 $\pm$ 0.04 µg/g, respectively.

The consensus values for methyl mercury for the two samples E and H were 1.04 $\pm$ 0.22 µg/g and 0.056 $\pm$ 0.014 µg/g, respectively; these represented coefficients of variation of 21% and 26%, respectively.

The ACMP concurred with the MCWG conclusion that the exercise had shown that methyl mercury intercomparisons can be conducted for biological tissue and that a good level of performance had been achieved by all participants. This exercise, therefore, represents a significant advance in the ICES intercomparison programme, i.e., it was the first intercomparison for analyses of organo-mercury in biological tissue and showed what could be achieved by cooperation between analysts experienced in a particular technique. The ACMP further noted that, although some laboratories had specifically measured methyl mercury and others had measured total organic mercury, no differences between the results of the application of these different techniques had been observed.

The ACMP noted that there were no proposals for a repeat exercise in the near future and accordingly advises any other laboratories interested in assessing their analytical performance for the measurement of methyl mercury in biological tissue to contact one of the participants to arrange a bilateral intercomparison exercise.

The ACMP recommended that, subject to minor editing, the report on the results of this exercise be approved for publication in the ICES Cooperative Research Report series.

12.5 Overview on the Results of Intercalibration Exercises for Trace Metals in Sediments

The ACMP reviewed an analysis, prepared by Dr S. Berman and approved by the Working Group on Marine Sediments in Relation to Pollution (WGMS), of the results from three different intercalibration exercises on trace metals in marine sediments, in which there had been some commonality of samples used.

The three samples used in the ICES Intercalibration Exercise for Trace Metals in Marine Sediments (1/TM/MS) had also been used in three other independent intercalibration exercises conducted, respectively, by the Joint Monitoring Group, the National Research Council of Canada, and the former ICES/SCOR Working Group on the Study of Pollution of the Baltic. It was thought that further information might be gathered from a study of the combined results of all four intercalibrations. However, after a preliminary examination of the results of the JMG intercalibration with the results of ICES 1/TM/MS for sample ICEMS-A, it was concluded that the two samples were probably not the same.

One sample (ICEMS-B) had been used in a 1984 domestic Canadian intercalibration exercise, with results being obtained from 41 laboratories. The means, after exclusion of outliers, for six elements (Cr, Cu, Zn, Cd, Hg, and Pb) obtained from the Canadian and ICES exercises were statistically identical for all the metals except mercury. The ICES exercise appeared to produce two sets of mercury results for ICEMS-B, a low set and a high set. The mean for mercury of the high set was indistinguishable from the excluded mean produced by the Canadians.

It would appear that 9 out of 18 laboratories that analyzed mercury in ICES 1/TM/MS had serious problems with the mercury procedure recommended for this exercise (see Cooperative Research Report No. 143). On the other hand, 19 out of 21 Canadian laboratories submitted good results for mercury, with an interlaboratory relative standard deviation (RSD) of 13%. There had not been a recommended procedure for mercury analysis in the Canadian exercise. The ACMP felt that it was possible that the poor results obtained for mercury during ICES 1/TM/MS by many participants was because they had been using a recommended method new to most of the participants. A similar observation had been made during the JMG intercalibration exercise, where the results obtained with an imposed procedure were much more scattered than those obtained from laboratories using their usually applied methods, despite the diversity of the latter procedures.

In the light of these findings, the ACMP suggests for further intercalibrations either that only very simple analytical procedures should be made mandatory or that, in addition to a common relatively sophisticated recommended method, the participants should be requested to apply their normal procedure.

Differences between the results of the ICES and the Baltic exercises (ICEMS-C/MBSS samples) were somewhat more difficult to interpret. An excluded mean was calculated for each set using a t-test criterion for the rejection of outliers. These means were then compared statistically using a null hypothesis at the 95% confidence level.

The results are shown in Table 3. The uncertainties are standard deviations. The number in parentheses is the number of results reported by the laboratories. The mean values obtained for Cr, Mn, Fe, Ni and Cu in the Baltic exercise are significantly lower than those from ICES 1/TM/MS. However, it should be noted that while all the results for ICEMS-C are from material digested using hydrofluoric acid (HF) (except for Hg), only a minority of the Baltic exercise laboratories used HF. Due to the wide variety of procedures used for 'total' analyses in the Baltic exercise, no correlation could be found between various procedures used to digest the samples or determine the metals.

Two possible conclusions can be drawn, either that the two subsamples are not identical or that samples not digested with HF have yielded lower trace metal values than samples digested by procedures that include HF. The coordinator of the Baltic Sediment Intercalibration Exercises (Dr L. Brügmann) described the precautions taken in the preparation and packaging of MBSS samples and, in the light of this explanation, it was felt that the latter conclusion is more likely.

In reviewing the results given in Table 3, the ACMP considered that, rather than contamination problems being responsible, very often the reason for unreliable, non-comparable results of the determination of the trace metal concentrations in sediments using different analytical procedures could be the low recovery of certain metals using some extraction methods relative to the recovery using total digestion procedures.

The values quoted in Table 3 for ICEMS-C may be used as consensus values for total metals in Sample MBSS.

TABLE 3

	ICEMS-C				MBSS				Same
Al	5.22	± 0.48	%	(10)	5.14	± 0.73	%	(6)	Yes
Cr	70	± 12	ppm	(18)	42	± 12	ppm	(18)	No
Mn	418	± 22	ppm	(11)	378	± 33	ppm	(24)	No
Fe	3.28	± 0.19	%	(13)	2.95	± 0.43	%	(25)	No
Ni	31	± 4	ppm	(14)	25	± 4	ppm	(21)	No
Cu	32	± 4	ppm	(23)	28	± 1	ppm	(19)	No
Zn	156	± 9	ppm	(21)	149	± 7	ppm	(25)	Yes
Cd	0.54	± 0.13	ppm	(16)	0.60	± 0.23	ppm	(20)	Yes
Hg	0.093	± 0.026	ppm	(13)	0.080	± 0.021	ppm	(15)	Yes
Pb	53	± 10	ppm	(20)	55	± 2	ppm	(21)	Yes

12.6 Video on Analysis of Metals in Sediments

The ACMP considered a video tape prepared by Dr D. Loring and R. Rantala, together with an explanatory text, that have been recommended for publication in the ICES series Techniques in Marine Environmental Sciences. The video tape shows the detailed procedures for 'total' digestion of sediment samples using HF plus aqua regia in a Teflon 'bomb', and procedures for the partial extraction of sediments using acetic acid, including the subsequent analysis of metals in the resulting solutions by flame and flameless atomic absorption spectroscopy. The ACMP endorsed the recommendation of the Working Group on Marine Sediments in Relation to Pollution (WGMS) that ICES consider the possibility of publishing video tape presentations of techniques, together with written texts, in the Techniques in Marine Environmental Sciences series.

12.7 Analysis of Total Organochlorines

The ACMP was informed that the MCWG had considered a request from the Helsinki Commission on the applicability of measurements of total organic chlorine for the purpose of establishing standards, and for compliance monitoring of discharges of wastes containing organochlorines, with particular reference to effluents from paper and pulp mills.

The ACMP agreed with the MCWG conclusions that any one of a number of such procedures could be recommended as a suitable approach for screening effluent discharges from paper and pulp mills, provided that the composition of the effluent remained essentially unchanged with time. However, total reliance on this procedure would be unwarranted, since it does not provide any insight as to the nature and quantity of individual halogenated compounds in the waste discharges or the toxicity of the waste, both of which might vary with time. If some assessment of the toxicity of the wastes were required by the Helsinki Commission, the ACMP recommended that the wastes should also be screened using toxicity tests. Finally, it should be stressed that measurements of total organic chlorine will not provide data of much value in the context of assessing the incidence and distribution of organochlorine compounds in the receiving environment. Thus, any reliance on total organic chlorine for compliance or surveillance monitoring of industrial plant discharges should be combined with periodic detailed analyses of effluent composition, from which more reliable estimates of chemical influences on the receiving environment can be made.

12.8 Quality Assurance and Reference Materials

The ACMP was informed that the MCWG had prepared at its last meeting an update of its 1987 paper on quality assurance in relation to the measurement of trace metals in marine samples. The revised version, given below, reflects the current views on such matters as the role of intercalibration exercises, good laboratory practice, and the need for, and role of, the different types of reference materials.

Intercalibration exercises

There have been, to date, 15 intercalibration exercises sponsored by ICES for trace metals in marine samples; eight related to biological materials, six to marine waters, and one to marine sediments. Although discouraging in the early exercises, the results of the later exercises have shown marked improvements in the abilities of many ICES, JMP, and BMP laboratories to analyse marine samples for trace metals. This is a result of two factors: (1) the general improvement in analytical chemistry technology over the last decade, whereby instrumentation and procedures are now available that permit trace metals to be readily and reliably determined at environmental levels, and (2) the fact that many marine laboratories, aware of these developments, have upgraded their facilities, techniques and personnel in order to improve their performance. However, there remains a significant number of laboratories which have not demonstrated an ability to analyse trace metals in marine samples at the levels necessary for monitoring purposes.

Intercalibration exercises are invaluable in focusing attention on analytical problems and providing a means of assessing performance, improvements and intercomparability. However, it must be remembered that the exercises for biological tissue and sediments to date are only valid with respect to sample digestion and/or metal measurement procedures. The sampling, sample preparation and preservation procedures applied by the laboratories have never been assessed. These steps add to the variance of the overall data, but a study to adequately intercompare laboratories for the complete process has yet to be devised.

Intercalibration exercises will have to be conducted in the future for ICES, JMP, and BMP laboratories, but not necessarily with the same frequency as in the past. Furthermore, exercises on the scale of 7/TM/BT, 6/TM/SW, or 1/TM/MS will not be possible without significant financial support. For the forseeable future, efforts should be devoted to ensuring that laboratories adopt quality assurance (QA) procedures and good laboratory practices (GLP) whereby they can demonstrate, both to themselves and the monitoring agencies, through the use of various reference materials and some very elementary statistics, that their analyses are accurate and under statistical control. The information in the recent ICES publication on GLP and QA (Vijverberg and Cofino, Techniques in Marine Environmental Sciences, No. 6 (1987)) can be used to establish such procedures.

Reference Materials

The role of reference materials within QA and GLP is well established (Vijverberg and Cofino, op. cit.). There is now available a range of certified reference materials covering various concentrations of trace metals in marine biological tissues, waters and sediments (details of these materials can be found in Annex IV of the first report of the IOC/IAEA/UNEP Group of Experts on Standards and Reference Materials for Marine Chemistry or in "Standards and Reference Materials for Marine Science", prepared by the U.S. National Oceanic and Atmospheric Administration, Dept. of Commerce, Rockville, Maryland, USA). More materials are in production and work is in progress to produce reference materials which resemble more closely the samples analysed in the laboratories (for details, contact Dr S. Berman, National Research Council of Canada, Division of Chemistry, Montreal Rd., Ottawa, Ontario, Canada, or Dr K. Okanoto, National Institute for Environmental Studies, Yatabe-nachi, Tsukuba, Ibaraki 305, Japan). Apart from certified reference materials, which enable the accurate testing of analytical procedures before they are used routinely in monitoring studies, the ACMP considered that there is a need for other types of reference materials to be used for quality control on a regular basis.

The first type of material, which may be called an internal reference material (IRM), is a homogeneous material similar in nature to the samples analysed. The concentrations of the analytes in the IRM need not be accurately known and such material can be prepared by each laboratory. Repeated analyses of the IRM will provide a quality control record and a good assessment of the true laboratory variance for a particular analytical procedure. Knowledge of the variance is essential in a monitoring programme in order to determine the laboratory's ability to differentiate between different concentrations of the analyte in samples.

