ICES COOPERATIVE RESEARCH REPORT

RAPPORT DES RECHERCHES COLLECTIVES

No. 204

REPORT OF
THE ICES ADVISORY COMMITTEE ON THE MARINE ENVIRONMENT, 1994

https://doi.org/10.17895/ices.pub.7984

ISBN 978-87-7482-685-9

ISSN 2707-7144

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Palægade 2-4, DK-1261 Copenhagen K
DENMARK

September 1994

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EXECUTIVE SUMMARY

The ICES Advisory Committee on the Marine Environment (ACME) met in Copenhagen from 25 to 31 May 1994, preceded on 24 May by a joint meeting with the ICES Advisory Committee on Fishery Management (ACFM). Based on this joint meeting, preliminary scientific criteria have been prepared for the establishment of undisturbed areas in the North Sea for scientific purposes. Advice on this topic was requested by the European Commission as a result of the declaration from the Intermediate Ministerial Meeting (Copenhagen, 7 - 8 December 1993), and based on the outcome of the *North Sea Quality Status Report* 1993. The Joint ACFM/ACME Report has been published as *ICES Cooperative Research Report* No. 203.

The present report contains advice deriving from the deliberations during the 1994 ACME meeting, based on questions posed to ICES by the regulatory Commissions, specifically the Oslo and Paris Commissions and the Helsinki Commission, as well as other issues considered relevant by the ACME.

Information in direct response to requests from, or which is relevant to, the work of both the Oslo and Paris Commissions and the Helsinki Commission

Monitoring

The ACME report contains advice in Section 4 on the formulation of specific quantifiable objectives for temporal trend monitoring, determining the power (or effectiveness) of temporal trend monitoring programmes, and choosing the correct organisms for this type of monitoring; a more detailed coverage of these topics is given in Annex 1. Section 4 also contains guidelines for designing and evaluating the effectiveness of temporal trend monitoring programmes.

The ACME has adopted a new statistical method for analysing data on contaminants in fish and shellfish for temporal trends (Section 5.2.1); the details of this method will be published in the *ICES Techniques in Marine Environmental Sciences* series in late 1994.

In terms of monitoring the spatial distribution of contaminants using marine biota, Section 5.1 of the report provides criteria for the selection of organisms for this monitoring purpose. Using these criteria, the ACME has proposed the use of the viviparous blenny (eelpout) and, particularly in coastal areas, benthic macroalgae in such programmes.

The 1994 ACME report contains information (Section 5.4) on biological monitoring techniques which are designed to determine the toxicity of sediments and sediment pore water; these techniques are particularly relevant to determining sediment quality and to the potential development of sediment quality objectives.

As a supplement to the Guidelines on the Use of Sediments in Marine Monitoring Programmes, presented in the 1993 ACME report, the ACME accepted a detailed description of a methodology for analysing chlorobiphenyls in sediments. This will be published in the *ICES Techniques in Marine Environmental Sciences* series in late 1994. In addition, further progress is reported on methods for the normalization of trace metal concentrations in sediments (Section 5.5.2) and the use of one of these methods, geochemical normalization, over wide geographical areas is demonstrated (Section 5.5.3).

Quality Assurance and Intercomparison Exercises

The ACME reviewed the results of several quality assurance activities, including the Fifth ICES Intercomparison Exercise on the Analysis of Nutrients in Sea Water (Section 6.6), the final step (Step 4) of the ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of Chlorobiphenyls in Marine Media (Section 6.3), and Phase 2 of the Intercomparison Exercise on the Analysis of Trace Metals in Suspended Particulate Matter (Section 6.7). Some of the implications of the results of these exercises for monitoring programmes are indicated.

Overviews of Contaminants in the Marine Environment

Brief summaries of information on the following contaminants in the marine environment: 3,3'-dichlorobenzidine, atrazine, and toxaphene (chlorinated bornanes) are provided in Section 12 of the report. Detailed overviews on the latter two contaminants will be published in the open literature.

Report sections responding to requests specific to the Oslo and Paris Commissions

Data Handling

The annual review of data handling activities relevant to Joint Monitoring Programme data by the ICES Environmental Data Centre is included in Section 2.2 of the 1994 ACME report. In addition, as requested by OSPARCOM, there is a feasibility study for establishing a data bank on marine benthos, particularly relating to the North Sea (Section 11.2 and Annex 4).

Report sections responding to requests specific to the Helsinki Commission

Marine Environmental Studies in the Baltic Sea

Preliminary information on the sites sampled in the Baseline Study of Contaminants in Baltic Sea Sediments is presented in Section 7.1 of the report. In addition, the final report of the ICES Steering Group on Fisheries/Environmental Management Objectives and Supporting Research Projects in the Baltic Sea is provided as Annex 2.

Status of Seal Populations in the Baltic Sea

ICES has been requested to provide an assessment of the impact of contaminants and by-catches on Baltic seal populations. However, there are presently insufficient data to be able to make such an in-depth assessment of the impact of contaminants or by-catches on these populations. Accordingly, the ACME proposed that a number of actions be taken by countries surrounding the Baltic Sea to collect relevant data. These proposals are contained in Section 10.2 of the report, along with some information on the present status of seal populations in the Baltic Sea.

Environmental Modelling

ICES has been asked to provide advice to HELCOM concerning the development of an environmental model for the Baltic Sea. The ACME, however, did not find the request sufficiently precise to be able to provide any direct advice. Some information regarding the types of activities for which models can be a useful tool is contained in Section 16.

Information on topics of general interest

Dredging of Marine Aggregates

The ACME approved Guidelines for Environmental Impact Assessments of Marine Aggregates Dredging. These guidelines (Section 15) specify the types of information required so that the physical and biological impacts of proposed extractions of marine sand, gravel, and shell deposits can be obtained and the overall impact on the environment evaluated.

Environmental Impacts of Mariculture

The ACME reviewed recent information on environmental impacts of mariculture, including new approaches to environmental assessment and monitoring of mariculture operations, guidelines on the evaluation of the environmental effects of therapeutic chemicals, and mariculture considerations relevant to coastal zone management (Section 13).

Introductions and Transfers of Marine Organisms

The ACME approved a revised Code of Practice on Introductions and Transfers of Marine Organisms, to be used particularly with regard to mariculture operations (Section 14.1 and Annex 3). This code now also includes the use of genetically modified organisms. Information is also included in the report on accidental transfers of organisms via ballast water and their effects, and on several specific cases of proposed or completed introductions of marine organisms.

Fish Diseases and Related Issues

The ACME reviewed available information on the occurrence of an unknown mortality factor, termed M-74, in salmon hatcheries in the Baltic Sea and endorsed a list of research needs relevant to developing a better understanding of the causes and consequences of this phenomenon (Section 9.1). The ACME also briefly reviewed the occurrence of *Ichthyophonus* in herring, and progress in studies of fish diseases in the Baltic Sea (Sections 9.2 and 9.3). In addition, approaches to investigating relationships between fish diseases and pollution are described in Section 9.4.

Ecological Quality Criteria and Objectives

A review of the ACME discussion of the potential role of ICES in the development of ecological quality criteria is found in Section 17.

Sources of information considered by the ACME at its 1994 meeting

At its 1994 meeting, the ACME considered, *inter alia*, the most recent report of the following ICES groups:

BEWG	Benthos Ecology Working Group
MCWG*	Marine Chemistry Working Group
SGCBS	Steering Group for the Coordination of the Baseline Study of Contaminants in Baltic Sea Sediments
SGFEM	Steering Group on Fisheries/Environmental Management Objectives and Supporting Research Programmes in the Baltic Sea
SGM74	Study Group on the Occurrence of M-74 in Fish Stocks
SGQAB	Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea
SGQAC	Steering Group on Quality Assurance of Chemical Measurements in the Baltic Sea
SGSFI	Study Group on Seabird/Fish Interactions
SGSSC	Study Group on Seals and Small Cetaceans in European Seas
SGZP	Study Group on Zooplankton Production
WGBEC*	Working Group on Biological Effects of Contaminants
WGBME	Working Group on the Baltic Marine Environment
WGEAMS*	Working Group on Environmental Assessment and Monitoring Strategies
WGEEMS	Working Group on the Effects of Extraction of Marine Sediments on Fisheries
WGEIM	Working Group on Environmental Interactions of Mariculture
WGHAB	ICES/IOC Working Group on Harmful Algal Bloom Dynamics
WGITMO*	Working Group on Introductions and Transfers of Marine Organisms
WGMS*	Working Group on Marine Sediments in Relation to Pollution
WGPDMO	Working Group on Pathology and Diseases of Marine Organisms
WGPE	Working Group on Phytoplankton Ecology
WGSAEM*	Working Group on Statistical Aspects of Environmental Monitoring

*These groups report directly to ACME

Reports of the following other activities were also considered:

Joint Meeting of the ICES/IOC Working Group on Harmful Algal Bloom Dynamics and the Working Group on Shelf Seas Oceanography

Joint Meeting of the Working Group on Marine Sediments in Relation to Pollution and the Working Group on Biological Effects of Contaminants

Meeting of the Sub-group on Temporal Trend Monitoring Programmes for Contaminants in Biota

ICES/HELCOM Workshop on Quality Assurance of Benthic Measurements in the Baltic Sea

1 INTRODUCTION

The Advisory Committee on the Marine Environment is the Council's official body for the provision of scientific advice and information on the marine environment, including marine pollution, as may be requested by ICES Member Countries, other bodies within ICES, and relevant regulatory Commissions. In handling these requests, the ACME draws on the expertise of its own members and on the work of various expert ICES Working Groups and Study Groups. The ACME considers the reports of these groups and requests them to carry out specific activities or to provide information on specific topics.

The ACME report is structured in terms of the topics covered at the ACME meeting on which it has prepared scientific information and advice; the topics include both those for which information has been requested by the Commissions or other bodies and those identified by the ACME to enhance the understanding of the marine environment. Information relevant to the Commissions' requests and specific issues highlighted by the ACME for their attention is summarized 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 PROGRESS ON TASKS FOR THE OSLO AND PARIS COMMISSIONS, INCLUDING AUTOMATIC DATA PROCESSING OF JMP DATA

2.1 Progress on Tasks on the 1994 Work Programme

A summary of the progress on the 1994 programme of work requested by the Oslo and Paris Commissions is given below, along with reference to the relevant sections and annexes of the report where more detailed information may be found. *This summary is provided according to the format of the Work Programme, with the headings and questions on the Work Programme shown in italics and a summary of the ACME advice below in normal print.*

1. MONITORING TECHNIQUES

1.1 to provide definitive recommendations for monitoring contaminants in sediments;

In Annex 1 of the 1993 ACME report, ICES provided Guidelines for the Use of Sediments in Marine Monitoring in the Context of Oslo and Paris Commissions Programmes. These Guidelines contain generic advice on sampling, analysis, and data interpretation, followed by four technical annexes containing more detailed information on these topics, as well as information on normalization techniques, statistical aspects, and quality assurance requirements.

Section 5.5 of the 1994 ACME report provides a brief summary of guidelines for the analysis of CBs in sediments that have been prepared to accompany the above-mentioned overall guidelines. The detailed methodology will be published in the *ICES Techniques in Marine Environmental Sciences* series. In addition, this section contains a review of the advantages and disadvantages of the two main types of normalization techniques used in studies of contaminants in sediments, an example of the use of geochemical normalization on trace metal concentrations in sediments from various geographical areas, and brief notes on several analytical issues.

1.2 to identify suitable organisms for spatial monitoring of contaminants in biota;

In Section 5.1 of this report, the ACME has provided criteria for the selection of organisms for use in monitoring the spatial distribution of contaminants in biota, and has proposed the inclusion of viviparous blenny (eelpout) and, particularly in coastal areas, benthic macroalgae in such monitoring programmes.

1.3 to investigate the use of new species or techniques for biological effects monitoring;

Some information on this topic is presented in Section 5.3 of this report.

2. QUALITY ASSURANCE

2.1 to report on the implications of the results of the fifth intercomparison exercise on nutrients in sea water for laboratories reporting data to OSPAR programmes;

Section 6.6 of this report contains a summary of the results of this intercomparison exercise, with some indications of the implications for laboratories contributing to OSPARCOM monitoring programmes for nutrients.

2.2 to provide, for the contaminants currently monitored under the JMP, information on the level of comparability achieved among participating laboratories in the most recent relevant intercomparison exercise;

Section 6.8 provides a summary of the level of comparability achieved among laboratories participating in the most recent intercomparison exercises for analyses of nutrients in sea water and chlorobiphenyls in sediments and seal blubber. No information can be provided at this time for trace metal analyses.

2.3 to consider the need for an intercomparison exercise for measurements of lipids in marine samples;

Some information on this topic is contained in Section 6.5 of this report.

3. METHODOLOGIES

3.1 to further develop statistical techniques for the evaluation of data on temporal trends of contaminants in fish and shellfish;

In Section 5.2 of this report, the ACME adopted a revised statistical method for analysing data on contaminants in biota for temporal trends; this is the method that was utilized for the 1993 assessment of JMP data. The full method will be published in the *ICES Techniques in Marine Environmental Sciences* series. The ACME also reviewed graphical techniques for presenting the results of temporal trend assessments in a management context.

In addition, the results of a major review of strategies for monitoring temporal trends of contaminants in biota were reviewed in terms of preparing a more quantitative definition of monitoring objectives, the determination of the effectiveness of the programme to meet these objectives, and the choice of monitoring organisms. A summary of this information is contained in Section 4.1 of this report, with a more detailed treatment in Annex 1.

3.2 to prepare a report on the biological availability of contaminants in sediments and dredged material and the relevance of sediment quality standards;

In continuation of work reported on in the 1993 ACME report, Section 5.4 of the present report contains information relevant to the assessment of the availability of contaminants in sediments, including a review of various types of tests to provide relevant data. A review has also been prepared of several approaches to the development of sediment quality standards utilizing biological and chemical information.

DATA HANDLING IN 1994

1. *to carry out data handling activities relating to:*

   1.1 trend data for biota and sediments;

   1.2 data on seawater;

   1.3 data on biological effects;

   1.4 the possible re-assessment by AHWGM of the data of the 1990 Supplementary Baseline Study of Contaminants in Fish and Shellfish;

2. *to study the feasibility of integrating the benthos data currently held in a data base in Yerseke (the Netherlands) in the ICES data base.*

The data handling activities carried out relating to contaminants in biota, sediments and sea water and biological effects are briefly described in Section 2.2, immediately below. A summary of a feasibility study regarding the establishment of a benthos data bank in ICES is contained in Section 11.2 of this report, with the detailed information attached as Annex 4.

2.2 Handling of data for the Oslo and Paris Commissions

The ACME reviewed information presented by the ICES Secretariat on activities related to the handling of data from the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions. These data are stored in the ICES Environmental Data Bank which includes fish disease prevalence data and data on biological effects measurements in addition to data on contaminants in biota, sediments, and sea water.

2.2.1 The AHWGM assessment of data for temporal trends in contaminants in biota

ICES assisted the OSPARCOM *Ad Hoc* Working Group on Monitoring (AHWGM) in the assessment of JMP data for temporal trends in contaminant concentrations (organics and trace metals) in biota (fish and shellfish). This assistance involved incorporation of the data submitted for the programme into the Environmental Data Bank, validation of the data, distribution of quality assurance (QA) data to QA-experts nominated by OSPARCOM, checking the data for compliance with the guidelines, and preparation of output products during the assessment meeting, which was held in November 1993.

The AHWGM meeting assessed data from 1978 up to and including 1991. The deadline for submission of the data was 30 April 1993, but fewer than half of the countries met this deadline. First and second validation rounds were conducted to resolve outstanding problems with the data. Again, fewer than half of the countries were able to meet their deadlines.

In order to facilitate the handling and validation of the data, the eighteenth meeting of the OSPARCOM Joint Monitoring Group (JMG18) decided that each country should nominate national coordinators to be responsible for reporting monitoring data to ICES. One country met the deadline for nominating its coordinator, eleven countries nominated experts up to five months after the agreed deadline. The staff at the ICES Secretariat found that the system of national coordinators functions satisfactorily. It improved the contact with the national data centres and resulted in better quality data submissions.

JMG18 decided that quality assurance (QA) information should be supplied together with the monitoring data on contaminants in biota, and that this information should be evaluated by nominated QA-experts prior to the assessment. Two QA-experts were nominated by OSPARCOM, and the ICES Environment Department supplied them with the necessary information. The results of their work formed the basis for the evaluation of data for the assessment.

The data sets to be assessed were checked for compliance with monitoring guidelines prior to the assessment, to the extent possible. The JMG Guidelines state that 25 individual fish or three pools of 20 individuals of shellfish should be collected and analysed for trend monitoring purposes. A review of the data sets demonstrated that this requirement is often violated, thereby reducing the ability of the programme to detect trends.

The statistical procedure previously applied for the analysis of temporal trends in contaminant concentrations in biota had several weaknesses, including sensitivity to extreme outliers and unequal variances. Moreover, the method required a considerable amount of judgement and intervention by the assessors during the analysis. Therefore, members of the ICES Working Group on Statistical Aspects of Environmental Monitoring developed a more robust procedure to overcome these shortcomings. The new procedure was implemented on the ICES computer system and applied during the 1993 temporal trend assessment (see also Section 5.2.1, below).

During the meeting of the AHWGM the ICES Environment Department supplied the meeting with results of the application of the agreed statistical procedure to the data sets and supplementary figures, maps, tables, etc.

The Environmental Data Bank holds approximately 110,000 records on contaminants in biota. Approximately 55,000 records were subject to analysis during the assessment.

2.2.2 Data on contaminants in sea water

The data bank on contaminants in sea water has received less attention over the years than the other environmental data banks. OSPARCOM has supported the maintenance of the data bank, but not any development. Moreover, neither the JMG nor scientists from other groups have shown an interest in assessing these data recently. For the data bank to be of any value in the future, a considerable effort is now required. This will involve the development of a program to check new data, as well as the use of manpower to check historical data. The 1994 meeting of the ICES Marine Chemistry Working Group (MCWG) addressed this issue and demonstrated a significant scientific interest in the data bank. The MCWG plans to conduct a workshop on the fate of trace metals in estuarine waters in 1995, where these data would be invaluable.

2.2.3 Other relevant activities

The ICES Environment Department supplied the OSPARCOM 'Workshop on Assessment Criteria for Chemical Data of the Joint Monitoring Programme (JMP)' with data on concentrations of contaminants in biota, sediments and sea water.

2.2.4 Improvements in data handling

The 1993 meeting of the AHWGM demonstrated the need to handle quality assurance data in a more consistent way. The AHWGM recommended ". . . that ICES be requested to include additional quantitative quality assurance information in the ICES data base, covering, for example, the composition of relevant reference materials, consensus values in intercomparison exercises, results submitted to intercomparison exercises, and other appropriate data." This recommendation was endorsed by JMG19. The Environment Department has initiated this work by setting up a data base on the composition of reference materials, based on the publication Standard and Reference Materials for Marine Science, prepared by the United States National Oceanic and Atmospheric Administration (NOAA).

Data submitted to the Environmental Data Bank should be in ASCII files with a structure and content as described in the ICES Environmental Data Reporting Format. To check a particular data file for compliance with this format, a PC-based screening program has been developed. This program was distributed to data originators as a test version in July 1993. The response has been positive, and the use of this screening program has removed the need for a great deal of the manual data checking by the Environment Department. A second version of the program was planned for release in August 1994.

3 PROGRESS ON TASKS FOR THE HELSINKI COMMISSION

The present status of work on 1994 requests by the Baltic Marine Environment Protection Commission (Helsinki Commission) is as follows:

Continuing responsibilities

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

A brief coverage of this topic is contained in Section 10 of this report. Better information is needed on by-catches of marine mammals in the Baltic Sea, and several proposals have been made concerning the collection of this information.

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

In Section 12, information is provided on atrazine in the estuarine environment and toxaphene in the marine environment. Brief notes are also provided on several other topics.

3. **To coordinate quality assurance activities on biological and chemical measurements in the Baltic Sea and report routinely on planned and ongoing ICES intercomparison exercises, and to provide a full report on the results;**

Sections 6.1 and 6.2 provide a summary of the activities coordinated by ICES concerning the development and implementation of quality assurance procedures for chemical and biological measurements in the Baltic Sea.

4. **To provide advice on further improvement of the BMP, particularly better sampling strategy and further improvement of the quality of the BMP data base;**

Section 4.1 of this report summarizes the results of a major review of strategies for monitoring temporal trends of contaminants in biota in terms of the preparation of a more quantitative definition of monitoring objectives, the determination of the effectiveness of the programme to meet these objectives, and the choice of monitoring organisms; more detailed treatment of this topic is contained in Annex 1.

In Section 4.2, guidelines for designing and evaluating the effectiveness of temporal trend monitoring programmes are provided.

In Section 5.1, the ACME sets out criteria for the selection of organisms for use in monitoring the spatial distribution of contaminants in biota, and proposes the inclusion of the viviparous blenny (eelpout) and, particularly in coastal areas, benthic macroalgae in such monitoring programmes.

Finally, Section 5.3 contains some information on biological effects monitoring techniques.

Special studies

5. **To coordinate the Baseline Study of Contaminants in Sediments, 1993, and the compilation and review of results;**

A review of some preliminary results of this Baseline Study is provided in Section 7.1. Analyses of the sediment samples for geochemical characteristics and contaminant concentrations are being conducted during 1995, and the results will be compiled and reviewed during 1996.

6. **To report on plans for and progress in investigations relevant to the estimation of net inputs of contaminants into the Baltic Sea;**

ICES has been unable to make progress on this task. A number of investigations have been initiated by different organizations in various areas of the Baltic Sea that are relevant to this topic. Information on the results of these projects will become available in due course. Accordingly, the ACME requests that this topic be removed from the work programme.

7. **In cooperation with the Baltic Marine Biologists, to prepare a preliminary report on fish diseases in the Baltic Sea and to provide plans for future studies of fish diseases in the Baltic Sea;**

Section 9.3 provides a brief summary of the activities that are being carried out in 1994 to collect information on fish diseases in the Baltic Sea and develop a standard methodology for cooperative studies of diseases in wild fish populations in the Baltic Sea.

8. **To provide guidance for the development of a model for the Baltic Sea suitable to be used for the prediction of changes in concentrations of relevant substances in Baltic marine compartments in response to specific reductions in the inputs of these substances;**

Some information on this topic is contained in Section 16, below. The ACME feels that this task cannot be accomplished on the basis of the information presently available on the use of such a model.

9. To prepare a chapter on fisheries and fish stocks, including coastal species of fish, in the Baltic Sea, as a contribution to the Third Periodic Assessment.

A brief report on the progress in the preparation of this chapter and other activities coordinated by ICES in association with the Third Periodic Assessment is presented in Section 7.3, below.