The second type of material, which may be called an uncompromised reference material (URM) (i.e., containing known, but undisclosed, concentrations of analytes), is a homogeneous material, similar in type to the samples to be analyzed, but prepared in large quantities by a central laboratory on behalf of the monitoring agency and distributed to the monitoring laboratories. This material should be analysed alongside the samples collected in the monitoring programme or baseline study. The results of the analyses of the URMs, preferably combined with data from the intralaboratory quality assurance programme (IRMs and CRMs), should be sent to a coordinator to allow an assessment of accuracy and intercomparability. Once the URM is "compromised", i.e., the values for the concentrations of analytes have been established and are well known by the users, any remaining supplies will still be useful as reference materials.

The ACMP considered that a URM could serve the same purpose as an IRM for laboratory day-to-day quality control and for providing information on long-term variance of the analytical procedure. However, sufficient quantities of the URM would have to be available to meet the two purposes and this production would have to be financed, since none of the ICES laboratories appear likely to undertake this task on a voluntary basis. The ACMP discussed various methods of financing the production of URMs (i.e., by approaching the IOC/IAEA/UNEP Group of Experts on Standards and Reference Materials, whose terms of reference include such matters, or by requesting laboratories to jointly fund such production by building the necessary financing into their unit analytical costs or by approaching the regulatory Commissions, which sponsor monitoring programmes, to provide the necessary funding through a contract). The ACMP agreed that before such approaches could be pursued it was necessary to conduct a market survey to establish both the need for such materials by the relevant organisations, and the willingness of individual laboratories to purchase and use such materials for their quality control procedures. The ACMP recognized that if the use of such materials by laboratories was considered mandatory by the respective Commissions, then the necessary finances would have to be provided by either the laboratories or the Commissions or by contributions from both groups.

The ACMP noted that MCWG had recommended that guidelines be prepared for laboratories on the procedures to be used for the preparation of internal reference materials. It agreed that such guidelines should be drafted by MCWG if the financing of uncompromised reference materials, on the scale indicated by ACMP, could not be achieved.

The ACMP accordingly draws the attention of ICES and the Commissions to the need for provision of the necessary finances for future intercomparison exercises for measurements of contaminants in marine samples, and for the preparation and distribution of uncompromised reference materials.

13 ICES BASELINE STUDY OF TRACE METALS IN COASTAL AND SHELF SEA WATERS

The ACMP was informed of the progress in the MCWG review of data submitted for the 1985-1987 Baseline Study of Trace Metals in Coastal and Shelf Sea Waters, particularly the criteria to be used for the inclusion, assessment and reporting of data. The ACMP noted that, on the basis of an examination of a preliminary report on 1986 data, the MCWG had agreed the following guidelines for the preparation of its final report on this study:

a) Only data for 1985-1987 were to be included in the review.

b) All data for coastal water samples were to be included, but a salinity cut-off of 20 would be applied to estuarine data, with values at lower salinities used only to help decide on the quality of data.

c) Data on unfiltered samples would be accepted unless the samples are classified as estuarine by geography or contain suspended particulate matter (SPM) concentrations >1 mg/l; in such cases only data from filtered samples would be used.

d) The geographical basis for selecting the data would be decided by the chairman of the review group, in consultation with appropriate national representatives, in sufficient time to allow the ICES Secretariat to do the necessary computing before the final assessment.

e) There was no need to change the protocol derived at the 1987 MCWG meeting for the assessment of the data. However, it was noted that the use of reference stations has not been as extensive as requested.

f) In addition to those data specifically collected by ICES laboratories for the Baseline Study, it was agreed to include selected JMP data that have been flagged for use by ICES.

g) With regard to the analysis of the data, it was agreed that metal/salinity relationships should be investigated and that these would have to be area specific. National representatives would be consulted as to whether data should be averaged for each year or over all three years. The statistical treatment and presentation of data should include box-and-whisker plots for each salinity range in each geographical area.

h) It was recommended that a coordinator be identified to consult with national representatives on how to treat national data and to liaise with the ICES Secretariat so that they could provide the necessary computer software to deal with the data analyses.

The ACMP endorsed this proposed approach to the assessment of these data.

The ACMP noted that the Oslo and Paris Commissions had decided at their 1988 meeting to conduct a further baseline survey of trace metals in sea water in 1990, despite the fact that the results of the first survey are not yet known or assessed. The ACMP considered this decision to be somewhat premature and urged that it be reviewed at a later date, when the outcome of the 1985-1987 Baseline Study of Trace Metals in Coastal and Shelf Sea Waters has been assessed.

14 STUDIES OF CONTAMINANTS IN SEDIMENTS

14.1 Normalization Techniques for Sediment Quality Criteria

The ACMP noted that the Working Group on Marine Sediments in Relation to Pollution (WGMS) had further considered various aspects of the physical and chemical properties of sediments in relation to the normalization of trace metal levels. That Group had particularly discussed three papers relevant to this topic. One of them, "Normalization of heavy metal data" by Dr D. Loring, had been especially appreciated and will be submitted for publication in the open literature. In response to a request from the Oslo and Paris Commissions for advice on normalization of the concentrations of trace metals in sediments, the WGMS had provided draft guidelines on this subject.

Although significant progress had been made by the Working Group, it was insufficient to produce a set of coherent and specific guidelines. The ACMP agreed that there is now adequate knowledge and competence within the WGMS to reach, in the near future, an agreement on the definition of guidelines concerning the sampling and analytical procedures, as well as the key parameters that should be determined in order to perform various normalization techniques. The ACMP looked forward to reviewing these guidelines produced by the WGMS at its 1989 meeting. In the meantime, the ACMP reaffirms its advice on normalization contained in Section 15.2 of the 1987 ACMP Report (Cooperative Research Report No. 150), noting that that section of its report contained basic information on normalization techniques but that the topic will be described in considerably greater detail in its 1989 Report.

14.2 Procedures for Storage of Sediment Samples to be Used for Temporal Trend Assessment of Contaminants

The ACMP reviewed and accepted, after minor amendment, the recommendations on storage conditions for sediment samples intended for different analytical purposes, proposed by the WGMS in response to a request from the Oslo and Paris Commissions. These are given in the following paragraphs.

Samples for Trace Metal Analysis

For analysis of total metals, except mercury, there is no evidence that storage conditions are critical as long as the sample is kept under non-contaminating conditions. For mercury, samples must be stored in glass or quartz containers, as mercury can move through the walls of plastic containers.

Samples for Total Organic C, N, P, and Trace Organic Analysis

Sediment samples taken for the analysis of trace organic contaminants must be stored frozen in proper non-contaminating containers (e.g., glass, teflon). For longer-term storage, temperatures of -80° C or lower are preferred. However, even at these low temperatures, it is unclear how long such samples may reliably be stored.

Samples for Bacterial Analysis

Samples of sediment collected for bacterial analysis must be refrigerated, not frozen, and analysed within a few hours (e.g., for coliform bacteria) to a few days (e.g., for spores of Clostridium perfringens), depending on the nature of the species involved.

14.3 Results of the Suspended Matter Questionnaire

The ACMP noted that during 1987 the WGMS had distributed a questionnaire to determine interest in an intercalibration exercise regarding determination of the suspended particulate matter (SPM) content of sea water and to identify the problems and analytes of concern. Responses had been received from 73 laboratories. Sixty of the respondents were in favour of an intercalibration exercise; 48 of these respondents were concerned with measurements of trace metals in SPM. Most laboratories reported that they collected SPM by filtration of discrete water samples. The analytical problems identified seemed to be the result of limited sample size, requiring most analysts to work near their limits of detection and thus amplifying contamination problems. It appeared that many of the problems noted would be resolved if larger quantities of SPM could be collected, for example, by continuous centrifugation, but with the caveat that other contamination problems may be created by this approach.

The ACMP noted that the Marine Chemistry Working Group had emphasized the vital role of the analysis of SPM and had endorsed the concept of an intercalibration exercise. Considering that the great majority of laboratories use filtration through 0.4 µm Nuclepore filters, it is essential that the various filtering procedures be intercalibrated and the laboratories' abilities to analyze SPM be assessed. The problem of comparing the results obtained using various collection methods, including continuous flow centrifugation, has also been considered.

14.4 Proposal for Intercalibration Exercises on Analysis of Trace Metals in Suspended Particulate Matter (SPM) and on Collection of SPM

The ACMP noted that the WGMS had recommended that, in view of the experience already existing in some laboratories and the experience gained in the course of a pilot exercise for the analysis of trace metals in SPM conducted in 1985, together with the great interest expressed through the SPM questionnaire, two independent studies should be initiated. The first should be an analytical intercalibration exercise, whereby a set of solid homogeneous samples would be distributed along with filtered sea water. The samples would then be suspended in the sea water, filtered through 0.4 µm Nuclepore filters and analyzed. The second exercise should be a comparison of field sampling methods for SPM. This latter should be a shipboard exercise comparing most of the commonly used filtration techniques and continuous flow centrifugation.

The ACMP endorsed the proposal for the first exercise devoted to an intercomparison of analyses of trace metals in SPM and advocated that ICES adopt the project as described in Annex 1. The ACMP believed, however, that there would be considerable advantage in including the distribution of filters containing SPM, in a similar manner to that adopted for the 1985 Pilot Intercalibration, but appreciated that this would depend on various practical problems being solved.

Concerning the intercomparison exercise for sampling SPM at sea, the ACMP considered that the programme, as presented by the WGMS, required further definition and justification. It is anticipated that the subject will be discussed at the 1989 meeting of the WGMS.

14.5 Methods Leaflet on Determination of Suspended Particulate Matter

The ACMP noted a paper on the "Collection of Suspended Particulate Matter for Gravimetric and Trace Metal Analysis", prepared by Dr P.A. Yeats and Dr L. Brügmann. The ACMP welcomed this initiative in relation to the present interest in SPM and endorsed the recommendation of the MCWG and WGMS to publish this paper in the ICES Techniques in Marine Environmental Sciences series.

14.6 Sensitivity of Sediments in Pollution Monitoring

The ACMP examined a document entitled "Sensitivity of Sediments in Pollution Monitoring", which had been presented to the WGMS. This document provides a summary of the results of a study of the vertical distribution of lead-210 in one hundred sediment cores collected in the Danish seas. Using a steady-state model, the authors had been able to evaluate the rate of sedimentation, the depth of mixing and the vertical mixing coefficient. These values were then applied to a non-stationary model in order to evaluate the change in concentration of contaminants in the upper first centimeter produced by various changes in the input flux and after various periods of time.

The results of their calculations show that sediments in the Danish seas would be sensitive enough indicators to monitor changes in fluxes to the sea floor in only a very few favourable cases.

The ACMP noted that the numerical calculations performed used rather low values for the mixing depth and the mixing rate and that similar limitations in the sensitivity of sediments for contamination measurements would apply to many other coastal areas where higher values for these parameters are observed. It was also noted that detailed examination of sub-samples of box cores in other areas of the world had indicated the potential for variability, even within a core.

Considering the value of this study as a model for the critical assessment of data on contaminant concentrations in sediments, especially from near-shore areas, the ACMP agreed to attach this document as Annex 2, after only minor editorial change.

15 EFFECTS OF SAND AND GRAVEL EXTRACTION ON FISHERIES

The ACMP took note of an executive summary of the report from the meeting of the Working Group on Effects of Extraction of Marine Sediments reflecting the main activities of that group. The group had collected information on the extent of sand and/or gravel extraction performed in 1986 in Belgian, British, Canadian, Dutch, French, and Swedish waters and plans for such extractions in Finnish waters in 1988.

The ACMP noted that the Working Group is in the process of preparing a report on the "Effects of Sand and Gravel Extraction on Fisheries", and that this is presently in the first draft stage. This document is being prepared with a view to publication in the ICES Cooperative Research Report series; drafting will continue intersessionally and at the next Working Group meeting. According to a draft table of contents, the paper will cover most aspects of marine aggregate extraction and its associated environmental impact, including

- effects on living resources and fisheries,
- related activities, such as navigational dredging, trawling, island and reef construction, which influence the state of the seabed, and
- management problems, such as planning and licensing procedures, mapping of superficial sediment, surveillance, physical and biological monitoring.

Regarding the draft Code of Practice on marine aggregate extractions that was appended to the Working Group report, the ACMP agreed that a key issue to be covered in permits for extraction was the requirement to leave behind a habitable substrate of generally the same composition and configuration type as existed prior to extraction, i.e., the removal of the total thickness of the deposit being exploited should be avoided and all material dredged should be removed from the site so that there is no significant outwash of fine material. Any significant return of fines to the seabed will lead to alteration of the pre-existing substrate. If these requirements were strictly observed, many of the effects on fishery interests and other problems could be avoided. Accordingly, the ACMP recommended that a statement to this effect be included in the proposed Code of Practice and as a licence condition to all nationally issued permits.

16 INFLUENCE OF CONTAMINANTS ON THE SEA THROUGH RIVER DISCHARGE AND ATMOSPHERIC DEPOSITION

16.1 Gross Riverine Inputs

The ACMP discussed the report of the Third Meeting of the Paris Commission's *ad hoc* Working Group on Input Data and the MCWG's comments on this report. The ACMP considered this report to be evidence of a very positive and laudable trend in the development of programmes to assess inputs of contaminants from rivers and believed that a programme mounted on these lines would yield valuable data on the scale of contaminant discharges to the PARCOM area. Nevertheless, the ACMP felt that if some revisions to the details of the programme were made, it would give even better results.

A review of the document "Objectives of the PARCOM Comprehensive Study on Riverine Inputs" brought forward the following suggestions. The objectives should clearly specify that these measurements apply to *gross* riverine inputs. It would be preferable that the contaminant measurements specified in Section 2.1 of the document be made in both the dissolved and particulate phases, wherever possible, rather than as total measurements. Paragraph 6.3.3, in which it is proposed that the sampling requirements be relaxed for rivers in which the contaminants were found to be predominantly below the limits of detection, should be deleted or replaced with a requirement that methods with improved detection limits be applied in such cases. In the view of ACMP, which supports that adopted by MCWG, it would be unwise to place any stress on measurements in estuarine mixing zones in the programme because the interpretation of such data will be difficult and the effort will detract from the main focus of the programme, which should be to estimate gross riverine fluxes of contaminants to estuaries. However, the need to assess direct pipeline inputs is noted as being of relevance in the context of assessing gross inputs into the estuaries.

The decision to move sampling sites further upstream, away from marine influences, taken by the Federal Republic of Germany, was both justified and sensible. It appears that a similar upstream displacement of sampling stations in the Dutch programme in the case of the Rhine and Meuse river measurements would be equally justified, but this had not been decided. The optimism the PARCOM group had expressed with regard to temporal trend detection in the objectives of the riverine inputs programme was probably unjustified in view of the limited frequency of measurement and the likely uncertainties associated with individual annual estimates of contaminant discharge.

This is further complicated by what appears to be an inappropriate selection of limits of detection for contaminant determinations. The proposal that methods should be chosen to provide quantitative values for contaminants in 70% of the samples seems insufficiently specific. The ACMP recommends that the methods chosen have detection limits that are a factor of five lower than the expected concentrations. In its view, this would be a far more realistic criterion for the selection of detection limits, especially if the detection of trends is an objective of the programme. In this respect, appropriate and readily achievable detection limits for the contaminants in water would be as follows:

Hg	1 ng/l
Cd	5 ng/l
Zn	100 ng/l
Cu	100 ng/l
Pb	10 ng/l
γ-HCH	500 pg/l
PCBs	200 pg/l

The values for these metals are suggested partly on the basis of the compilation of metal concentrations in rivers provided in Section 14 of the 1985 ACMP report (Cooperative Research Report No. 135). It is again recommended that, if at all possible, measurements be made in both the dissolved and particulate phases, rather than as suggested in Section 8.2 of the plans for the PARCOM riverine input study, that advocates only total measurements. The use of more appropriate detection limits should reduce the need for the construction of maximum and minimum estimates based on the provisions of Section 8.3 of those plans.

Finally, the riverine input monitoring programme should be planned and executed in conformity with the principles of good laboratory practice (GLP) and quality assurance (QA) as outlined in Report No.6 in the ICES series "Techniques in Marine Environmental Sciences" and in the January 1988 revision of the JMG guidelines for sampling and analyses of trace metals in sea water.

16.2 Net Riverine Inputs

The ACMP noted the following points arising from an examination by the MCWG of GESAMP Reports and Studies No. 32 on "Land/Sea Boundary Flux of Contaminants: Contributions from Rivers", which the MCWG considered was a valuable document and represented a good synopsis of the state of the art. The points noted are:

a) Net input methods only agree within an order of magnitude, so they cannot be used for trend monitoring.

b) The report does not describe direct inputs to estuaries or their effect on estuarine distributions.

c) Redox effects on estuarine behaviour were not considered.

d) K_ds (distribution coefficient water:sediment) may not be useful for estuaries, because equilibrium may not be established in estuaries.

e) Some discrepancies, such as the DTI (dissolved transport index) for Hg, were identified.

f) The limitations of some procedures, e.g., scaling river data to the global situation, have not been adequately described. There are serious limitations on the accuracy of estimates of effective river concentrations that are based on extrapolations of metal/salinity relationships to zero salinity.

The ACMP noted these comments but emphasised that, if net fluxes are to be established, an essential pre-requisite is the measurement of gross riverborne fluxes. The approaches to net flux estimation outlined in the GESAMP report are similar to those described in ACMP's previous advice on this topic (see Annex 1 of the 1984 ACMP Report (Cooperative Research Report No. 132)). The GESAMP report, however, contains an analysis of a number of recent oceanographic data sets for metal/salinity relationships to provide numerical estimates of the net fluxes of several metals in offshore transport. These estimates have been compared with net flux estimates deduced from mass-balances for marginal sea areas.

Based on information in the GESAMP Report No 32, it would appear that one way to estimate net river inputs to the deep ocean from the outer continental shelf is to use the zero-salinity intercept extrapolation method based on samples collected from the outer part of the coastal zone to oceanic surface waters. However, further inshore this will not always be successful because it depends on obtaining unambiguous relationships between metals and salinity. These are not often observed because of the non-steady-state regime of the input flux or the non-conservative behaviour of the element during the mixing of fresh and sea water. In addition, the errors resulting from extrapolations of metal/salinity relationships to $S = 0$ mean that the error associated with the apparent river concentration will be large, resulting in, at best, only an imprecise estimate of net input to deep sea waters. Nevertheless, this method should provide an approximate estimate of net inputs to the deep sea.

Net fluxes from estuaries to offshore areas can probably best be estimated by conducting surveys of metal distributions/behaviour in major estuaries. The GESAMP report reviews the subject of the study of metal geochemistry in estuaries. The JMG guidelines for sampling and analyses of trace metals in sea water also describe the assessment of trace metal behaviour in estuaries, but the detailed design of individual surveys would depend on the characteristics of each estuary. These surveys would have to be conducted at least seasonally and probably more frequently. It would be essential to measure dissolved metal, particulate metal, and suspended particulate matter (SPM) concentrations in samples from the entire salinity range from fresh water to offshore coastal waters. Studies of SPM budgets are essential for the elucidation of particulate metal fluxes. Thus, it is important to measure in both the dissolved and particulate phases rather than just total metals, because these measurements greatly increase the ability to decipher the metal geochemistry in an estuary.

The metal/salinity relationships for samples from the outer parts of estuaries and the coastal zone provide a basis for estimating net fluxes in terms of the hydrographic understanding of particular shelf regions and the broad-scale exchange of water between the deep ocean and continental shelf areas. Heterogeneities in shelf waters are both spatial and temporal and, in consequence, studies in shelf waters need to be much more intensive than those in the deep ocean.

In summary, the ACMP considered that estimates of net riverine fluxes can be determined based on these guidelines. Since estuarine behaviour will vary greatly from estuary to estuary, studies of net river inputs will have to be designed by scientists who have a good understanding of the physical and geochemical characteristics of each estuary (i.e., sediment transport and hydrology). The actual strategy for determining processes and fluxes in individual estuaries will thus have to be designed for each estuary. In this context, one important consideration in many estuaries will be the need to determine additional direct inputs to the estuary from local direct discharges. Finally, it should be noted that net flux estimates obtained in these ways are likely to be of inferior precision to those of gross fluxes and to be representative of broader-scale influxes of material than those from single rivers. In this respect, the net fluxes of nutrients to the sea are becoming a matter of increasing interest in the context of algal blooms. The ACMP anticipated that it will pay increased attention to net nutrient fluxes and the interpretation of regional marine trends in its future work.

16.3 Atmospheric Inputs

The ACMP noted that the Paris Commission's Working Group on the Atmospheric Input of Pollutants to Convention Waters had considered, at its Fifth Meeting in November 1987, the ACMP advice on this topic provided in its 1987 Report. The Paris Commission's Working Group concluded that this ACMP advice was a useful summary of the state-of-the-art, that the views expressed were similar to those of the Working Group, especially from an inorganic chemical perspective, and that no further advice on this topic was required of ICES. Aspects of the advice provided by ACMP in 1987 were, inter alia, having an influence on the nature of the PARCOM atmospheric input monitoring programme. The ACMP expressed strong interest in being kept informed of developments in the Paris Commission's programme with respect to measurements of the atmospheric deposition of contaminants to the sea.

The Helsinki Commission's Group of Experts on Airborne Pollution of the Baltic Sea Area (EGAP) had also considered the ACMP advice on this topic at its fifth meeting in May 1988. This group had found the information to be very useful, and had expressed interest in obtaining more information on deposition mechanisms for organic contaminants. In terms of evaluating the results of its monitoring programme, EGAP has encountered problems with calculating deposition over the sea from data obtained at coastal monitoring stations.

17 ACID RAIN STUDIES

The ACMP reviewed the 1988 report of the ICES Study Group on Acid Rain that had originally been convened in 1987 to address four questions submitted by the North Atlantic Salmon Conservation Organization (NASCO). These questions were:

a) identify freshwater habitats which support, or have supported, Atlantic salmon populations and classify these habitats in relation to their vulnerability to loss of productivity of Atlantic salmon due to acidification;

b) describe the trends in acidification of habitats identified in question a), and in the fish populations supported by these habitats;

c) describe the influence of acidification of freshwater habitat on growth and survival of Atlantic salmon fry and parr and the implications for smolt and adult production; and

d) describe the effectiveness of mitigation measures such as liming and the extent to which the measures are in current use.

The Study Group had been reconvened in 1988 to reconsider these questions plus two others raised by NASCO in 1987. These additional questions were:

a) if new information is available, provide estimates of the amount of salmon habitat available, areas vulnerable to acidification, and areas lost to production; and

b) provide estimates of the number of salmon lost due to acidification.

In most respects, the ACMP found that the report provided responses to the NASCO questions which appear to be balanced and understandable and to answer satisfactorily the basic questions asked by NASCO in relation to habitats and salmon stocks affected by acidification. The ACMP did, however, consider that, although the effect on stock assessment estimates would probably be small, the question of whether it is low pH *per se* or low pH plus aluminium that affect salmon, had not been adequately explained. In this context, it was noted that, when a similar question had arisen in Norway, it had been found that the timing of sampling and analysis of river waters and land run-off in relation to snow melt had been critical. The ACMP, therefore, continues to question whether the dissolved organic carbon content of Nova Scotian rivers is sufficiently different from that of rivers in Scotland and Norway to imply differences in the cause of salmon mortalities. The ACMP also noted that, although liming had been found to be an effective remedial measure in Europe, the Study Group had concluded, without providing adequate justification, that the practical difficulties of liming in Nova Scotia ruled out all but very limited use of this measure. The ACMP does, however, agree that the only practical long-term solution is to reduce the source scale of the acid deposition.