4 MONITORING STRATEGIES AND REVIEW OF MONITORING PROGRAMMES

4.1 Strategies for Monitoring Temporal Trends of Contaminants in Biota

Request

There is no specific request; this is part of the general work of ICES to review monitoring strategies and techniques on a regular basis.

Source of the information presented

The report of the Subgroup on Temporal Trend Monitoring Programmes for Contaminants in Biota; this Subgroup was established to review this type of programme and provide information on any necessary revisions.

Status/background information

The purposes of the Cooperative ICES Monitoring Studies Programme (CMP), the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions (OSPARCOM), and the Cooperative Monitoring in the Baltic Marine Environment (COMBINE) Programme under the Helsinki Commission are stated clearly, but there are no definitions of detailed quantitative objectives appropriate for any particular monitoring exercise.

At the 1993 ICES Statutory Meeting, a Sub-group on Temporal Trend Monitoring Programmes for Contaminants in Biota, composed of representatives from ICES working groups, was established (C.Res.1993/2:7:7) to reconsider the temporal trend monitoring programme for contaminants in biota (Objective 3 of the CMP).

The objectives, design and effectiveness of current temporal trend monitoring programmes for contaminants in biota were discussed and a detailed report was prepared by the Subgroup.

The ACME agreed that this report constitutes a sound basis for future improvements in monitoring programmes. Accordingly, the ACME agreed to include a summary of the Subgroup report below and attach more detailed information as Annex 1.

Monitoring Objectives

Within ICES and OSPARCOM, temporal trend monitoring of contaminants in biota has mainly been carried out to assess the efficacy of control measures. The broad objectives of the international programmes must be followed by more detailed, quantified objectives for each series of measurements. These detailed objectives should specify, at least, the control measure stimulating the programme, the expected change in contaminant concentration in the monitoring organism, the location of the sampling site, the species to be sampled, the period over which the expected change is predicted to occur, and the statistical power of the monitoring programme. With regard to trend monitoring in other matrices, or using different techniques, or for purposes other than assessing the efficacy of control measures, it is recommended that similarly detailed and quantified objectives be developed for these programmes as well.

Power

Power measures the effectiveness of a monitoring programme by quantifying the types and magnitudes of changes that are likely to be detected. Specifically, power is the probability that a specified change is detected.

Changes in sampling and analytical design can improve the power of the CMP, but quantifying this improvement is difficult without good estimates of the variance components, which are difficult to obtain. Indications, based on the recent JMP assessments, confirm that the present temporal trend monitoring programme of contaminants in biota would not, in general, be expected to detect a change of 10% per year over a 10-year period. The within-batch analytical precision seems to be sufficient, as does the number of samples analysed. Therefore, the poor power is due to one or more of the following:

a) the between-batch analytical variance is large;

b) the variance in the sampled population on the scale of a few weeks is large;

c) the random between-year variance in contaminant levels in the population is large.

Quality assurance (QA) data from the JMP suggest that the between-batch analytical variance for metals is small. A proper estimation of the corresponding value for organic contaminants, and of the variances described in b) and c) above, is not possible at present.

With estimates of the variance components, it is possible to calculate the benefit, in terms of the reduced total variance (and hence increased power), of

- dividing the chemical analyses among a number of separate batches each year, thereby reducing the influence of between-batch variation;

- collecting the samples on a number of separate expeditions each year, thereby reducing the influence of week-to-week variation in the population.

Although good estimates of the variance components are not available, preliminary calculations using data from the CMP and JMP suggest that either

- analysing 25 fish samples for organic contaminants in 5 batches of 5, rather than 1 batch of 25, or
- collecting fish samples on two expeditions each year rather than one

would decrease the total variance by about 20%.

Choice of Monitoring Organism

Temporal trend assessments of data are undertaken in order to assess the effectiveness of measures taken for the reduction of marine pollution. The interpretation of trend series of data on contaminant concentrations in biota has been hampered in the past by the lack of comprehensive time series data on contaminants in the marine environment.

Not all organisms are equally suitable as indicators for trends in contaminant levels. In order to find a relationship between control measures on inputs of contaminants and the concentrations of these contaminants in biota, the following basic requirements should be fulfilled:

- organisms should have an integrative ability for the target contaminants, i.e., they should have the capacity to smooth ambient variations of contaminant concentrations as a result of favourable rate constants of uptake and loss processes for the contaminant;
- organisms should have a high bioconcentration factor for the target contaminants;
- the uptake and elimination processes should take place at an appropriate rate in relation to the temporal sampling frame of the monitoring programme.

Furthermore, some practical considerations, such as ease of collection, a widespread distribution, an appropriate life span, and the fact that the organism should reflect the levels at the sampling site and therefore should be restricted to a certain area, are of importance.

The organisms selected for the JMP seem to be mostly chosen for practical reasons. In order to design an effective monitoring programme to link changes in the contaminant input rates to changes in contaminant concentrations in the biota, more attention should be given to the choice of the appropriate organism and the appropriate tissue. Information about uptake and elimination rates for the different monitoring organisms for different contaminants is of vital importance. Furthermore, attention should be given to the influence of factors which might affect the uptake and clearance rates, such as salinity, water temperature, seasonal variation, interaction between different contaminants in uptake, size and growth effects, etc.

A better understanding of the physiological processes would allow an estimate to be made of the expected change in contaminant concentrations in the biota as a result of the control measures, and also give some idea about the sources of variation. The monitoring programme can then be designed in such a way that it has the power to detect the expected changes.

To link the trends in biota to the trend series in inputs (or to trend series in water or sediment), the different monitoring programmes should be designed so that the frequency, the locations, and the periods of sampling will match.

Choice of Basis and Adjustment for Covariables

More work is necessary to determine the appropriate bases on which time series should be statistically analysed. In the meantime, it is important to emphasize the need to follow the ICES reporting guidelines, i.e., data should be reported on the basis on which the samples were chemically analysed, and supporting data should be included to allow the analyses to be expressed on other bases.

Adjustment for various covariables might improve the power of a time series. For example, when metal concentrations in cod liver are to be assessed, the fat content ought to be considered and adjusted for, if variation with fat content is found.

General

Although most of what has been discussed has been in the context of temporal trend monitoring with respect to control measures, the principles and methods are relevant to other monitoring purposes. For example, the effectiveness of baseline or spatial studies would improve if they were designed for an explicit target population and quantified objectives.

4.2 Guidelines for Designing and Evaluating the Effectiveness of Trend Monitoring Programmes

Request

There is no specific request; this is part of the general work of ICES to review monitoring issues on a regular basis.

Source of the information presented

Report of the Working Group on Environmental Assessment and Monitoring Strategies (WGEAMS) which includes a review of relevant issues from the report of the Subgroup on Temporal Trend Monitoring Programmes for Contaminants in Biota (SGTTM).

Status/background information

The Subgroup on Temporal Trend Monitoring Programmes for Contaminants in Biota (SGTTM) discussed in some detail the formulation of objectives for temporal trend monitoring programmes under the Cooperative ICES Monitoring Studies Programme (CMP) (which is also applicable to the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions (OSPARCOM)), the statistical definition of the power of these programmes, and the source of variance in temporal trend monitoring data. The choice of monitoring organisms and the bases on which to express contaminant concentrations in trend monitoring programmes so as to maximize the power (reduce the variance) were discussed to a lesser extent. This information was then reviewed by the Working Group on Environmental Assessment and Monitoring Strategies in the context of developing guidelines for evaluating the effectiveness of monitoring programmes.

The ACME agreed on the following guidelines for designing and evaluating the effectiveness of temporal trend monitoring programmes for contaminants in marine biota, as provided by WGEAMS.

Design

Concerning the design of a monitoring programme, the main conclusions are as follows:

- There are substantial benefits to be gained in trend monitoring programmes if the broad objectives of the programmes, for example, as stated in the JMP Guidelines and corresponding ICES documents, are supplemented by more detailed and quantified expressions of the objectives of individual monitoring efforts. Examples of possible formulations of such supplementary objectives are given in Annex 1, and they include the delineation of:

  1) the control measure giving rise to the programme,
  2) the contaminant to be measured,
  3) the species to be sampled,
  4) the precise location for sample collection,
  5) the duration of the programme,
  6) the starting date,
  7) the change in concentration to be detected by the programme,
  8) the period over which the change is expected to occur,
  9) the year in which the change is expected to start,
  10) the power of the programme to detect this change.

- The power of the programme expresses the probability of the programme to detect a change of a defined magnitude over a particular number of years. It is largely a function of the residual between-year variance once any underlying trend is removed. The larger the variance, the lesser the ability of the programme to detect changes.

The most important points on the evaluation of the effectiveness of monitoring programmes are that objectives should be quantified and programmes defined with the required power, or conversely that efforts should be made to quantify the power of existing monitoring programmes in order to assess the magnitude of change that should be detectable with an acceptable power. The latter expression could be used in comparison with expected changes to indicate whether existing monitoring programmes are likely to be able to detect changes considered to be important (i.e., interesting or significant, either environmentally or in relation to regulatory constraints). The value of specifying objectives if the effectiveness of monitoring programmes is to be assessed was also recognized, since a critical form of assessment would be to determine whether the programmes have met their objectives.

Evaluation

Concerning evaluation, it was recognized that the process of preparing environmental assessments, based on monitoring data, could be seen as providing an evaluation of the effectiveness of the monitoring effort, in that it could identify shortcomings and gaps in the information and could suggest new areas for monitoring or research. However, when using this approach, care should be taken to distinguish between data which have been provided for, and fully funded by, the monitoring programmes designed to provide the basis for the assessments, and those data which were obtained under other funds, yet made available to the assessment. The true cost of the data in an assessment is usually substantially greater than the funding allocated to monitoring activities.

It was also discussed whether an evaluation of the effectiveness of a monitoring programme should include references to the cost of the programme. Notwithstanding the difficulties that can occur in identifying true cost, the ACME felt that cost should be included on the grounds that effectiveness should include considerations of value-for-money. Programmes redesigned to give the same power at lower cost, or greater power at the same cost, must be considered to be improvements.

Based on the above discussions and relying heavily on being able to calculate the power of the programme and the ability to optimize sampling and analytical procedures in relation to the declared objectives, the following structure represents a feasible approach for evaluating the effectiveness of a monitoring programme for temporal trends of contaminants in biota:

1. ***What are the objectives of the programme?*** Preferably these will have previously been defined in quantitative terms.

2. ***Appoint a group of independent experts to carry out the evaluation.***

3. ***Decide what type of evaluation is required.*** For example, is an evaluation of the scope of the programme needed (i.e., were the most important subjects of concern included), which might lead to the recognition of gaps in the current work programme in relation to current objectives, or are the evaluators to look for new directions for the work? Other objectives might be centred on the power of the programme in relation to its objectives, or the value-for-money of the programme.

4. ***Present the objectives of the evaluation as a series of questions to the evaluators.***

5. ***Decide how to define success of the programme.*** Do the objectives contain sufficient quantitative material to allow the development of simple criteria to define "success" and "failure" (and degrees between these two)?

6. ***If there are sufficient quantitative criteria, an assessment of the power of the programme in relation to the declared objectives should be made.*** If the objectives are not sufficiently quantified, the power of the programme should be estimated and placed against the likely changes to be observed.

7. ***Ensure that the evaluators have access to sufficient information about the programme,*** including general and detailed objectives, procedures, effort, results, and costs.

8. ***Ask the assessors to decide whether the monitoring meets the programme's requirements,*** i.e., whether both design and execution are adequate.

9. ***Assess whether changes in procedures can improve the power or performance of the programme,*** both in scientific and in financial terms.

It would be extremely useful to have similar advice prepared in relation to spatial distribution programmes, i.e., addressing the use of sediments and organisms, in particular, and providing advice on mapping procedures using sediments where the sediment characteristics are patchily distributed and on the use of biota, which are also patchily distributed.

5 MONITORING GUIDELINES AND TECHNIQUES

5.1 Organisms for Spatial Monitoring of Contaminants in Biota

Request

Item 1.2 of the 1994 Work Programme from the Oslo and Paris Commissions and, more generally, item 4 of the requests from the Helsinki Commission.

Source of the information presented

The 1994 report of the Working Group on Environmental Assessment and Monitoring Strategies (WGEAMS).

Status/background information

The current OSPARCOM Guidelines for the Joint Monitoring Programme (JMP), in relation to purpose (c), recommend as first choice species *Mytilus edulis* (blue mussel), *Limanda limanda* (dab), and *Gadus morhua* (Atlantic cod). Second choice species are *Crassostrea gigas* (Pacific oyster), *Nephrops norvegicus* (Norway lobster), *Platichthys flesus* (flounder), *Merlangius merlangus* (whiting), and *Merluccius merluccius* (hake). The HELCOM Baltic Monitoring Programme (BMP) Guidelines list the species *Gadus morhua* (Atlantic cod) and *Clupea harengus* (herring) as obligatory species, with *Macoma balthica* (Baltic tellin), *Mytilus edulis* (blue mussel), and *Mesidotea entomon* (an isopod) as tentative species. In the context of these guidelines, 'first choice' or 'obligatory' species means that these species are required to be sampled under the monitoring programme, if they occur in the area under investigation. If not, 'second choice' or 'tentative' species should be sampled; these latter can also be sampled to obtain supplementary information.

The ACME noted the specific request for advice on suitable organisms for monitoring the spatial distribution of contaminants in biota under the JMP, and agreed that this information could also be useful for the HELCOM BMP.

When selecting species to be monitored for contaminants and biological effects, some basic prerequisites should be considered, where possible:

- The organisms should accumulate the contaminant without being killed by the levels encountered in the marine environment.
- The organisms should be sedentary in order to be representative of the study area.
- The organisms should be resident within the study area throughout their life, including during the sensitive reproductive period and early life stages.
- The organisms should be abundant throughout the study area.
- The organisms should be sufficiently long-lived to allow the sampling of more than one year-class, if desired.
- The organisms should be of reasonable size, giving adequate amounts of tissue for chemical, biochemical, and physiological analyses.
- The organisms should be easy to sample and hardy enough to survive in the laboratory, allowing defecation before analysis (if desired), laboratory studies of contaminant uptake, and studies verifying biological field observations.
- The organisms should tolerate brackish water.
- The organisms of a given species used in a survey should exhibit the same correlation in the surrounding water, at all locations studied, under all conditions.

In addition to the organisms mentioned above that are already used in the JMP and BMP, the following organisms may be useful as supplementary species for coastal monitoring programmes:

a) **Viviparous blenny**

Only a few fish species are fully sedentary in the coastal waters of western Europe and the Baltic Sea. One species has, however, attracted attention not only due to its well-documented sedentary behaviour, but also because its mode of reproduction allows very specific studies to be made. This species, the viviparous blenny or eelpout (*Zoarces viviparus)*, has a wide distribution, including in estuaries, which makes it useful for all types of monitoring work, including pollution site monitoring.

A number of basic studies have been conducted to evaluate the possibility of including the viviparous blenny on the list of accepted indicators or as sentinel species for contaminant monitoring.

Its sedentary behaviour has been further documented by tagging experiments, verifying the previous opinion that it is a non-migratory species. Tagging, laboratory tests, and field experiments have confirmed that reproductive problems, expressed as mortality and slow growth of embryos, appear at low levels of contaminant exposure even when there are no signs of effects on the mother fish.

As in all organisms studied, seasonal variations in contaminant concentrations have been observed. However, the variations within samples were generally small, allowing trends to be detected with acceptable power provided that all sampling is carried out during a short and specified period of the year.

b) Benthic Macroalgae

Benthic macroalgae, *Fucus vesiculosus* (bladderwrack) in particular, can be used as indicator organisms for several metals in sea water, if the following precautions are taken:

- Samples should be collected within a limited period of time to avoid seasonal variation.
- Samples should be collected from localities with similar exposure to the sea.
- Parts of the bladderwrack of the same age should be compared, to avoid age-dependent differences in metal content.
- Depth, salinity, and water temperature at the different localities where the bladderwrack are collected should not fluctuate too much.
- The samples of bladderwrack should be free from epiphytes.

The information on the use of benthic algae for monitoring the distribution of contaminants can be summarized as follows:

- Benthic algae can be used to study accumulation from the water of, at least, the metals cadmium, zinc, lead, copper, and mercury.
- Benthic algae offer a potential for studying the accumulation of organic contaminants because polycyclic aromatic hydrocarbons (PAHs) have been successfully included in the monitoring of an aluminium smelter (however, the PAHs were determined as a group rather than as individual compounds).
- Benthic algae can be used to follow gradients in concentrations as well as variations in contamination within a year and between years.
- In gradient studies, the metal concentrations in algae seem to decline more rapidly with distance from the source than do the metal concentrations in mussels.
- Since only the new sprouts of algae are analysed, algae can provide a much faster response to decreasing levels of contamination than mussels. In a specific example of monitoring the lead contamination in a Greenland fjord, about 10–15 years were needed before a declining trend was observed in lead concentrations in mussels, whereas the algae showed a declining trend in lead concentrations after one year.

The metals listed above are not necessarily the only ones that can be monitored in algae, but rather reflect the results of two specific studies. The ACME noted that the following radionuclides can also be monitored in benthic algae: Cs-134, Cs-137, and Sr-90.

The general view of the ACME is that, in some circumstances, benthic algae are acceptable monitoring organisms and provide useful data if the sampling protocols are well designed and rigorously applied. However, the uncertainties about the effects of external environmental factors and internal physiological responses on the kinetics of uptake and excretion of metals indicate that benthic algae could most usefully be applied in projects restricted to localized areas or small regions. It should be borne in mind that only a fraction of the contaminants in the water may be available for uptake by benthic algae, i.e., the bioavailable fraction. This fraction may vary in both space and time.

c) Seabird Eggs

The ACME was informed that there is growing interest in the use of seabird eggs for monitoring marine contaminants, and an increasing need within the new ICES framework to become more involved in work with marine top predators, including seabirds. However, the expertise and information available at the present time are not sufficient to make a balanced assessment of the potential usefulness of seabird eggs in contaminant monitoring programmes.

Recommendations

The ACME recommends that *Zoarces viviparus* and benthic macroalgae be included in the JMP and the BMP as supplementary monitoring organisms, and points out that these organisms are particularly useful for coastal monitoring programmes.

The ACME further recommends that an intersessional review be carried out on the use of seabird eggs, and possibly other seabird tissues, in monitoring to determine the spatial distribution of contaminants in the marine environment.

5.2 Statistical Aspects of Environmental Monitoring

Request

Item 3.1 of the 1994 Work Programme from the Oslo and Paris Commissions.

Source of the information presented

The 1994 report of the Working Group on Statistical Aspects of Environmental Monitoring (WGSAEM).

Status/background information

Information is given below on a new method for the analysis of data on contaminants in fish and shellfish for temporal trends and on a new proposal for increasing the ability to interpret such assessments.

5.2.1 Revised Guidelines for Temporal Trend Analysis of Data on Contaminants in Fish and Shellfish

In 1986, the former ICES Advisory Committee on Marine Pollution adopted Guidelines for Temporal Trend Analysis of Data on Contaminants in Fish and Shellfish (ICES, 1987). These guidelines were used for a number of years, but recently members of the Working Group on Statistical Aspects of Environmental Monitoring (WGSAEM) began work to prepare a simpler and more robust method. This new method was thereafter tested in the assessment of OSPARCOM Joint Monitoring Programme data on contaminants in fish and shellfish for temporal trends, conducted in November 1993.

During the WGSAEM meeting, this revised method for temporal trend analysis and its application to the JMP data were reviewed. It was noted that this new technique presents the following advantages:

- it is simple and easy to apply and understand;
- it is robust (it requires no special treatment of outliers);
- it takes into account any possible size dependency of contaminant concentrations;
- it allows the assessment of the component of random between-year variation.

Some possible weaknesses of the method were evaluated and it was noted that the 3-point moving average used in this method does not introduce any important bias for trends typical of the marine environment, and the reduction in the power of the test for a linear trend resulting from the use of the median instead of the mean is small. Given the fact that this new method has proved satisfactory in the 1993 JMP assessments, the ACME was of the opinion that this new method should supersede the method published in the 1986 ACMP report for use in temporal trend analyses of data on contaminants in fish and shellfish. Rather than publish this method in the ACME report, the ACME recommended that it be published in the *ICES Techniques in Marine Environmental Sciences* series.

ICES, 1987. Guidelines for Temporal Trend Analysis of Data on Contaminants in Fish. *In* Report of the ICES Advisory Committee on Marine Pollution, 1986. ICES Coop. Res. Rep. 142: 15–17, 115–128.

5.2.2 Presentation of temporal trend data in formats for non-statisticians

The WGSAEM reviewed a method that had been developed to comply with the ACME request to review and report on further progress in the presentation of statistical data in formats readily acceptable by non-statisticians.

In addition, two graphical techniques were presented for exploring different monitoring designs. This presentation was the basis on which further work was done to incorporate costs into the graphs. The graphs basically consist of the plot in the plane of sampling and analytical efforts of the isopower lines on which are superimposed the effective cost isolines. The use of a non-parametric test (Mann-Kendall) for trend analysis was discussed. Current temporal trend assessments tend to focus on whether the contaminant level changes systematically over time. From a management point of view, it is however equally important to evaluate the current level of the contaminant and the variability of the data.

The WGSAEM has over the years prepared several proposed methods for increasing the interpretability of results from temporal trend assessments of contaminant concentrations. A new technique provides several means by which data might be more fully and usefully exploited. These include:

1) comparing trends against some 'management' or 'guidance' level,

2) in connection with 1), constructing a standardized index which can be compared across media, tissues, contaminants or areas, and

3) predicting future levels.

The method involves the calculation of the upper 95% confidence limit for a three-year-ahead forecast of the levels of a specific contaminant in a particular organism from a given area. This value is expressed relative to a defined 'management' level, and gives an index which can be compared across media, tissues, contaminants and areas.

The ACME found that these techniques are very useful and provide a good means of summarizing the large volume of information obtained during temporal trend assessments. It recommended that these methods be applied in future temporal trend assessments.

The WGSAEM also produced a report on a comparison of statistical tools and means to relate algal bloom occurrences to other factors; this report was complemented by a contribution dealing with multivariate trends in groups of phytoplankton species. This demonstrated that the choice of a good method depends on a well-formulated question being addressed by biologists to statisticians.

Finally, the WGSAEM reported on further progress in the use of covariables in the expression of contaminant concentrations and the reduction of residual variance on the basis of three examples:

1) the relationship between trace metal concentrations and lipid content in fish liver;

2) the effect of biological variables including shell length on contaminant concentrations in mussels; and

3) the most appropriate basis (wet weight, dry weight, or fat weight) on which to express the concentrations of contaminants, particularly organic contaminants.

5.3 Progress in the Development of Biological Effects Monitoring Techniques

Request

Item 1.3 of the 1994 Work Programme from the Oslo and Paris Commissions.

Source of the information presented

The 1994 report of the Working Group on Biological Effects of Contaminants (WGBEC).