18 OVERVIEWS ON CONTAMINANTS IN THE MARINE ENVIRONMENT

The ACMP examined an overview on mercury in the marine environment which had been prepared by Dr D. Cossa (IFREMER). A number of amendments were suggested and, in order to allow sufficient time for the author to deal with them, it was agreed to refer this item to the 1989 meeting of ACMP.

The ACMP was informed that the Marine Chemistry Working Group was considering the preparation of a number of overviews on selected organic compounds, possibly for presentation at its next meeting. The ACMP requested that the MCWG also give consideration to the preparation of overviews on chromium and nickel, since these metals are of interest to the Commissions.

19 STUDIES OF THE BALTIC SEA ENVIRONMENT

19.1 Patchiness Investigation (PEX)

The ACMP noted that a draft of the main report on the results of the Joint International Multi-Ship Investigation of Patchiness in the Baltic Sea (PEX) had been prepared during a meeting held at Wustrow, in the German Democratic Republic, in April 1988. As the report was not available to ACMP, no discussion of its content took place but the ACMP confirmed that it looked forward to seeing this report at its next meeting. Furthermore, as an aid to its discussion then, it is hoped that copies will be made available to the Hydrography Committee, the Biological Oceanography Committee, the Working Group on the Baltic Marine Environment and the Marine Chemistry Working Group so that they may assess the scientific results of the PEX experiment and provide input, in their respective fields of expertise, to any discussion of future similar experiments.

19.2 Report of the Working Group on the Baltic Marine Environment

The ACMP considered the draft report of the Working Group on the Baltic Marine Environment (WGBME).

The Working Group had reviewed the planned activities of the newly established Study Group on Baltic Sea Modelling aimed at modelling the Baltic Sea and its water quality. Attention will also be paid to other relevant ongoing activities, e.g., in the ICES Working Group on Shelf Seas Oceanography. The final goal of the work should be to create operational models that are urgently needed, inter alia, as a basis for evaluating plans for bridge or tunnel construction and water flow modifications.

On the basis of a more general discussion, the Working Group had concluded that the Baltic Sea is extremely sensitive to changes in the external water balance. Taking into consideration the fact that well-developed plans already exist for the construction of bridges, tunnels, and dams, which can influence the Baltic Sea water balance, the Working Group recommended that a critical and comprehensive discussion of all such planned constructions be held among the Baltic Sea countries. Such discussion should permit all interests in this regional sea area to be considered before construction is approved. The ACMP endorsed the proposal that ICES try to channel a request for discussion and mutual investigations on activities such as large water construction works, which may have an influence on the Baltic Sea water balance, to the authorities concerned.

The status of the BALTEPP (Baltic BATHY/TESAC Pilot Project) programme as a joint ICES/IOC/IGOSS project was noted by ACMP. This aims to obtain real-time information on the occurrence of salt water inflows into the Baltic Sea. The implementation of the project requires a data centre to screen the incoming BATHY/TESAC messages and to alert the Baltic Sea countries in case of an expected inflow event. The Swedish Meteorological and Hydrological Institute (SMHI) is willing to serve as this data centre. Even though funding problems for this task are not yet solved, it seems to be a matter of urgency that progress be made with the project. Final instructions will be distributed by the SMHI to all Baltic Sea countries, including details on obtaining and submitting the necessary data. IGOSS will be informed of these plans by the organizers. The ACMP supported the recommendation that the BALTEP Programme begin in November 1988.

The ACMP took note of an assessment by the WGBME regarding the severe winters 1984 to 1987 and their impact on the Baltic Sea environment. The unusual winter seasons, together with the relatively 'cold' spring/summer 1987, were reasons for negative temperature anomalies at all depths down to the bottom of the Baltic Proper. The intermediate winter water in the Bornholm and Gotland Basins was considerably colder than normal (down to -3^{0}C) and was located deeper than usual. Surprisingly, the phytoplankton development was delayed in only one case, after the winter 1984/1985. In contrast, the zooplankton biomass was low in the spring of all three years. Apparently, one generation of the zooplankton was missing during the spring, but in all three years an unusual increase of zooplankton had been observed during the summer outburst.

Direct consequences for the fishery resulted from the limitation of the fishery season by ice and from increased migration activity, especially for pelagic fish stocks. Indirect consequences stemmed from the impairment of the spawning behaviour of pelagic fish stocks, from reduced recovery of the pelagic fish larvae because of delayed zooplankton development, and from the influence of the low water temperature in winter and spring on the metabolism of pelagic fish stocks (herring), directly or via the food chain.

The ACMP took note that the WGBME had proposed a new coding system for the stations used in the Baltic Monitoring Programme based on a new areal sub-division of the Baltic Sea.

The ACMP was informed that the HELCOM had requested ICES to continue the work on evaluating the size of seal populations in the Baltic Sea and to assess their condition in relation to contamination. Noting that there have been unusually high mortalities among seals in the Baltic Sea area and elsewhere in northern Europe, the ACMP proposed that this matter should initially be channelled to the Marine Mammals Committee for further consideration and that the Baltic Seal Working Group should be reactivated.

19.3 Sediment Studies in the Baltic Sea

The ACMP noted the present state of the preparations for an assessment on Baltic Sea sediments, the "Critical Review of Contaminants in Sediments in the Baltic Sea". More than 20 geochemists and sedimentologists from all Baltic Sea countries had responded positively to an invitation and questionnaire asking whether they would be willing to contribute to the different chapters of that assessment and/or to participate in a preparatory meeting to be held in Tallinn on 13-15 September 1988. The objective of the meeting is to agree upon the content of the "Critical Review", on the conveners, authors and co-authors for the different chapters, and on a preliminary timetable for a first draft document. To accelerate the work, a further meeting of the Study Group on Baltic Sea Sediments, preferably before the next WGBME meeting in April 1989, would seem necessary.

The ACMP supported the recommendation of the WGBME that the experience gained from the work of the ICES Working Group on Marine Sediments in Relation to Pollution should be utilized in the preparation of the "Critical Review", especially in relation to methodological guidance.

The ACMP looks forward to seeing in due course a draft of this document, which it noted had been requested by the Helsinki Commission several years ago.

20 REGIONAL ASSESSMENTS

20.1 Guidelines for the Preparation of Regional Environmental Assessments

In 1983, the ACMP developed guidelines for the preparation of regional environmental assessments of individual coastal or marginal sea areas within the ICES geographical area (see Annex 3 of the 1983 ACMP report (Cooperative Research Report No.124)). These guidelines were based upon the review of the "Assessment of the Effects of Pollution on the Natural Resources of the Baltic Sea", (Melvasalo et al., 1981), carried out jointly by the International Baltic Marine Environment Protection (Helsinki) Commission and ICES. It was thought timely to stimulate the preparation of similar reviews for other areas so that a more comprehensive picture of the state of contamination and/or pollution within the whole ICES area might be obtained. Since 1983, a number of additional regional assessments have been prepared, two of which have followed these guidelines for assessments of the Skagerrak/Kattegat area (ICES, 1987) and the Irish Sea (Dickson and Boelens, 1988). In addition, an independent assessment of the North Sea was carried out under the auspices of the Second International Conference on the Protection of the North Sea (Quality Status Report for the North Sea) (Anon., 1987). These additional regional environmental assessments warranted a re-evaluation of the ACMP guidelines of 1983 to determine whether revisions were appropriate. The task of considering the extent to which the existing guidelines required modification was delegated to the Working Group on Environmental Assessments and Monitoring Strategies (WGEAMS), which was also authorised to draw up new proposals, if it considered them necessary.

The ACMP considered the proposals as drawn up by the WGEAMS and noted that two major amendments had been made. Firstly, the WGEAMS had recognised that, in addition to being of interest to scientists, a regional environmental assessment document can provide a very sound background on which to base administrative decisions regarding action to rectify pollution or prevent other threats to the resources[1] of a particular area. In order to meet this need, greater emphasis should be given to the uses, actual and potential, of an area and an additional chapter giving an overall assessment in relation to regional environmental management strategies was now essential. Secondly, the WGEAMS had concluded that, although the original guidelines continued to be valid in their emphasis on the disciplinary approach, some elaboration was necessary as to the details to be covered in each section, so as to meet the new applied uses of the proposed documents.

The ACMP discussed the revised guidelines in detail and agreed that they appeared to meet the new and increased requirements for regional environmental assessments. The revised guidelines, after some abreviation and clarification of the original text proposed by WGEAMS, are reproduced in the following text.

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[1] Throughout this text, the word resources means marine organisms, exploitable or otherwise, or some other usable resource, e.g., seabed deposit or amenity interest.

20.1.1 The Purposes of Regional Environmental Assessments

The following statement of the purpose of a regional environmental assessment was developed by the ICES and OSPARCOM Secretariats in preparation for the preliminary meeting of the North Sea Scientific Task Force:

> "The results of an environmental assessment provide the basis for strategic analysis of the requirements for regulatory action necessary to protect the marine environment in a given area, particularly for determining the adequacy and/or shortcomings of existing environmental regulations and controls pertaining to the protection of the environmental health and quality of the marine environment. It can form the basis of appropriate management plans."

Thus, the primary purpose of a regional environmental assessment is to provide as complete as possible an authoritative synthesis and evaluation, from a multi-disciplinary perspective, of scientific information pertaining to a specific marine area. In this sense, the regional environmental assessment is a product of a rigorous and detailed review of data on conditions in the subject marine area, the objective of which is to determine the nature and severity of environmental disturbances and trends that are the consequence of anthropogenic activity.

It should be noted that this is rather different from the environmental impact assessments (EIA) carried out in connection with a planned local development, although the regional environmental assessment may well provide information that can be used in an EIA.

Each assessment is intended to comprise a review of the kinds and degrees of anthropogenic disturbances to the area set in the context of existing knowledge of the physical, chemical and biological conditions. A regional environmental assessment should, therefore, provide an analysis of existing or perceived concerns regarding damage to the environment and uses of a marine area in the context of all relevant scientific information. It should show where these concerns are supported by scientific findings and indicate where regulatory action would be justified, either to rectify existing adverse effects or to forestall potential threats. Finally, some priority should be assigned to the environmental concerns about a particular marine system in relation to the significance and severity of adverse effects on the system and its amenities.

The results of the regional environmental assessment should serve to determine the adequacy and/or shortcomings of existing regulations and controls aimed at protecting the health and quality of the marine environment, and the continued viability of its resources and other amenities. The assessment forms the basis for the introduction or development of management plans. It is, therefore, important that the assessment be restricted to the collection, review and evaluation of scientific data. These data should be provided in a form that is wholly intelligible to a non-scientific audience. In short, the task of the scientists is to collect and analyse the information and explain its implications in clear unambiguous language for the policy makers and the public to use for reaching conclusions and environmental protection decisions. In this latter context, it is important that the assessment of what is, and is not, known about an area be kept entirely separate from the process of defining management options.

20.1.2 Content

To be useful, the entire regional environmental assessment should be brief so as to ease the assimilation of the information contained within it and to give proper and clear emphasis to the most serious environmental disturbances and the uses or activities of man which cause them.

Another requirement is uniformity of presentation. This will allow identification of problems common to several areas which alone might not merit action but together might present a more pressing case, e.g., litter on beaches derived from shipping. The use of a common approach might also lead to signs being identified in several areas which together might lead to the conclusion that an issue of uncertainty may not be one of real concern, e.g., mercury in tuna or swordfish, which was originally identified as a pollution issue but which is now known to be a natural occurrence.

The main types of marine information needed for the preparation of an assessment are physical (hydrographic), chemical, and biological (including fisheries-related) data. A disciplinary approach greatly simplifies the initial stages of the preparatory process. While the final overall assessment should contain a multi-disciplinary analysis, the main body of the document should be developed from individual disciplinary perspectives. In the North Sea Quality Status Report, a separate chapter was prepared detailing the uses made of the area by man. Such a chapter tends to be descriptive and simply adds to the length of the document. It is, therefore, suggested that, provided the various uses are kept clearly in mind from the start, the individual disciplinary sections can adequately cover the various uses made of the region and its resources and the extent to which they interact and affect each other or the quality of the environment.

If the regional environmental assessment is to be used subsequently in a public education context, the main conclusions should be published separately in a readily assimilable illustrated format. For ministerial or senior administration use, the key issues requiring action (and those not requiring further attention) should be spelled out in a 1- to 2-page Executive Summary. The more extensive overall summary and the detailed assessments from which it is derived will provide the necessary substantiative statements.

20.1.3 Areal Coverage

Assessments should be conducted on a regional basis and, where the region involves the interests of more than one country, they should involve international cooperation. It is not possible to give general guidelines as to the minimum or maximum geographical extent of an area, but natural boundaries such as surrounding land masses or current systems should provide the basis, rather than national Exclusive Economic Zones (EEZ) or latitude-longitude lines. For large sea areas, such as the North Sea and the eastern seaboard of North America, it may be appropriate to assemble separate assessments for several sub-areas for subsequent collation into a single report, rather than attempting to conduct the assessment over an entire area at once. If such an approach is adopted, the sub-areas might be delineated either by natural physical or hydrographical boundaries or by perceived common interests, e.g., in the Wadden Sea.

20.1.4 Procedure and Format

Main text

The main body of an assessment should comprise self-contained disciplinary sections, each of which should start with a review of the existing knowledge of the area concerned. This should be gleaned, as far as possible, from existing published information rather than from a large data-gathering exercise, which might itself consume significant effort. Where unpublished data are required, emphasis should be placed upon obtaining information summaries from scientists closely involved in the discipline and region of interest.

The subsequent part of each disciplinary section should attempt to describe the extent to which the region has been, or might become, affected by anthropogenic activities or uses of the area in their broadest sense and, in turn, the effect one use might have on another.

Thus, in the context of the section dealing with physical characteristics, anthropogenic activities should include dredging, in connection with both port and harbour operations, and the extraction of mineral resources from the sea bed. It should also include the impact of changes in the terrestrial environment, e.g., reduced run-off due to impoundment of rivers, major alterations to natural coastlines through the construction of barrages and flood protection or land reclamation schemes. Whilst some such changes will clearly be regarded as beneficial to Man's interests, they may also have adverse effects, e.g., interference with fish migration patterns, traditional spawning areas or fishing grounds.

The chemical disciplinary section should include information on inputs to the marine environment from the atmosphere, rivers, and direct discharges, including dumping and routine shipping activities. Each source should be assessed in terms of its impact on the concentrations of contaminants found in the environment including sediments, and its impact on man's other uses of the sea. Wherever possible, this section should include an assessment of the speciation of the contaminants and their behaviour between input and loss from the system, e.g., by transport out of it or by incorporation into the sea bed.

Similarly, the biological section should include information on the flora and fauna present and assess whether this matches the normal expectations for the area and the extent to which species appear to be under stress, e.g., by alteration of population density or size of individuals, limitations in reproductive success or susceptibility to disease.

In each case, the sections should include an assessment of whether trends are detectable and the extent to which they can be attributed to anthropogenic impacts as opposed to natural processes. Modelling procedures, physical, chemical and biological, are now being developed and can greatly assist in this process. Each section should conclude with an evaluation of the degree to which evidence of the effects of anthropogenic activities has been acquired and what additional information is needed to confirm such effects. In view of the fact that intercalibration results show that many types of analyses still present major problems for a large number of laboratories, critical evaluation of the level of confidence which can be placed on the data utilised in a regional environmental assessment must be an essential part of the report. Data that are not reliable should not be used or should only be used with considerable caution.

Overall Assessment

Each regional environmental assessment should be accompanied by an overall assessment. This should be developed after the remainder of the report has been completed and should be written in clear, but precise, terms. It should state succinctly what is known well and what is either not known or uncertain and should identify, wherever possible, effects and the probable causes. A maximum length of 8-10 pages is suggested. It is important that this section clearly addresses the responsibilities of both the scientific managers and the environmental policy makers, so that they can take well-informed decisions on the necessary courses of action in terms of further research or monitoring work or control of certain activities. It is equally important that it states clearly what is not a matter for concern and thus does not require further attention.

A structured approach to the preparation of this overall assessment section is strongly recommended. This should take the following form.

Review the evidence for environmental effects, and assess the strength of the evidence against the following questions:

a) Can an effect or change be detected with reasonable confidence?

b) Can the geographical area in which the effect occurs be defined with any spatial gradient and/or trends over time?

c) Can a cause be attributed to the change or effect?

d) If the cause is anthropogenic, what is the significance of the change or effect? Can we relate it to the background situation or to a standard/criteria/guideline?

e) Can a list be prepared, with reasonable confidence, of changes which are adverse, significant and which can be associated with a cause?

f) If more information is required, how can it most effectively be obtained?

The issues which need to be addressed include effects on plankton populations, benthos, fish and fisheries (including those for molluscs and crustacea), fish disease incidence, and marine mammals and birds.

In essence, the overall regional environmental assessment constitutes a synopsis of the conclusions reached in the disciplinary sections, but every effort should be made to relate the disciplinary sections to one another and to weigh their relative importance in striking an overall balance between the disciplines. It is this overall assessment that will ultimately provide the basis for initial intercomparisons of the environmental conditions and severity of anthropogenic effects in different regions. The disciplinary sections would provide greater detail for these intercomparisons, whilst any background documents, cited in the assessment, would provide even greater detail, if needed.

The layout, or format, of the assessments would be as follows:

	Pages	Words
1. Executive Summary	1-2	300-800
2.1 General circulation and physical oceanography 2.2 Extent of anthropogenic modifications to the physical oceanography	8	2500
3.1 General marine chemistry and incidence and distributions of potential contaminants 3.2 Modifications to chemical fluxes and extent of contamination	10	3000-5000
4.1 General biology and fisheries of the area 4.2 Biological trends and/or disturbances due to anthropogenic activity (including exploitation of fisheries resources)	12	3500-5000
5. Overall Assessment	8-10	2500-5000
6. References		

The total length of the document would then be _ca_. 40 pages, or between 12,000 and 15,000 words. It has purposely been suggested that the physical oceanographic sections be somewhat shorter, and the marine biological sections somewhat longer, than the average section length because of the relative diversities of the information involved in these disciplines. Summary tables and figures might be included in addition to the text, because they may simplify the comparisons between different regions. The sole justification for increased length of an assessment should be the ability to present more detailed conclusions as to the nature and extent of anthropogenic disturbances. Additional tabular material might comprise mass-balances for particular contaminants or summaries of trends in species diversity, year-class success or contamination of marine biota. Reference should only be made to detailed compendia of information and other literature that provide greater detail and amplification of the contents of the assessment. If a comprehensive bibliography is considered valuable, this should be published independently and merely referenced.

It is fully appreciated that the argument for brevity may result in the document being more controversial than it would otherwise be. However, the need to resolve controversy, in order to prepare the disciplinary sections, may well prove to be of great advantage in putting together a concise, reasoned and widely accepted description of prevailing conditions. Overall, it is strongly felt that brevity will demand the preparation of an easily comprehensible and relatively straightforward document that will greatly simplify subsequent intercomparisons of the extent to which regional areas have been affected by anthropogenic activities. At the same time, this will permit decisions on research, monitoring, or pollution control action to be taken on the basis of clearly stated needs.

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20.2 Regional Assessments of the North Sea and Other Areas

The ACMP noted that, in the Quality Status Report prepared on the North Sea in connection with the 1987 Second International Conference on the Protection of the North Sea, it had been recognized that the extent of concern and available information differed markedly among the different sub-regions. The ACMP further noted that it was likely that the next assessment of the quality status of the North Sea would follow the new guidelines on the conduct of regional environmental assessments described above.

Discussion then focussed on whether the North Sea should be treated as an entity, or as sub-regions, in this assessment work. Realising the advantages and disadvantages of both approaches, the ACMP recommended that a sub-regional division should be used initially and that these assessments should then be linked either by a main chapter providing the balanced synthesis of the information or in the preparation of a final overall document. The sub-regions should cover all areas of the North Sea, though not necessarily with the same degree of detail, and these should include the Wadden Sea, the German Bight, the Southern Bight of the North Sea, the Channel to the east of 5^0W (unless the Channel is considered as a whole in a separate assessment), the northeastern coast of the United Kingdom, the northern North Sea, the central North Sea, and the coastal areas of the Skagerrak (particularly the border area between Norway and Sweden).

In making this suggestion, the ACMP recognized that other areas of great interest for the conduct of regional environmental assessments should also be identified. These included (in approximate order of priority) the Gulf of Maine/George's Bank, the New York Bight, the Gulf of St. Lawrence, the Bay of Biscay (both the French and the Spanish parts), and the Iberian Peninsula (the Spanish and Portuguese coastlines facing the Atlantic Ocean).

21 REGULATORY APPROACHES TO ENVIRONMENTAL MANAGEMENT

Some statements about alternative approaches to environmental management and regulations have been made by ACMP in its 1986 and 1987 reports. The ACMP reaffirmed its intention to continue the preparation of a detailed explanation of an environmental management framework, partially in the context of the assimilative capacity concept, the precautionary approach and other management options (e.g., the Environmental Quality Objective and Emission Standard approaches). The developed framework will reflect the consensus view of the ACMP and is primarily intended as an explanation to recipients of advice from ACMP as to the basis and general background for the formulation of such advice.

The ACMP agreed that it would aim to complete its work in drafting the outstanding sections of its management article during the 1988-1989 intersessional period with a view to finalizing the article in its 1989 report or, depending on progress, in its 1990 report.

22 AUTOMATIC DATA PROCESSING ISSUES

The ACMP took note of a number of issues relating to the automatic data processing (ADP) of the marine pollution data sets of the Cooperative ICES Monitoring Studies Programme and the Oslo and Paris Commissions' Joint Monitoring Programme (JMP), as raised in a document submitted by the ICES Secretariat to the Ad Hoc Monitoring Group under the JMG. The ACMP was informed that, at its January 1988 meeting, the JMG consideration of the issues raised had resulted in certain important conclusions with respect to the ADP activities practised by ICES in its capacity as data centre for the JMP data.

Concerning scheduling of ADP activities, the ACMP noted the decision that, in future, laboratories submitting data for the JMP must strictly adhere to the agreed deadlines. Data submitted after the deadlines would normally not be included in the data products distributed to the various experts conducting assessments of the JMP data.

On the subject of whether data submitted for one of the defined purposes of monitoring could also be included in data products prepared for another purpose, the ACMP concluded that if monitoring guidelines were correctly followed, data for one purpose would not normally be suitable for another purpose. This conclusion re-emphasized the importance of following the guidelines developed for the conduct of the various components of the monitoring programmes.

In the case of general requests for data, for use in studies not related to any of the purposes of monitoring as defined in the various programmes, the ACMP agreed that, if not subject to exchange restrictions, the data requested should be made available according to the ICES policy regarding data distribution. The ACMP further noted that in such cases it would be the responsibility of the persons requesting the data to ensure that the data supplied are appropriate for their needs.