Status/background information

At its 1994 meeting the WGBEC developed a strategy for incorporating biological effects monitoring in an integrated monitoring strategy, developed criteria for assessing biological effects techniques, and compiled a list of possible tools that are currently available for biological effects monitoring. Further refinement of this work will be carried out intersessionally between members of the WGBEC and the ACME.

5.3.1 Scope for growth

Scope for growth measurements in bivalve molluscs have been widely used to assess environmental quality during the past decade. Deployment of these techniques has occurred at two IOC-GEEP Biological Effects Workshops (Oslo, 1986; Bermuda, 1988), and two FAO/UNEP training workshops have been held where scope for growth measurements were a major component (Nice, 1992; Thailand, 1993). Dr J. Widdows has authored a paper on scope for growth ("Role of physiological energetics in ecotoxicology and environmental pollution monitoring") which will be published by FAO in the MAP Technical Report Series. The WGBEC agreed that this paper should also be considered for publication in the *ICES Techniques in Marine Environmental Sciences* series, in parallel with its publication by FAO, subject to agreement by FAO.

An interlaboratory comparison exercise on scope for growth measurements was recommended at the 1993 Statutory Meeting but has not yet been implemented.

5.3.2 New techniques

In response to ACME's request to review new developments in biological effects monitoring, the WGBEC considered studies on lysosomal stability (Lowe *et al.*, C.M.1993/E:32), a regional programme using the viviparous blenny as an indicator of environmental conditions in the OSPARCOM region and a joint pilot study in the OSPARCOM and HELCOM areas, and a report on the interfacial accumulation of contaminants. Further information on lysosomal stability, including the results from the ICES/IOC Bremerhaven Workshop, will be reviewed intersessionally and evaluated at the 1995 meeting of WGBEC. A review on molecular techniques for biological effects monitoring will also be considered.

5.4 Coordination of Chemical and Biological Effects Measurements for Sediment Quality Assessment

Request

Item 3.2 of the 1994 Work Programme from the Oslo and Paris Commissions.

Source of the information presented

This information is taken from the 1994 report of the Joint Meeting of the Working Group on Marine Sediments in Relation to Pollution (WGMS) and the Working Group on Biological Effects of Contaminants (WGBEC).

Status/background information

The ACME agreed to the following extract of the report of the 1994 Joint Meeting of WGMS and WGBEC.

5.4.1 Assessment of the availability of contaminants in sediments

At the outset of the consideration of this topic, it was noted that there was no clear consensus of the group as to how *availability* should be defined. Some members took *availability* to mean "available for bioaccumulation", whereas others took a rather wider view and allowed evidence of some reaction by organisms (a biological effect) to be considered as indicating *availability*. Reactions such as avoidance, or the induction of torpor, or cessation of normal feeding/ventilation processes could arise in response to a contaminant without there being significant accumulation of the contaminant in the organism. However, bioavailability is recognized to occur if a substance:

a) is bioaccumulated or bioconcentrated, and/or

b) if biological effects are observed.

After discussion, it was agreed that *a substance is bioavailable if an organism is exposed to it*, but that this has little meaning if the exposure does not result in *biological effects*.

The group agreed on chemical approaches to assess the availability of lipophilic neutral organic contaminants and inorganic contaminants in sediments. The most promising approach for the assessment of the availability of lipophilic neutral organic contaminants has been the equilibrium partitioning (EP) method. This approach is based on the assumption that uptake from the sediment by benthic organisms takes place through the mediation of the interstitial water. The concentrations of the contaminants in the interstitial water are calculated from carbon-normalized concentrations in the sediment by the organic carbon adsorption coefficient. The concentrations in organisms are then estimated using the derived concentration in interstitial water and another partition coefficient between the dissolved phase and the organism. All concentrations are assumed to be in equilibrium and governed by relatively simple principles of physical chemistry. This approach has been widely investigated by the U.S. Environmental Protection Agency (U.S. EPA), which is in the process of issuing sediment quality guidelines based on this approach for five chemicals, two polycyclic aromatic hydrocarbons (PAHs) and three chlorinated pesticides, whose properties make them particularly suited to this approach.

This approach has some application as a first step in a risk assessment, and it has been partially validated for a few compound/organism/sediment combinations by comparisons with direct measurements of sediment toxicity. However, detailed investigations have shown that the equilibrium partitioning approach tends to underestimate the accumulation potential. The calculations omit possible uptake by the oral route, synergistic relationships, steric factors, temperature effects, and toxic effects which may work to affect the rate of uptake (e.g., chemicals which cause gill damage may not be absorbed effectively through the gills). Furthermore, the susceptibility of certain benthic organisms (e.g., annelids) cannot be satisfactorily predicted because these types of organisms are not generally represented in the water column and their response to contaminants is therefore poorly understood.

It was agreed that equilibrium partitioning could provide an initial stage in risk assessment, but that it is not wholly reliable and requires support by actual experimental determinations.

To estimate the availability of inorganic contaminants in sediments, a number of approaches are available such as extraction with weak acetic acid, hydrochloric acid or acid volatile sulphide. However, the use of acid volatile sulphide measurements to estimate the available fraction of some metals has turned out to be rather less informative than had been anticipated a few years ago.

The equilibrium partitioning approach cannot be applied to polar organic contaminants or to metals. The physico-chemical processes influencing the behaviour of these substances in the environment are much more complex than those for neutral organics, and are not amenable to analysis using simple physico-chemical procedures.

Information recently published in the open literature clearly demonstrates that there is much to learn about the speciation of trace metals in marine sediments in order to assess better their potential biological effects. Also, it seems that pore water is a key medium through which metals become available to benthic organisms. Although there are very few reliable data on metals in marine pore waters, results from the Laurentian Trough reveal that the concentration of dissolved cadmium in sediments can vary by orders of magnitude in the first 5 cm below the sediment surface. The importance of research on the early diagenetic cycle of trace metals in marine sediments in relation to their availability to biota was clearly recognized.

The most common aim of chemists in investigating bioavailability is an assessment of the potential for the bioaccumulation of the chemical in question. In the case of organic compounds, one common approach is based on the total concentration of the contaminant in the sediment, probably together with some supporting parameters (such as organic carbon concentration, temperature, etc.) and from these measurements to predict the concentration that would arise in the target organism.

The prediction might be based on partitioning theory, uptake and excretion kinetics, or more complex bioenergetic models that can accommodate changes in feeding behaviour, partitioning of the contaminant between different phases of the sediment, and partitioning between different organs. In each case, the end product is an estimate of the final equilibrium concentration. Such approaches cannot include synergisms or additive toxicities.

On the other hand, toxicity tests seek to describe the impact of the contaminants on the test organism. Lack of understanding of the underlying mechanisms, and other complications including the number of possible uptake routes (e.g., through gills, orally, by direct contact with contaminated solids, etc.), the range of possible biological effects, and the number of potential test organisms, can make assessment of the toxicity of a sediment difficult without direct measurements.

In practice, the chemical approach seeks to estimate the *potential* availability, whilst the toxicological approach expresses the *actual* availability/toxicity of the compound(s) in the test conditions. The interface between the two approaches is not well defined, and few studies have attempted to cross it. Two possible approaches are:

a) undertaking more chemical analyses of organisms showing effects under test conditions, and linking the effects to contaminant concentrations in particular organs;

b) undertaking investigations of compounds having a known mode of exerting toxic effects, and exploring the mechanisms behind uptake, accumulation, metabolism/depuration, biological effect causation, etc.

These approaches could be used to increase the benefits from chemical and biological approximations of sediment toxicity.

It was suggested that, rather than attempting to estimate the bioavailable fraction of a contaminant in a sediment, the measurement that is actually required is an expression of the exposure of the organism to the contaminant in question. In the case of pelagic organisms, this is straightforward, and amounts to the concentration of the substance in the aqueous phase. Difficulties arise with organisms that consume sediment, or that consume other organisms in contaminated sediment (i.e., food chain/web effects). The exposure of the whole organism was considered to arise from three main routes:

a) through the water phase, i.e., substances in solution. These could be absorbed through the gills, the body wall, or the gut (drinking);

b) by direct exposure to contaminated solids, resulting in uptake without mediation by an aqueous phase;

c) orally, i.e., by feeding on sediments or on other organisms.

It is necessary to examine and quantify the potential for uptake by all these routes, and to link the resultant concentrations in tissues to effects measurements. A similar series of mechanisms should be constructed for the transfer of contaminants within organisms, using particular organs as accumulation and biological effects 'targets'.

In general, our theoretical understanding of actual bioavailability of contaminants from sediments is poor, therefore, the only reliable approach is the empirical one of measuring bioavailability directly.

Biological approaches and measurements to assess the bioavailability of contaminants from sediments were then considered.

Four main approaches have been used to assess bioavailability by direct toxicity measurements: solvent elutriation, seawater elutriation, pore water assessment, and whole sediment tests. The limitations of each approach were discussed in relation to sensitivity, difficulties of interpretation, and altering the availability of certain contaminants.

Whole sediment toxicity tests include standard regulatory assays in the United States and Canada. These toxicity/bioassay tests are the only available approach which permits sediment dwellers to be tested under conditions which approximate normality. However, currently available methods are almost exclusively short-term/acute in nature and are therefore not sensitive enough. Accordingly, long-term/chronic endpoints, such as cellular and subcellular responses, should be developed which promise to be considerably more sensitive.

As pore water is believed to be the primary controlling exposure medium in the toxicity of sediments to infaunal organisms, special attention was paid to the development and evaluation of the pore water test approach in the United States and the results appear to correlate well with sediment quality criteria developed in that country.

A variety of biological techniques are currently in use in national and regional monitoring programmes. These are summarized in the table below:

Type of test	Response	Organism
a) Biomarkers	Subcellular EROD Metallothionein AChE	Target organs in demersal fish, particularly flatfish
b) Whole sediment reworker	Acute toxicity and behaviour	*Corophium* *Arenicola* *Echinocardium* *Abra* *Rhepoxynius* *Ampelisca* *Neanthes*
c) Elutriate	Abnormal development Inhibition of luminescence Inhibition of growth	Oyster and *Mytilus* embryos Microtox Microalgae
d) Pore water	Abnormal larval development Decrease in luminescence Inhibition of growth	Oyster and *Mytilus* embryos Microtox Microalgae Sea urchin larvae Polychaetes
e) Sediment extract	Abnormal larval development Decrease in luminescence Inhibition of growth Mutagenicity	Oyster and *Mytilus* embryos Microtox Microalgae Sea urchin larvae Polychaetes Bacteria (Mutatox) Genotoxicity assay using bivalve and sea urchin embryos Ames test
f) Fish disease	Gross fish disease Liver histopathology	Particularly flatfish
g) Benthic community structure	Species diversity and abundance	Macro-, epi-, and meiobenthos

The microalgal growth tests, Microtox and Mutatox, should be regarded as experimental techniques. The other methods listed have been used in national monitoring programmes and have provided useful and interpretable data.

a) The biomarker techniques that have been widely used are EROD (ethoxyresorufin-O-deethylase induced by planar molecules), metallothionein ((MT) induced by copper, cadmium, zinc, and possibly mercury), and AChE (acetylcholinesterase inhibition by organophosphorus compounds and carbamates). In general, demersal fish are used since they live on the seabed close to the sediments and/or feed on animals that live in the sediments.

   The route of uptake is via pore water or through the food chain. The assays are carried out on appropriate target organs (e.g., brain/muscle for AChE). There are inherent problems with most biomarker assays: the fish are mobile which may lead to false negatives or positives; although there are good and validated methods, it is frequently difficult to interpret results due to complicating factors such as size, sex, and sexual maturity which may affect the response. In addition, opinions differ on whether biomarkers are markers only of exposure or indeed are markers that are indicative of a higher order response, such as liver or genetic damage.