On the issue of data exchange, the ACMP was also informed about the concern of data originators in certain fields regarding the further distribution of data submitted to ICES, and the adverse effect this has had on the flow of hydrographic and hydrochemical data, in particular, into the ICES Data Centre. The ACMP was informed that for marine pollution data, in addition to complying with the moratorium on the exchange of JMP data not flagged for use by ICES, it is normal practise for ICES to seek the permission of the data originator before supplying data to meet requests, particularly requests by scientists outside the ICES community. It was noted that possibilities for flagging data which should only be exchanged subject to the permission of the originator do exist, but a problem can still arise with respect to further distribution of these data once they have been exchanged outside of ICES. The ACMP, therefore, recommends that, if the data originator has agreed to a second party having access to otherwise restricted data, ICES should emphasize to that party that the data were released for his purpose only, as specified by the originator.

The ACMP agreed that, in the case of ICES data on contaminants in marine media, the free availability of these data should be encouraged and restriction of these data should not be applied as a matter of course. Where the originator wishes to restrict the exchange of his data, this should be indicated when the data are submitted. The JMP data are not subject to this requirement, as they are covered by a two-year moratorium.

ANNEX 1

PROPOSAL FOR AN INTERCOMPARISON EXERCISE ON ANALYSES OF TRACE METALS IN SUSPENDED PARTICULATE MATTER

Introduction

To study contaminant fluxes in the marine environment, especially those between river mouths and offshore areas, measurements of the concentration (mass per unit-volume), physical properties, and chemical composition of suspended particulate matter (SPM) are desirable. For the understanding of biotic and sedimentary fluxes, it is important to distinguish between contaminants in the particulate and the dissolved phase. In addition, substantial quantities of contaminants, especially in the case of trace metals, are discharged into rivers and estuaries in a particulate form (e.g., industrial wastes, dredged material).

In most studies, filtration procedures are used for collecting SPM. Generally, the filtration results in only small quantities (a few mg) of SPM. Thus, analytical treatment for trace metal determinations requires well-experienced laboratories, sensitive detection methods, and a high degree of quality assurance measures. This latter includes participation in intercomparison exercises organized in an appropriate manner.

The analysis of responses to a questionnaire has shown that nearly 60 respondents out of 73 were interested in participating in an intercomparison exercise dealing with trace metals in SPM. On the basis of the results of the ICES pilot intercomparison exercise on analyses of trace metals in SPM, carried out in 1983, such an intercomparison exercise seems feasible. This exercise, conducted among eight experienced laboratories, permitted the following conclusions to be made:

a) At least one laboratory is able to prepare a reasonable number of filters loaded with a representative mass of identical SPM.

b) Both the necessary experience on micro-analytical techniques for leaching/digestion of filters, as well as sensitive detection methods, mainly flameless AAS, exist to determine, with a relatively high degree of accuracy and precision, the trace metal content of mg amounts of SPM on 0.4 µm/47 mm Nuclepore filters.

A repetition of this type of intercomparison exercise for a larger number of laboratories would broaden the experience gained from the Pilot Study. However, it would increase the value of the intercomparison exercise considerably if, in addition to a comparison of the digestion of pre-loaded filters and the subsequent trace metal determinations, the filtration step could be included. Therefore, it is proposed to distribute small amounts of solid sub-samples (e.g., 3 to 6 replicates of 2 to 5 mg each) of material, typical of coastal environments, which had previously been checked thoroughly on its homogeneity at the mg sample level. Preferably, such material should be marine SPM collected, for instance, by continuous flow centrifugation. If the preparation and homogenization of SPM for such purposes is very complicated, sub-samples of sediment reference materials used in previous intercomparison exercises could be used. The participants would receive a set of solid sub-samples, packed, e.g., in small plastic vials, together with a bottle of pre-filtered sea water, about 500 ml per sub-sample.

This exercise should permit the testing of both the ability of laboratories to sample SPM without contamination and their capacity to solve the problems posed by very small quantities of materials.

Each participating laboratory should be provided with two sets of samples of SPM, Sample A and Sample B. Sample A will be analyzed directly. The results from this set will permit the assessment of the analytical procedure. Sample B will be resuspended in sea water, filtered, and the filter analyzed. Participants will be requested to filter the re-suspended samples through 0.4µm/47mm Nuclepore filters using their normal techniques and filtering devices. Data obtained from this latter analysis will enable variance in the sampling and analytical procedure to be assessed.

Additional information, especially on the relative magnitude of sampling to analytical errors, will be obtained from comparing the data from Samples A and B, provided the materials used in Samples A and B are the same.

Participants should have at least four months to perform the analyses and to report the results. At least double this period will be required for the organizing laboratory to prepare the samples and to conduct homogeneity tests.

<u>Provisional Timetable</u>

If ICES approves the conduct of this exercise at the 1988 Statutory Meeting, the following schedule could be met for the first intercomparison exercise on trace metals in SPM:

1989:	February-April	- Preparation of the detailed protocol
	April	- Review of the protocol by WGSATM
	May-August	- Preparation of materials
	September	- Distribution of materials
	December	- Receipt of results by coordinator
1990:	January-February	- Assessment of results

Drs L. Brügmann, J. Skei, and L. van Geldermalsen have agreed to serve as coordinators for the continued planning of this intercomparison exercise.

ANNEX 2

SENSITIVITY OF SEDIMENTS IN POLLUTION MONITORING

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Abstract

Estimations of the sensitivity of a given sediment monitoring site for pollution studies are given. Input parameters (accumulation rate, mixing depth and mixing intensity) are obtained by modelling Pb-210 profiles. The sensitivity of the sediments to show changes in the flux of contaminants is not constant, but varies from one site to another due to differences in the sedimentation parameters. In this study, the accumulation rate (w = 1 mm/yr) and mixing depth (Zm = 2 cm) are kept constant and the sensitivity is calculated as a function of varying mixing intensities. This study shows that a 200% increase in contaminant flux to the sediment surface over a three-year period will result in an increase in surface concentration (0 - 1 cm) of between 105% and 130%, depending on the mixing intensity. Thus, it appears that sediment monitoring sites should be selected carefully and only after evaluation of the sediment parameters.

Introduction

Many contaminants are significantly concentrated in the bottom sediments relative to the water or biota in a recipient water body. Moreover, mud sediments are generally more stationary than the water and more long-lived than the organisms. Bottom sediments are, consequently, often the best available medium for long-term monitoring of contaminants in aquatic environments. The value of a sediment monitoring programme is strongly dependent on the sensitivity of the sediment site for monitoring temporal trends. In other words, how much must the flux of a compound (contaminant) to the sediment surface change before a statistically significant change in the concentration in a "surface sample" of the sediment can be detected? Unfortunately, many sediment monitoring programmes are related to baseline surveys and not to a quantitative evaluation of the capability of the sediments to show short-term changes in contaminant flux.

The purpose of this paper is to investigate the possibility of using quantitative criteria for an evaluation of a sediment monitoring site. The paper deals with a model which describes the changes in the concentrations of compounds in the sediment surface layer as a function of sedimentation rate (mm/year) or accumulation rate (g/m^2/year), depth and intensity of bioturbation or related mixing processes, thickness of the surface layer analyzed, and change of flux to the sediment surface of the compound in question. The model is based on parameters which can be estimated from Pb-210 dating of the sediment cores and from chemical analysis.

Determination of sediment parameters

Basic sediment parameters, such as the variation of dry matter with depth, ignition loss, and mean grain density, should be known. A determination of time dependent sediment parameters is based on the vertical distribution of the natural radioactive isotope Pb-210 (for more details, see Pheiffer Madsen and Sørensen, 1979). The content of unsupported Pb-210 (that is Pb-210 not produced in the sediment) decreases regularly downwards in undisturbed and steadily deposited sediment owing to radioactive decay. Departures from this predictable Pb-210 profile in the topmost sediment column permit an assessment of mixing and/or intermittent erosion. A condition for a sensitive monitoring site is a reasonably rapid and continuous sedimentation with no, or only a limited degree, of mixing. By the study of Pb-210 profiles, it is possible to identify such sampling sites before expensive chemical analyses for contaminants are carried out.

It is not possible to describe exhaustively the mixing by bioturbation, etc. However, mixing which does not result in complete homogenization, and which still can be treated as random mixing, is, according to Berner (1980), best described in terms of a "biodiffusion" coefficient.

Accordingly, the observed depth profiles of unsupported Pb-210 can be modelled by the following advection-diffusion equation:

$$\frac{dC}{dt} = D\frac{d^2C}{dz^2} - w\frac{dC}{dz} - \lambda C \qquad (1)$$

where z (cm) is the depth below the sediment-water interface, D (cm^2/year) is the mixing coefficient, w (cm/year) is the linear accumulation rate, λ ($year^{-1}$) is the radioactive decay constant, C (dpm/g) is the concentration of the radiotracer, and t (year) is the time. Christensen and Bhunia (1986) have modified the model so that variable bulk density due to compaction and a variable diffusion coefficient in the mixing zone (which is much more realistic) can be taken into account.

In the present work, it is assumed that the mixing coefficient is constant to mixing depth z = I and equal to 0 below that level. This simplification seems to work well in mud sedimentation areas of the Danish Seas and in the Baltic Sea.

Using the steady-state solution for equation (1), the parameters w, D, I and the flux of Pb-210 to the sediment surface can be calculated. Figure 1 illustrates the influence on the Pb-210 profiles of changing values of D; the other parameters are kept constant.

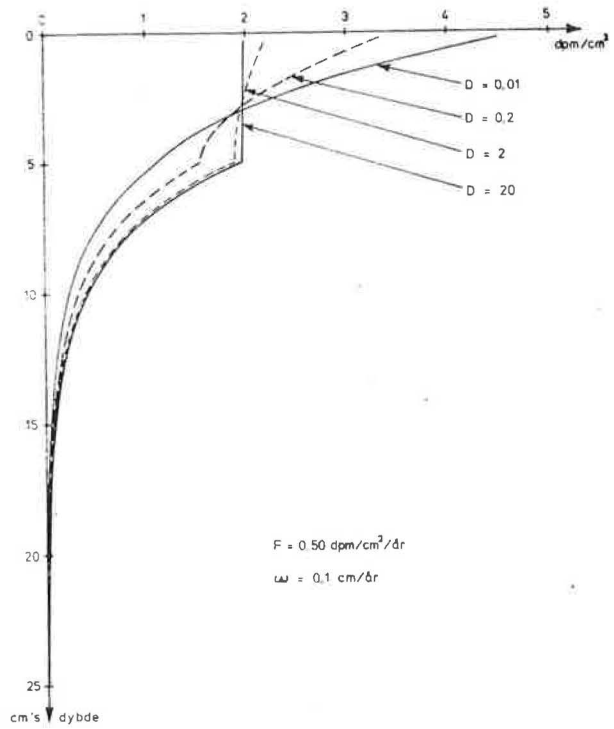

Figure 1 Pb-210 profiles caused by different mixing coefficients.

Sediment parameters from the Kattegat and the Belt Sea

Approximately 100 mud or muddy sand cores from the Danish Seas and the Baltic have been dated by the Pb-210 method. Most of the stations were at sites judged by geological mapping to be rather undisturbed accumulation areas. In Table 1, accumulation rates and mixing parameters are given (from Pheiffer Madsen and Larsen, 1986).

Table 1 Sediment parameters from approximately 100 sediment cores from the Danish Seas.

Quartile	Accumulation rates g/m^2/year	mm/year	Mixing depth cm	Mixing coefficient cm^2/year
25 %	250	0.6	2.5	0.5
50 %	385	1.0	5.5	10
75 %	650	1.7	9.5	∞

It appears that the accumulation rates in the mud accumulation basins frequently are 200 - 500 g/m^2/year or 0.5 - 1.5 mm/year. Only 25% of the cores show a mixing depth less than 2.5 cm, corresponding to 25 years of deposition and mixing coefficients less than 0.5 cm^2/yr. This means that most cores are disturbed in the surface layers even in rather sheltered seas.

Concentrations in surface samples

For practical use, surface samples in sediment monitoring programmes are the topmost 1 cm of the sediment. By using better sampling techniques and by freezing the sediment cores before slicing (Silverberg *et al*., 1985), the thickness of the surface sample could be reduced, which would give a better resolution of the sediment profile.

The observed concentration of a compound in a surface sample is not only a function of the recent flux of that compound but also a function of the other three parameters mentioned above.

The principle of this model is to use the mixing parameters (D,I) and accumulation rates w, evaluated from the Pb-210 profile, in the calculation of the concentration of the compound in the surface sample, in response to changes in flux of that compound to the sediment surface. This implies changes through time, so a steady-state solution of equation (1) is not possible.

The flux of a contaminant is, in contrast to the flux of lead-210, not constant with time. A non-steady-state solution of equation (1) can be carried out using the implicit finite differential equation (Crank-Nicholson) method (Christensen and Bhunia, 1986). The solution gives a concentration profile from a known historical input flux. The historical flux can be calculated from a known concentration profile by the deconvolution method (Christensen and Goetz, 1987). The concentration of a contaminant can be expressed as:

$$C(z,t) = \quad Co(z,t - \tau)\ f(\tau)\ d\tau \qquad (2)$$

where $C(z,t)$ is the concentration in depth and time, $Co(z,t - \tau)$ is the impulse response time in the time τ (calculated from the non-steady-state solution of equation (1) using a unit response signal obtained by a given sediment profile with known sedimentation parameters given a random input flux of short duration) and $f(\tau)$ is the flux of the contaminant at the time t ($0 < \tau < t$).

Equation (2) is solved using Fourier transformation of $C(z,t)$ and $Co(z,t - \tau)$.

Examples

As an example of the use of the model, a sediment profile with a fixed accumulation rate of 1 mm/yr and with a fixed mixing depth I = 2 cm has been chosen.

Figure 2 shows the relationship between increased flux (in percent of initial 100) for the period indicated (1, 3, 5 and 9 years) and the resulting increase in concentration in the topmost 0 - 1 cm sample after that period. The relationship is shown for varying values of the mixing rate. For no mixing (D = 0), the figures show the consequences of the annual addition of 1 mm sediment with the increased concentration to the sediment profile and consequent loss of the lowermost layer by burial. By increasing themixing rate, a greater amount of the new added material is mixed below the sampling depth.

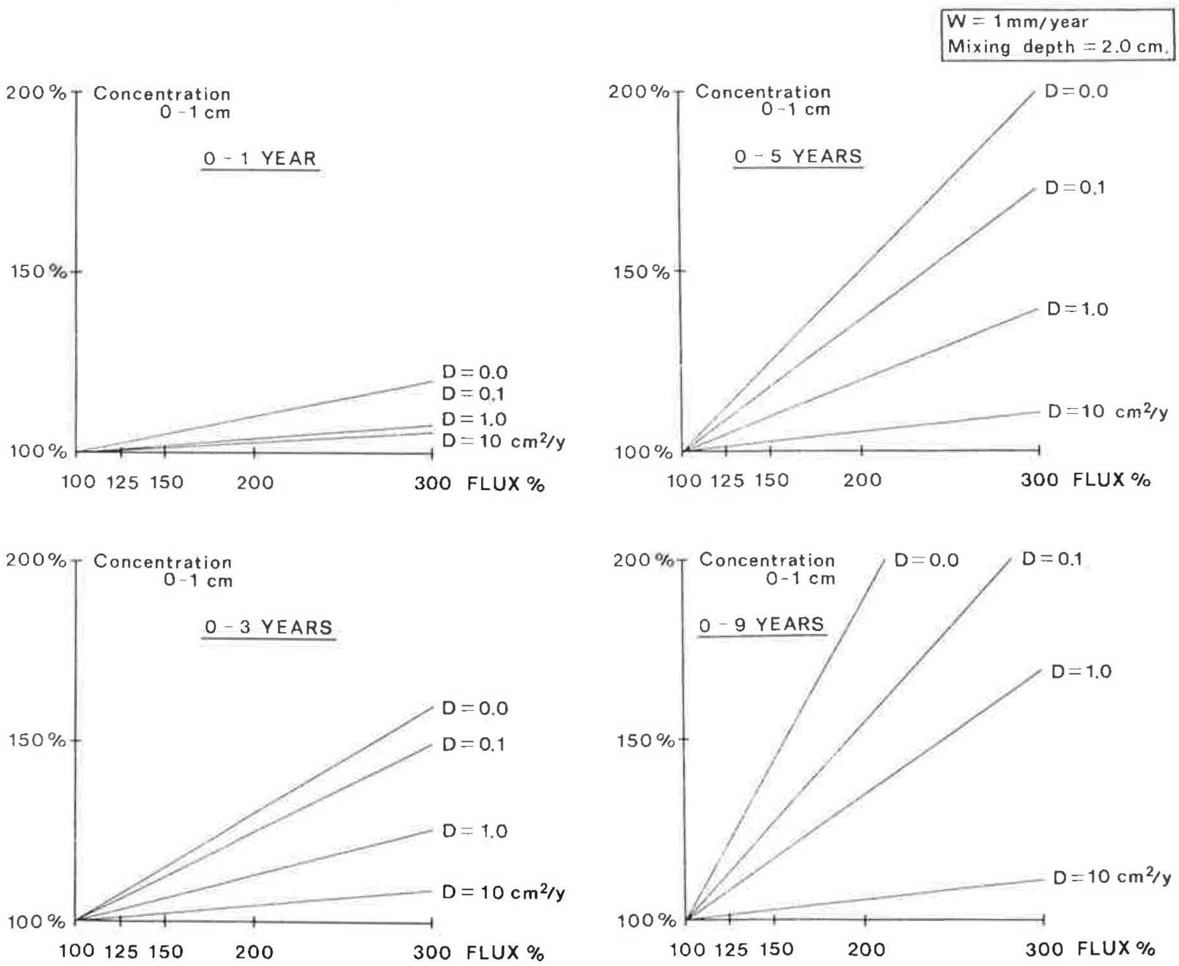

Figure 2 Surface concentration as a function of changing flux for different mixing coefficients (D) and for different time spans.

If the flux of a compound has been doubled (increase 200%) for a three-year period, the concentration in the topmost 0-1 cm sample will increase 130% with no mixing, but only 113% if the mixing rate is 1 cm^2/yr.

Use of the graphs for sensitivity analysis

The diagrams may be used to estimate the change in the flux of a compound necessary before a significant change in the concentration of that compound is detectable. Chemical analysis for trace metals is carried out with standard deviations not less than 5% (Loring, 1987) and it is accepted that a difference of at least two times the standard deviation is necessary before a significant change between samples can be detected.

As seen from Figure 2, an increase of 135% in the flux during the entire three-year period, with no mixing produces the lowest detectable concentration difference of 110% between samples. If $D = 1\ cm^2/year$, the change in flux must exceed 170% for the entire period in order to produce a detectable difference in concentrations.

Conclusion

These examples indicate that it is possible to make estimations of the sensitivity of a given sediment site for trend monitoring, using parameters obtained by modelling Pb-210 profiles. The sensitivity is not a constant, but varies from one site to another due to differences in the sedimentation parameters. The accumulation rate of 1 mm/year used in this example is fairly typical for mud basins in the Danish Seas and the Baltic. The mixing depth of 2 cm used in this study is among the smaller values. Thus, it appears that in only a few circumstances are sediments very sensitive indicators of changes in fluxes to the seafloor. Fluxes of most trace metals have increased by a factor of between 2 and 7 in the Danish Seas during the period from 1850 up to the present (Pheiffer Madsen and Larsen, 1986), which indicates that an annual increase of 110% in concentration should be considered large. It is, therefore, very important that sediment sites for long-term monitoring are very carefully selected, and that the mixing is checked at each sampling of the station; otherwise very substantial changes in the load of contaminants may go undetected.

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ANNEX 3

OVERVIEW OF INTERCALIBRATION/INTERCOMPARISON EXERCISES COORDINATED BY ICES

Trace Metals in Biota

First ICES Intercalibration Exercise on Trace Metals in Biological Tissue (1/TM/BT) 1972.

Coordinator : G. Topping, United Kingdom.
Sample : Fish flour prepared from commercial fish meal.
Metals analysed: Hg, Cu, Zn, Cd and Pb.
Participation : 8 laboratories from 7 countries around the North Sea.

Results published in Cooperative Research Report No. 80 (1978).

Second ICES Intercalibration Exercise on Trace Metals in Biological Tissue (2/TM/BT) 1973.

Coordinator : G. Topping, United Kingdom.
Samples : Fish flour prepared from unskinned muscle of inshore cod and acidified solution of metals.
Metals analysed: Hg, Cu, Zn, Cd and Pb.
Participation : 15 laboratories in 11 countries around the North Sea and the Baltic Sea.

Results published for North Sea laboratories in Cooperative Research Report No. 80 (1978) and for Baltic laboratories in Cooperative Research Report No. 63 (1977).

Third ICES Intercalibration Exercise on Trace Metals in Biological Tissue (3/TM/BT) 1975.

Coordinator : G. Topping, United Kingdom.
Samples : (a) Fish flour prepared from skinned muscle of distant water cod and (b) individual reference standard solutions for each metal.
Metals analysed: Hg, Cu, Zn, Cd and Pb.
Participation : 29 laboratories in 17 ICES member countries.

Results published for North Sea laboratories in Cooperative Research Report No. 80 (1978) and for Baltic laboratories in Cooperative Research Report No. 63 (1977).

Fourth ICES Intercalibration Exercise on Trace Metals in Biological Tissue (4/TM/BT) 1977.

Coordinator : G. Topping, United Kingdom.
Samples : Same fish flour as in 3/TM/BT.
Metals analysed: Cd and Pb.
Participation : 12 of the laboratories which had participated in 3/TM/BT.

Results published in Cooperative Research Report No. 108 (1981).

Fifth ICES Intercalibration Exercise on Trace Metals in Biological Tissue (5/TM/BT) 1978.

Coordinator : G. Topping, United Kingdom.
Samples : (a) Fish flour prepared from skinned muscle of distant water cod and (b) the same fish flour extracted to produce a lower Hg concentration.
Metals analysed: Hg, Cu, Zn, Cd and Pb.
Participation : 41 laboratories, including those associated with the Joint Monitoring Programme, from all 18 ICES member countries plus several laboratories in Australia.

Results published in Cooperative Research Report No. 108 (1981).

Sixth ICES Intercalibration Exercise on Trace Metals in Biological Tissue (6/TM/BT) 1979.

Coordinator : G. Topping, United Kingdom.
Samples : (a) White meat of edible crab freeze-dried and ground into powder, (b) commercial fish meal freeze-dried and ground into powder, and (c) digestive gland of Canadian lobster treated and ground into powder.
Metals analysed: Hg, Cu, Zn, Cd and Pb.
Participation : 52 laboratories from 17 ICES member countries plus Australia.

Results published in Cooperative Research Report No. 110 (1981).

Seventh ICES Intercalibration Exercise on Trace Metals in Biological Tissue - Part 1 (7/TM/BT-1) 1983.

Coordinators : S.S. Berman and V.J. Boyko, Canada.
Samples : (a) Lobster hepatopancreas homogenized, spray-dried and acetone extracted, (b) scallop adductor muscle freeze-dried and ground, and (c) plaice muscle freeze-dried and ground.
Metals analysed: Hg, Cu, Zn, Cd, As and Pb.
Participation : 51 laboratories from 17 ICES member countries.