   At present, flatfish are most commonly used as test organisms. Historically, dab was chosen for North Sea studies because it is ubiquitous in the North Sea and there is a higher prevalence of disease in dab populations than for other species. In future programmes, other species may be equally suitable; indeed flounder and dragonet have been used in estuarine studies. Documented data suggest that in some cases a good correlation exists between the responses of EROD, MT, and AChE and the concentrations of contaminants in the sediments (or food chain). There is a need to develop biomarkers for macrobenthos including infauna.

b) Whole sediment reworker tests use organisms that ingest, or feed directly on, sediment particles. The current tests measure acute toxicity and/or feeding behaviour over exposure periods of up to 10 days. All the techniques are robust and may be used on a variety of sediment types (with respect to particle size and anoxia), and are of similar sensitivity. The *Corophium* and *Arenicola* bioassays have been used routinely alongside the oyster embryo elutriate bioassay in monitoring programmes and comparable results have been obtained. At present, these bioassays are only suitable for use in heavily contaminated sediments. There is a pressing need to develop whole sediment reworker bioassays with chronic and sub-lethal endpoints (e.g., growth or reproduction).

c) Elutriation techniques have been used in the absence of suitable whole sediment reworker tests. A quantity of sediment is shaken with water (usual ratio 1:4), the sediment is removed by filtration or centrifugation, and the resultant filtrate is bioassayed using a water column organism. In principle, the bioassay may be carried out with any water column organism. However, the oyster embryo (or *Mytilus*) bioassay has been widely used with elutriation methods. A variation of this method is the exposure of the test organism to water overlying sediment. Microtox (inhibition of luminescence in bacteria) and microalgal growth have only been used experimentally with sediment elutriates. Results from elutriation bioassays are difficult to interpret. Some contaminants will preferentially elute from sediments, and the ratio of sediment to water used varies between studies.

   Elutriation techniques are perhaps most appropriate for studying the effects of dredged spoil disposal (at the site of dumping) and in areas where remobilization of sediment is a frequent occurrence.

d) Pore water tests involve the removal of interstitial water from sediments (e.g., by centrifugation, squeezing, or suction) and the subsequent bioassay of this water using a sensitive organism. As with elutriate bioassays, many organisms have been used but, in general, the same tests are employed (sea urchin bioassays, oyster or *Mytilus* embryo bioassay, and Microtox).

   Opinions differ on the value and interpretation of pore water tests. Clearly, the concentrations of contaminants in the interstitial water will depend on the partitioning of the contaminants between the sediments and the water phase. This will be different for each contaminant and each sediment. These tests are not commonly used in Europe, but are used routinely in North American monitoring studies. Pore water tests have the advantage of providing a rapid result and are therefore ideally suited as screening tests. Many samples can be analysed, dilution series can be prepared, and tests are sensitive compared to whole sediment tests.

e) There are several approaches that have been used to measure the mutagenicity of sediments but they have not been used routinely in monitoring studies. These tests include the Mutatox and Ames assays using organic extracts of sediments, and genotoxicity assays with sea urchin and bivalve embryos exposed to pore water.

f) Fish disease studies have been carried out for many years. Flatfish are most commonly used and studies may include gross fish disease and histopathology. Interpretation of the results is often difficult and, in many instances, it is not possible to link directly known levels and distributions of contaminants to disease occurrence. However, in some instances, contaminant-related effects have been observed, for example, in liver pathology in dab from the German Bight and around oil platforms in the North Sea; and in the USA in Boston Harbor (winter flounder) and in Puget Sound (Dover sole).

g) Benthic community analysis is a well-established and validated tool, especially in relation to point source discharges, and may include macro-, epi-, and meiofauna studies. There are many examples of contaminant-related effects, but considerable care is required to distinguish natural variations (e.g., arising from particle-size differences and water depth, or gradients of organic enrichment) from effects of contamination.

In general, the current suite of methods do not detect biological effects in offshore sediments. However, sediments near point sources (e.g., oil platforms) and in estuaries can show contaminant-related biological effects.

5.4.2 Opportunities for the utilization of biological and chemical information in the development of sediment quality standards

Three approaches to the development of sediment quality standards utilizing biological and chemical information were reviewed. It was recognized that other approaches have also been proposed in recent years.

OSPARCOM Workshop on Assessment Criteria

The OSPARCOM Workshop on Assessment Criteria for Chemical Data of the Joint Monitoring Programme (JMP) was held in Scheveningen, the Netherlands on 15–17 November 1993. The purpose of the Workshop was "to establish ecotoxicological reference values for chemical monitoring data of the North East Atlantic, i.e., concentration levels below which no harm to the marine environment is to be expected". All matrices relevant to the JMP were to be considered, i.e., water, sediments, and biota.

The following metals and organic contaminants were considered at the workshop: As, Cd, Cu, Cr, Pb, Hg, Ni, Zn, PAHs, lindane, DDE, dieldrin, PCBs, and tributyl tin (TBT). The workshop adopted the following rationale to derive reference values or ranges:

a) consider national guideline values (submitted by Canada, the Netherlands, Norway, and the United Kingdom); if values differed by more than a factor of three, a different approach was taken (see (b) below). If the national guideline values differed by less than a factor of three, the appropriate range was constructed (see (c) below).

b) i) evaluate available toxicity data for the relevant metals or organic contaminants,

   ii) apply a factor of 10, 100, or 1000 to the 'lower end' of toxicity data, depending on the quality and scope of toxicity data available (see Table 1).

c) construct a range of an order of magnitude encompassing the value resulting from (a) or (b), above, e.g., 1–10, 0.5–5, 10–100.

The workshop made a distinction between 'firm' and 'provisional' reference values (ranges). For a value (range) to be 'firm', the following data requirements had to be met (all for marine species):

- chronic or acute toxicity data were available for at least one fish, one alga, and one crustacean (or other 'sensitive' invertebrate);
- in addition, for sediment, data were available for one 'sensitive' sediment feeder for compounds with log K_{ow} >5;
- in addition, for biota, toxicity data were available for one mammal and one bird, as well as a measured bioconcentration factor (BCF) value for a fish or mollusc for compounds with log K_{ow} >5.

Table 1. Factors applied to the lower end of toxicity data to derive reference values (ranges).

Factor	Data requirement
1000	Acute $L(E)C_{50}$s, few data or few species (narrow range of species) – evaluate material carefully for outliers
100	i) Acute $L(E)C_{50}$s, many data, wide range of species ii) Chronic $L(E)C_{50}$s/NOEC, few data, few species
10	NOEC*, sufficient data and species

*NOEC – no observed effect concentration.

If the above requirements were not met, values (ranges) were designated as 'provisional'.

The approach outlined above was used in a straightforward manner for water. The reference values (ranges) refer to dissolved concentrations in sea water.

The reference values (ranges) for sediments refer to sediments with 1% organic carbon, although no general agreement was reached on methods of standardization. The equilibrium partitioning approach was used to derive reference values (ranges) for organic contaminants in sediment using the partition coefficient

$$K_d = 0.5 * K_{ow} * f_{oc}$$

where K_{ow} is the octanol/water partition coefficient and f_{oc} is the fraction of organic carbon in the sediment (0.01). Equilibrium partitioning was considered inappropriate for metals and TBT.

Sufficient toxicity data were available to derive 'firm' reference values (ranges) for trace metals and for TBT in sea water. For PAHs and lindane, the values were 'provisional' (based mainly on freshwater data).

All reference values (ranges) for sediments were 'provisional', as the quantity and quality of sediment toxicity data are limited. The proposed ranges were largely based on the North American Biological Effects Data Sets (BEDS). For some organic contaminants, the equilibrium partitioning approach was used to derive sediment reference values using water toxicity data. For some of the metals, the reference values (ranges) are close to or below background levels, and some further assessment may be needed.

Toxicity data relating to tissue concentrations are scarce and 'provisional' reference values (ranges) were only derived for strongly bioaccumulating compounds for which secondary poisoning is relevant (i.e., Hg, DDE, dieldrin, PCBs).

Sediment quality assessment guideline development in the United States

Sediment quality assessment guidelines have recently been developed, based on co-occurrence data on sediment chemistry and biological effects. Long and Morgan (1990) used co-occurrence biological effects data sets (BEDS) from freshwater, marine, and estuarine studies to develop ER-L (10th percentile) and ER-M (50th percentile) values of the BEDS for approximately 25 chemicals or classes of chemicals. More recently, MacDonald (1993) has used a similar approach to develop sediment quality guidelines with an expanded data set. MacDonald has limited his data to only marine and estuarine studies, but has included both BEDS and no biological effects data sets (NBEDS) to calculate no observed effects levels (NOEL) and probable effects levels (PEL) for 25 chemicals and classes of chemicals for which there is a sufficient number (>20) of acceptable co-occurrence data sets. A number of recent studies have shown a high degree of concordance between predicted (based on PEL values) and measured sediment toxicity (SAIC, 1992; USFWS, 1992; GERG, 1993; NBS, 1993).

United Kingdom sediment standards for disposal grounds

The work of the Metals Task Team of the UK Group Co-ordinating Sea Disposal Monitoring was reviewed. Their objective has been to develop Environmental Quality Standards (EQSs) for metals at sewage sludge disposal grounds to protect the ecosystem from the harmful effects of metals. The main reason for defining these values is the protection of the environment and this protection had to be available in the short term. It was therefore accepted that the scientific arguments used for such definitions, which are still being developed, had to be tempered with sound judgment in order to make valid values available for immediate use.

Initially, a review of methods for setting EQSs had been carried out. Of particular interest were the Apparent Effects Threshold (AET) and Long approaches from the United States, the Equilibrium Partitioning Approach, and the baseline value approach. After lengthy consideration, the UK group decided that exceeding the quality values defined should not require the initiation of management action, but should trigger further research, particularly biotesting. The results of such research might then lead to management action.

It was felt that the equilibrium partitioning approach was most suitable and this was used in conjunction with Water Quality Criteria from the U.S. EPA. Sediment values were calculated for cadmium, mercury, copper, lead, and zinc. However, the value for mercury was found to be lower than the crustal average and the value for cadmium to be unreasonably high. Therefore, these values were adjusted on the basis of expert knowledge and experience. Also, there were no Water Quality Criteria available for nickel or chromium, and these values were therefore defined on the basis of expert knowledge and experience. The values defined were termed Action Levels and are at present undergoing testing at UK sewage sludge disposal sites; the results are promising. Work is also underway to extend the Action Level concept for application at dredged material disposal sites.

Further development of sediment quality standards

In terms of the future development of sediment quality standards, two issues are important: the continued development of methods for the interpretation of existing chemical data for sediments and the adoption of biologically oriented monitoring programmes.

a) Ecotoxicological evaluation of chemical data

The interpretation of existing chemical data will be improved by an extension of the current approaches such as those described above. There is, however, a major requirement for more toxicological information on contaminants in marine sediments:

1) With regard to laboratory-based experimental work, there is a need for more tank studies using sediments spiked with individual contaminants.

2) At present there are several acute toxicity tests available for generating toxicologically based information, but there is a desperate need for toxicity assays that will give indications of chronic and sublethal effects on organisms. These would include whole life cycle, growth and reproduction tests, and bioassays conducted at critical points in the life cycle of representative marine organisms.

3) It is recognized that the existing approach does not consider the potential food chain effects of bioaccumulating contaminants. There is, therefore, a need to have information on the bioaccumulation of contaminants from sediments.