Results published in Cooperative Research Report No. 138 (1986).

Trace Metals in Sea Water

First ICES Intercalibration Exercise for Trace Metals in Sea Water (1/TM/SW) 1976.

Coordinator : P.G.W. Jones, United Kingdom.
Samples : Two standard solutions of metals.
Metals analysed: Hg, Pb, Ni, Co, Fe, Cr, Cu, Cd, Zn and Mn.
Participation : 41 laboratories from 14 ICES member countries.

Results published in Cooperative Research Report No. 125 (1983).

Second ICES Intercalibration Exercise for Trace Metals in Sea Water (2/TM/SW) 1976.

Coordinator	:	J. Olafsson, Iceland.
Samples	:	Two natural sea water samples and a mercury-spiked sea water sample; all acidified.
Metal analysed	:	Hg
Participation	:	14 laboratories from 10 ICES member countries.

Results published in Cooperative Research Report No. 125 (1983).

Third ICES Intercalibration Exercise for Trace Metals in Sea Water (3/TM/SW) 1977.

Coordinator	:	P.G.W. Jones, United Kingdom.
Samples	:	Two frozen samples of filtered sea water, one from open North Sea waters and one from coastal waters.
Metals analysed	:	Co, Fe, Ni, Pb, Cd, Cr, Cu, Mn, and Zn.
Participation	:	49 laboratories from 14 ICES member countries.

Results published in Cooperative Research Report No. 125 (1983).

Fourth ICES Intercalibration Exercise for Trace Metals in Sea Water (4/TM/SW) 1978.

Coordinators	:	J.M. Bewers, J. Dalziel, P.A. Yeats, and J.L. Barron, Canada.
Samples	:	Sets of six sea water samples consisting of four replicate sea water samples, one sample spiked with relevant metals and one dummy. Samples were frozen and acidified.
Metals analysed	:	Cd, Cu, Mn, Fe, Ni, Pb, and Zn.
Participation	:	43 laboratories from 13 ICES member countries plus Monaco.

Results published in Cooperative Research Report No. 105 (1981).

Fifth ICES Intercalibration Exercise for Trace Metals in Sea Water (5/TM/SW) 1982.

Coordinator	:	J.M. Bewers, P.A. Yeats, S.S. Berman, D. Cossa, Canada; C Alzieu, P. Courau, France.
Samples	:	(a) sea water samples, filtered and acidified, for analysis of metals except Hg; (b) sea water samples, natural and spiked, for analysis of Hg. In addition, 6 laboratories participated in an intercomparison of filtration procedures for coastal sea water samples.
Metals analysed	:	Cd, Cu, Pb, Zn, Ni, Fe, Mn.
Participation	:	59 laboratories from 15 ICES member countries plus Monaco.

Results published in Cooperative Research Report No. 136 (1986).

Exercises on trace metals in sea water coordinated by ICES for the Joint Monitoring Group of the Oslo and Paris Commissions (1979)

Cadmium

Coordinator	:	Y. Thibaud, France.
Samples	:	(a) Natural sea water, (b) sea water with a low Cd spike, and (c) sea water with a high Cd spike.
Participation	:	33 laboratories from all 13 member countries of the Oslo and Paris Commissions plus Canada and Monaco.

Mercury

Coordinator : J. Olafsson, Iceland.
Samples : (a) two samples of natural sea water, (b) sea water with a low Hg spike, and (c) sea water with a high Hg spike.
Participation : 36 laboratories from all 13 member countries of the Oslo and Paris Commissions plus Canada, Japan and the United States.

Results of both intercalibration exercises published in Cooperative Research Report No. 110 (1981).

Trace Metals in Marine Sediments

First ICES Intercalibration Exercise for Trace Metals in Marine Sediments (1/TM/MS) 1984.

Coordinator : D.H. Loring, Canada.
Samples : (a) Estuarine calcareous sandy mud sediment, (b) harbour sediment, and (c) Baltic mud sediment "MBSS" (from Baltic Sediment Intercalibration Exercise)
Metals analysed: Cd, Cr, Cu, Ni, Pb and Zn.
Optional metals: Ti, Fe, Mn and Al.
Participation : 40 laboratories from 11 ICES member countries.

Results published in Cooperative Research Report No. 143 (1987).

Baltic Sediment Intercalibration Exercise

Step 1: Intercomparison of Analyses of Reference Samples ABSS and MBSS, 1985.

Coordinators : L. Brügmann, German Democratic Republic and L. Niemistö, Finland.
Samples : Two mud sediments ("ABSS" and "MBSS") from different locations, dried and homogenized.
Analytes : Cu, Pb, Zn, Cd, Mn, Fe, Cr, Ni, and organic C.
Optional : Hg, Co, Al, inorganic C, P and N.
Participation : 42 laboratories from 15 ICES member countries.

Additional Exercise on Hg and Cd, 1985.

Coordinator : A. Jensen, Denmark.
Samples : Six samples, some of which were pre-treated.
Metals analysed: Hg and Cd.
Participation : 8 (Hg) and 10 (Cd) laboratories from 6 countries around the Baltic Sea.

Step 2: Intercomparison of Analyses of Sliced Wet Cores, 1984.

Coordinators : L. Brügmann, German Democratic Republic, L. Niemistö, Finland, and P. Pheiffer Madsen, Denmark.
Samples : 20 cm cores, sliced into 1-cm slices and deep frozen.
Main analytes : Cu, Cr, Zn, Pb, Mn, Cd, Fe, Ni, Al, Co, Hg, dry matter content, dating by Pb-210 technique.
Optional : Cs-137, organic C, N, P, clay minerals.
Participation : 11 laboratories from 6 countries around the Baltic Sea.

Results for the entire exercise published in Cooperative Research Report No. 147 (1987).

Organochlorines in Biological Tissue

First ICES Intercalibration Exercise for Organochlorine Residues in Biological Tissue (1/OC/BT) 1972.

Coordinator	:	A.V. Holden, United Kingdom.
Samples	:	(a) Natural fish oil and (b) same fish oil spiked with selected organochlorines.
Analytes	:	pp'-TDE, pp'-DDE, pp'-DDT, PCBs, dieldrin, γ-HCH
Participation	:	9 laboratories from 7 ICES member countries.

Results published in Cooperative Research Report No. 80 (1978).

Second ICES Intercalibration Exercise for Organochlorine Residues in Biological Tissue (2/OC/BT) 1974.

Coordinator	:	A.V. Holden, United Kingdom.
Samples	:	(a) unspiked maize oil and (b) same maize oil spiked with selected organochlorines.
Analytes	:	pp'-TDE, pp'-DDE, pp'-DDT, PCBs, dieldrin, γ-HCH
Participation	:	30 laboratories from 13 ICES member countries.

Results published in Cooperative Research Report No. 80 (1978) and, for Baltic laboratories, in Cooperative Research Report No. 63 (1977).

Third ICES Intercalibration Exercise for Organochlorine Residues in Biological Tissue (3/OC/BT) 1978.

Coordinator	:	A.V. Holden, United Kingdom.
Sample	:	Fish oil (capelin).
Analytes	:	pp'-TDE, pp'-DDE, pp'-DDT, PCBs, dieldrin, α-HCH, γ-HCH.
Participation	:	30 laboratories from 16 ICES member countries.

Results published in Cooperative Research Report No. 108 (1978).

Fourth ICES Intercalibration Exercise for Organochlorine Residues in Biological Tissue (4/OC/BT) 1979.

Coordinators	:	J.F. Uthe and C.J. Musial, Canada.
Samples	:	(a) Fish oil prepared from herring muscle tissue and (b) same oil spiked with PCBs.
Analytes	:	PCBs
Participation	:	23 laboratories from 12 ICES member countries.

Results published in Cooperative Research Report No. 115 (1982).

Fifth ICES Intercalibration Exercise for Organochlorine Residues in Biological Tissue (5/OC/BT) 1982.

Coordinators : J.F. Uthe and C.J. Musial, Canada.
Samples : (a) Herring oil and (b) same oil spiked with individual chlorobiphenyls (CBs).
Analytes : Individual CBs.
Participation : 30 laboratories.

Results published in Cooperative Research Report No. 136 (1986).

Sixth ICES Intercalibration Exercise for Organochlorine Residues in Biological Tissue (6/OC/BT) 1983.

Coordinators : L. Reutergårdh and K. Litzén, Sweden.
Samples : (a) Standard solution of 12 pure CBs, (b) solution of an internal standard, and (c) herring oil.
Analytes : Individual CBs.
Participation : 12 laboratories.

Results to be published in Cooperative Research Report series.

Hydrocarbons in Marine Samples

First ICES Intercomparison Exercise on Petroleum Hydrocarbons in Marine Samples (1/HC/BT and 1/HC/MS) 1980.

Coordinators : R.J. Law and J.E. Portmann, United Kingdom.
Samples : (a) Crude oil standard, (b) aliphatic fraction of crude oil standard, (c) marine sediment, and (d) mussel homogenate.
Analytes : Total hydrocarbons, aliphatic hydrocarbons (nC_7-nC_{33}), and several aromatic hydrocarbons.
Participation : 36 laboratories from 12 ICES member countries and Bermuda.

Results published in Cooperative Research Report No. 117 (1982).

ICES/IOC Intercomparison Exercise on Petroleum Hydrocarbons in Biological Tissues (2/HC/BT) 1984.

Coordinators : J.W. Farrington, A.C. Davis, J.B. Livramento, C.H. Clifford, N.M. Frew, A. Knap, United States.
Samples : (a) Three samples of frozen, freeze-dried mussel homogenate, (b) reagent grade chrysene, (c) methylene chloride solution of n-alkanes, (d) methylene chloride solution of aromatic hydrocarbons, and (e) Arabian Light Crude Oil standard.
Analytes : Aliphatic hydrocarbons (nC_{15}-nC_{32}) and selected aromatic hydrocarbons.
Participation : 38 laboratories from 13 ICES member countries and 12 laboratories from 11 IOC member countries (most, if not all, ICES member countries are also members of IOC).

Results published in Cooperative Research Report No. 141 (1986).

Third ICES Intercomparison Exercise on Polycyclic Aromatic Hydrocarbons in Biological Tissue (3/HC/BT) 1984.

Coordinators	: J.F. Uthe, C.J. Musial, and G.R. Sirota, Canada.
Samples	: (a) Acetone powder of lobster digestive gland, and (b) the oil extracted during the preparation of this powder.
Analytes	: 21 selected polycyclic aromatic hydrocarbons.
Participation	: 11 laboratories from 7 ICES member countries.

Results published in Cooperative Research Report No. 141 (1986).

ANNEX 4

RECENTLY PUBLISHED RELEVANT COOPERATIVE RESEARCH REPORTS

No.	Title
143	A Final Report on the ICES Intercalibration for Metals in Marine Sediments (I/TM/MS) (1987)
145	Reports of the Results of the ICES Coordinated Monitoring Programme: 1980 and 1981 (1987)
147	Report of the Results of the Baltic Sediment Intercalibration Exercise (1987)
149	Assessment of the Environmental Conditions in the Skagerrak and Kattegat (1987)
150	Report of the ICES Advisory Committee on Marine Pollution, 1987
151	Results of 1985 Baseline Study of Contaminants in Fish and Shellfish
152	ICES Sixth Round Intercalibration for Trace Metals in Estuarine Water (JMG 6/TM/SW)
154	Report of the *ad hoc* Study Group on "Environmental Impact of Mariculture"
155	The Status of Current Knowledge on Anthropogenic Influences in the Irish Sea
156	Marine Environmental and Water Quality Models

Indication of spine colours

Reports of the Advisory Committee on Fishery Management	Red
Reports of the Advisory Committee on Marine Pollution	Yellow
Fish Assessment Reports	Grey
Pollution Studies	Green
Others	Black

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