4) The existing US database on contaminated sediments from the field (co-occurrence data) will continue to be updated through monitoring programmes such as NOAA's National Status and Trends Program in the US and the inclusion of data from additional types of bioassays, such as pore water tests. It is recognized that other countries should be developing programmes that will contribute to this database, and

this is particularly so for the eastern Atlantic regions where the amount of existing data is minimal.

b) Development of biologically oriented monitoring

The criteria of sediment quality should be primarily biological. Therefore, the future development of sediment quality standards must address the question of how biologically based standards can replace the current domination of chemical criteria. The adoption of a problem-oriented basis for monitoring programmes, as suggested in recent proposals, will provide an opportunity for targeting coordinated biological and chemical measurements. Such an approach will require the selection of specific relevant biological effects techniques and the design of chemical programmes to assist in the interpretation of the biological measurements. This should provide more biologically focused monitoring activities and begin the process of moving towards biologically based criteria of sediment quality. There is a need to expand the repertoire of biological effects measurements that can be utilized in sediment monitoring.

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MacDonald, D.D. 1993. Development of an approach to the assessment of sediment quality in Florida coastal waters. Report prepared by MacDonald Environmental Sciences, Ltd., Ladysmith, British Columbia for the Florida Department of Environmental Regulation, Tallahassee, Florida, 133 pp.

National Biological Survey (NBS). 1993a. Toxicity testing of sediments from Pensacola Bay and St Andrew Bay, Florida. Final report submitted to U.S. National Oceanic and Atmospheric Administration, 18 pp + 22 tables and 4 attachments.

National Biological Survey (NBS). 1993b. Toxicity testing of sediments from Charleston Harbor, South Carolina and vicinity. Final report submitted to U.S. National Oceanic and Atmospheric Administration, 7 pp + 16 tables and 19 attachments.

Science Applications International Corporation (SAIC). 1992. Survey of sediment toxicity in Tampa Bay, Florida: Final Report. Report submitted by SAIC to NOAA, Ocean Assessment Division, Seattle, WA, 37 pp + 10 appendices.

U.S. Fish and Wildlife Service (USFWS). 1992. Amphipod solid-phase and sea urchin porewater toxicity tests of Tampa Bay, Florida sediments. Report submitted by the U.S. Fish and Wildlife Service to National Oceanic and Atmospheric Administration, Ocean Assessment Division, Seattle, WA, 9 pp + 19 appendices.

5.5 Techniques for Monitoring Contaminants in Sediments

5.5.1 Guidelines on the analysis of CBs in sediments

Request

Item 1.1 of the 1994 Work Programme from the Oslo and Paris Commissions.

Source of the information presented

The 1994 reports of the Marine Chemistry Working Group (MCWG) and the Working Group on Marine Sediments in Relation to Pollution (WGMS).

Status/background information

The ACME noted that in 1993 it had approved Guidelines for the Use of Sediments in Marine Monitoring Programmes, that had been prepared by the Working Group on Marine Sediments in Relation to Pollution (WGMS) at the request of the Joint Monitoring Group (JMG) of the Oslo and Paris Commissions. These guidelines comprise an introductory section containing generic advice on monitoring, sampling, analysis, and data interpretation, followed by four detailed technical annexes concerning, respectively, (1) sampling and analysis, (2) normalization techniques for studies of the spatial distribution of contaminants, (3) statistical aspects of the planning of sediment monitoring surveys and interpretation of the results, and (4) analytical quality assurance in the planning stage of sediment monitoring programmes and assessment. These guidelines have been published in the 1993 ACME report (ICES, 1994).

These guidelines do not include details of analytical methods, particularly with respect to organic contaminants. The Marine Chemistry Working Group (MCWG) had been requested to prepare information on the analysis of organic contaminants in sediments for ultimate inclusion in the guidelines.

At its 1994 meeting, the MCWG reviewed draft guidelines for the analysis of chlorobiphenyls (CBs) in sediments and provided them to the WGMS.

Following an examination of these draft guidelines on CB analysis in sediments, the ACME considered that they were too detailed for inclusion as a technical annex to the Guidelines for the Use of Sediments in Marine Monitoring Programmes. The ACME decided that they should be published in the *ICES Techniques in Marine Environmental Sciences* series, which could then be made available to the Commissions and other interested persons in this format. It should be noted that these guidelines will cover the following aspects of analytical work: general considerations; drying of sediment samples; extraction of both wet and dry samples; removal of sulphur from sediments; clean-up procedures; aspects of the measurement procedure by gas chromatography (column dimensions, stationary phases, carrier gas, injection techniques, and detection); and quality assurance procedures.

Recommendation

The guidelines on the analysis of CBs in sediments, as prepared by F. Smedes and J. de Boer, should be published in the *ICES Techniques in Marine Environmental Sciences* series.

ICES, 1994. Guidelines for the Use of Sediments in Marine Monitoring Programmes. *In* Report of the ICES Advisory Committee on the Marine Environment, 1993. ICES Coop. Res. Rep. 198: 45–57.

5.5.2 Progress on methods for the normalization of trace metal concentrations in sediments

Request

Technical Annex 2 of the Guidelines for the Use of Sediments in Marine Monitoring Programmes concerns the use of normalization as a procedure to compensate for the influence of natural processes on the measured variability in the concentrations of contaminants in sediments. Further consideration was given to this topic in 1994.

Source of the information presented

The 1994 report of the Working Group on Marine Sediments in Relation to Pollution (WGMS). The ACME noted that, in comparing and contrasting the two methods of normalization (geochemical and fine fraction approaches), the WGMS had drawn on papers submitted to the 1994 WGMS meeting and on the outcome of discussions during the evaluation of the results of the North Sea component of the data collected as part of the 1990 OSPARCOM Baseline Study of Contaminants in Sediments, as prepared by the ICES/NSTF/OSPARCOM *ad hoc* Working Group on Sediment Baseline Study Data Assessment (SEDMON) in 1990.

Status/background information

A summary of the advantages and disadvantages of the two methods of normalization is given below.

Geochemical normalization

Normalization with Al or Li, or Sc, Cs, etc. is used to compensate for the natural grain size and mineralogical variability of trace metal carriers in sediments. In a single geochemical province, where trace metal concentrations correlate with the Al or Li content, deviations from the regression line indicate a natural or anthropogenic enrichment. Li is generally superior to Al for normalization because it is not affected by feldspars in the coarse fraction. When this technique is used, chemical analyses are conducted on the whole sediment (<2 mm).

The ACME noted that the WGMS had identified the following advantages and disadvantages of geochemical normalization.

Advantages of geochemical normalization include:

- It represents compensation for grain size and most trace metal-bearing minerals;
- The total sediment is measured and therefore the total amount of the element per unit of mass or volume is known;
- The fraction of the metal of anthropogenic origin can be distinguished from the naturally incorporated amount of metal (if background data are available).

Disadvantages of geochemical normalization include:

- Areas with different levels of (general) contamination cannot easily be compared without data on uncontaminated background levels;
- In areas with some general level of contamination, the controlling variable giving the best correlation with a trace element varies from area to area. Each area may therefore have a different regression formula. In some cases organic carbon gives the best correlations, although it is not a conservative variable;
- The mineralogy of the sediment affects the relationship between the metal and aluminium. For example, sediments in areas that have been subjected to glaciation may contain aluminium-containing feldspars in

the coarse sediment fraction which reduce the Al-clay relationship;

- Calculations of the metal/Al ratios are sometimes problematic. When dealing with a regression with a large intercept, normalization of metal concentrations by division by the normalizer concentration can be misleading, particularly at low normalizer concentrations (e.g., in sandy sediments).

The above-mentioned phenomena influence the regression line between metal and normalizer. Whether the influence causes substantial errors in comparing data from wider areas, by the straightforward method of dividing metal content by Al (or Li) content, compared to other sources of variance, cannot yet be concluded.

Fine fraction normalization

Sieving is a method of physically separating that part of the sediment that has the highest specific adsorption capacity, namely, the fine fraction. Chemical analyses are then conducted on this fine fraction.

The ACME noted that the WGMS had identified the following advantages and disadvantages of normalization by sieving.

Advantages of normalization by sieving include:

- Specific trace metal concentrations in a fine size fraction are generally relatively high and many analysts consider that they are therefore measured with higher precision and accuracy;

- This method is equally applicable to trace metals and organic contaminants;

- In some small areas, normalization can be carried out relatively independently of mineralogy.

Disadvantages of normalization by sieving include:

- A grain size fraction does not represent a defined mineralogical entity;

- A larger quantity of original total sample is needed to obtain enough material for analysis (especially in the case of sandy samples: approximately 1–2 kg), which may make sampling difficult, especially in the investigation of cores;

- The total amount of the contaminant present at the site sampled is not determined;

- In some specific cases, contamination of a larger size fraction can be present and not detected unless the larger size fraction is analysed as well;

- Contamination of the sample with some elements (e.g., Zn and Ni) may occur during sieving and give an overestimation of the concentration of those elements. However, it should be noted that present experience shows no significant contamination;

- In the case of wet sieving (which gives better recovery than dry sieving), desorption might be possible and lead to an underestimation of contaminant concentrations, but this is generally not considered likely according to present experience.

Recommendation

Although the WGMS was unable to reach a unanimous conclusion about the relative value of geochemical and fine fraction normalization techniques, the ACME welcomed this comparative review and considered that this information would provide useful guidance to individuals and organizations using sediments for marine monitoring purposes.

In Section 5.5.3, below, additional information on normalization is presented in relation to the mineralogy of sediments and the application of normalization procedures in a number of different geographical areas.

5.5.3 Mineralogy of shelf sediments in the ICES area and its relevance with respect to normalization techniques

Request

There is no specific request; this is part of the general work of ICES to review monitoring-related issues on a regular basis.

Source of the information presented

The 1994 report of the Working Group on Marine Sediments in Relation to Pollution (WGMS).

Status/background information

Data for eastern Canadian sediments indicate that the mineralogy of the sediments is dominated by chemically immature material consisting of relatively unaltered primary silicate minerals in all size fractions, derived from the glacial erosion of unweathered crystalline rocks. The mineralogy of these sediments determines the major and trace metal composition.

The application of aluminium and lithium normalization procedures to sediments from the Arctic, the Gulf of St Lawrence area, the Bay of Fundy, the coastal areas off Florida, and the Gulf of Paria (between Trinidad and Venezuela) revealed the following:

- Aluminium can be used to normalize for most of the natural variability ($p < 0.001$) of chromium, copper, mercury, lead, vanadium, and zinc in most regions, with the exception of the Arctic (Cd, Cr, Cu, Hg, Pb, Zn), the St Lawrence estuary (Cr, Cu, Pb, V, Zn), Hg off Florida, and Pb in the Gulf of Paria.

- Lithium, however, can be used to normalize for most of the natural variability of Cd (data for Arctic only), Cr, Cu, Hg, Pb, V and Zn in all regions, except Pb in the Arctic and the Gulf of Paria, and Hg in the Arctic and off Florida. Overall, the metal:Li correlations are stronger than or equal to the metal:Al correlations in the different regions, except for the Cr:Al and Pb:Al correlations in the Florida sediments and the Cu:Al and V:Al correlations in the Gulf of Paria sediments.

- The main factor controlling the concentrations of Al, Li, and Li:Al ratios are climatic conditions. The mean Li content and Li:Al ratios tend to increase in the order of the maturity of the weathering products from immature glacial weathering products, to arid ones, and on to very mature humid ones.

The researcher concluded from this study that geochemical normalization is more effective than granulometric normalization (sieving).

On the basis of a report from the British Geological Survey concerning the lithic fragment and heavy minerals in seabed sediments from the Scottish coast and part of the northern North Sea, the distribution and nature of lithic fragments were shown to reflect aspects of the terrestrial geology. For example:

a) sediments west of the Hebrides contained fragments of high grade metamorphic basement rocks, as exposed on the Hebrides;

b) the area to the west of Scotland between Antrim and the North Minch contained materials derived from Tertiary igneous rocks, as found in Northern Ireland, Mull, Skye, and other areas of western Scotland;

c) coastal areas south of the Forth and Tay contained basic rock fragments, derived from the Midland valley of Scotland.

In general, the amount of heavy minerals, and their particle size, decreased offshore and with distance from source areas. There were clear indications of the transport of sand-grade sediment particles from the west of Scotland into the North Sea via the north of Shetland and also between Shetland and Orkney. These particles were not significant south of the Moray Firth.

The major element geochemistry of the sediment clearly reflected the different provenances of the material. Limited chemical analysis of trace elements indicated that concentrations were highest in the area containing particles from the west Scotland Tertiary igneous province.

The ACME also noted the outcome of intersessional German work on the applicability of multiple (complex) normalizers to samples that had been collected in the Kiel Bight and Lübeck Bight of the Baltic Sea, the central North Sea, the southeastern North Sea, and in the Iceland-Faroe area. In this study, whole sediments and sediment fines ($<20\ \mu m$), separated from the same samples, had been analysed for trace metals and for a number of candidate covariables (Al, Li, Fe, Ti, organic carbon, and carbonate) and the results assessed using a multiple linear model (STATGRAPHICS).

The multiple linear regression analysis identifies those covariables which contribute most towards accounting for the variance in the contaminant data. These most important covariables were found to vary between contaminant metals, to vary between areas for the same metal, and to vary between whole sediment and fine fractions for the same metal. The regression equations sometimes included significant constants, and in general accounted for more of the variance in whole sediment data than in fine fraction data.

Research

It is difficult to derive complex normalizers which are applicable over wider areas. Work on this topic will be continued under the WGMS and further information will be provided when available.

5.5.4 Sieving techniques for the separation of grain size fractions

Request

There is no specific request; some members of the WGMS carried out an examination of the relative efficiency of various sieving techniques for sediments as part of work towards the development of better advice on the use of sediments in marine monitoring.

Source of the information presented

The 1994 report of the Working Group on Marine Sediments in Relation to Pollution (WGMS).

Status/background information

The ACME noted the results of a study showing that when a freeze-dried mud was subjected to dry sieving, only a small quantity of fines passed through a 63 μm

mesh, whereas when a wet sieving method was used, about four times the quantity of fines passed through the mesh. It was evident from this work that dry sieving a freeze-dried mud in order to measure the quantity of fines in the sediment was unacceptable. These results, reported by one member of the WGMS, were confirmed by several other members.

The ACME noted, in contrast, that another member of WGMS had reported that wet sieving of a freeze-dried mud can be conducted successfully, provided that ultrasonic agitation and agate balls are used during the sieving process. This raised the question of whether freeze-drying before sieving should be a standard procedure, or whether it was acceptable to sieve some samples wet (immediately after collection) and others after freeze-drying.

In addition to addressing the sieving of samples for size fraction analysis, the WGMS had also discussed sieving procedures in relation to the chemical analysis of sediments. The ACME noted that four types of water could be used for wet sieving: de-ionized water, tap water, natural sea water, and artificial sea water. Although the WGMS agreed unanimously that tap water should not be employed for this purpose, the ACME noted that it was unable to come to a firm decision concerning the other options. The ACME also noted that, in the context of sediment metal analyses, the WGMS had addressed the questions of adsorption and loss of metals during the process of wet sieving.

Research

Since there were differences of opinion among members of the WGMS on both the quantitative measurement of sediment fines and the extraction of fines for chemical analysis, it was agreed that this situation should be clarified intersessionally through the compilation of existing information on this topic, which would then be reviewed by the WGMS at its 1995 meeting.

5.5.5 Determination of total organic carbon in sediments

Request

There is no specific request; the WGMS reviewed available methods for the determination of organic carbon concentrations in sediment, with a view to comparing instrumental methods (based on dry oxidation procedures) and methods involving wet oxidation techniques. This information will be of use in sediment monitoring work.

Source of the information presented

The 1994 report of the Working Group on Marine Sediments in Relation to Pollution (WGMS).

Status/background information

The methods available for the determination of organic carbon concentrations in sediments can be broadly divided into methods involving dry oxidation (often referred to as instrumental techniques) and those relying upon wet oxidation. In dry oxidation methods, the liberated carbon dioxide can be detected by a variety of techniques, including infra-red spectrometry, conductivity, gas burette, etc. Wet oxidation may be followed by detection of the liberated CO_2 as above, or else by determination of the excess oxidant not consumed during the digestion.

The WGMS concluded that elemental analysis by a CHN analyser was the more reliable method, provided that care was taken with the acid pre-treatment stage. Wet oxidation methods appeared to contain an unacceptable number of uncertainties, particularly those relying on the determination of excess oxidant.

The WGMS reported the following problems associated with the Loss on Ignition (LOI) method for determining the organic content of sediment:

a) there are unexpectedly high ratios between LOI and organic carbon levels;

b) a loss of water from clay minerals occurs during ignition, leading to falsely high results;

c) oxidation of sulphides occurs during ignition;

d) a partial decomposition of carbonates may occur during ignition. There is evidence in the scientific literature that aragonite and high magnesium calcite, and very fine-grained carbonate material, could be partially decomposed at the temperatures normally employed for ignition (450–550°C).

Research

The ACME noted that the WGMS will compile details of the methodologies used by its members in view of the possibly large number of variations on the basic wet or dry oxidation and acid pre-treatment techniques in use in the various laboratories; this may result in the beneficial exchange among members of useful information on small points of technique.

6 QUALITY ASSURANCE PROCEDURES AND INTERCOMPARISON EXERCISES

6.1 Quality Assurance of Biological Measurements in the Baltic Sea

Request

Item 3 of the 1994 requests from the Helsinki Commission.

Source of the information presented

A report containing a summary of the outcome of two workshops on quality assurance of biological measurements in the Baltic Sea, held in Kiel and Warnemünde, Germany, in March and April 1994, which was prepared by the Chairman of the Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea, and an extract from the 1994 report of the Benthos Ecology Working Group.

Status/background information

The ICES Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea organized two workshops in 1994, one for benthic parameters held in Kiel, Germany, on 23–25 March (Convener: Dr H. Rumohr) and one for pelagic parameters, held in Warnemünde, Germany, on 12–14 April (Convener: Dr J. Alheit). The workshops were requested to review and exchange information and experience about the potentials and limitations of current methodology, as well as to outline and plan relevant intercalibration/intercomparison exercises to be conducted in 1995. Furthermore, the ICES Benthos Ecology Working Group met in Yerseke, the Netherlands on 10–13 May 1994 and produced detailed guidelines on quality assurance (QA) procedures for benthos studies.

As the first step in a general implementation of QA procedures, the workshops recommended that each institute participating in the Baltic Monitoring Programme (BMP) of the Helsinki Commission should develop a QA programme for biological measurements and nominate one person to take responsibility for this task. The ACME recommended that the countries participating in the BMP follow these steps. The ACME further proposed that within the coming years an international project, similar to QUASIMEME (the Quality Assurance of Information for Marine Environmental Monitoring in Europe programme of the European Commission), should be established for biological measurements.

Furthermore, these two workshops pointed out that scientists have poor access to the HELCOM BMP database and, accordingly, the data are very rarely used by scientists.

6.1.1 Pelagic biological measurements

The discussion during the ICES/HELCOM Workshop on Quality Assurance of Pelagic Measurements in the Baltic Sea (Warnemünde, 12–14 April 1994) focused on both the implementation of QA procedures for the present Baltic Monitoring Programme and the revision of the BMP in terms of quality assurance. In this respect, the workshop was in a difficult position because the revision of the Baltic Monitoring Programme was scheduled to be discussed in another workshop two weeks thereafter, namely, the HELCOM Workshop on the Revision of the Baltic Monitoring Programme (BMP) and Guidelines (Copenhagen, 2–6 May 1994). Pending this revision, the QA Workshop could only consider methods contained in the present BMP, some of which were considered suitable for only very limited purposes. However, the QA Workshop produced a substantial set of recommendations for current methodology and documentation to ensure QA for various parameters.

High priority was given to training programmes and courses and to intercalibration/intercomparison exercises. Two training courses have already been organized under HELCOM for phytoplankton methods (Helsingør, 1992; Seili, 1993) and a third will be organized in Hel, Poland in late summer 1994. Similar courses were suggested for zooplankton and microbiological variables. The intercalibration/intercomparison exercises should be made on a disciplinary basis. A phytoplankton intercomparison exercise will be organized in connection with a training course in 1995.

For zooplankton, an intercomparison of different sampling gears has recently been conducted by the ICES Study Group on Zooplankton Production and this group is producing a new zooplankton methodology manual. In this connection, a task was given to the Baltic Marine Biologists (BMB) Working Group on Zooplankton to outline the types of intercalibrations needed for the Baltic Sea region. The HELCOM Expert Group on Microbiology has conducted intercomparison/intercalibration exercises on certain methodological steps and these will be continued during specific training sessions. In August 1994, a new joint multinational microbiology cruise in the Baltic Sea will be organized by Germany.

The ACME agreed that these types of disciplinary-based intercalibration/intercomparison activities might be the most effective, but stressed the responsibility of the Steering Group on Quality Assurance of Biological

Measurements in the Baltic Sea to guide, supervise and standardize the different activities.

New ideas and aspects to ensure better quality of the BMP data and to improve the cost-effectiveness of the programme were discussed during the workshop. Among these were (1) the inclusion of new techniques such as the use of 'ships of opportunity' into the BMP, (2) the conduct of baseline studies for biological parameters, e.g., biodiversity, and (3) dividing responsibilities among different nations and/or laboratories for monitoring some parameters or for geographical coverage. An example of the latter could be the establishment of an identification centre for phytoplankton and zooplankton or the nomination of one laboratory to make all analyses of some particular parameter which involves very expensive equipment.

The ACME considered that these new ideas were useful and supported them. However, it pointed out that dividing responsibilities, e.g., for species identification, should not result in a decrease of taxonomical skill in the other HELCOM countries but, rather, preferably increase it in all countries surrounding the Baltic Sea.

6.1.2 Benthic measurements

The ICES/HELCOM Workshop on Quality Assurance of Benthic Measurements in the Baltic Sea (Kiel, 23-25 March 1994) was satisfied with the present BMP sampling strategy. However, attention should be paid to the representativeness of the present sampling stations. A list of methodological recommendations to improve the quality of the BMP data was produced by this workshop; these were complemented and expanded to provide wider coverage of the ICES area by the Benthos Ecology Working Group. The importance of taxonomic workshops and other training activities, as well as the conduct of intercalibration/intercomparison exercises was emphasized.

It was decided that intercalibration/intercomparison exercises on macrozoobenthos in the Baltic Sea should be carried out on a regional basis in 1995. The workshop nominated countries to take responsibility for organizing the exercises in different subareas and determined which parameters should be included.

Recommendations

The ACME encouraged the development and implementation of QA procedures for biological measurements in the Baltic Sea area and the ICES area as a whole simultaneously in order that comparable methodologies and practices can be adopted over larger geographical areas.

6.2 Quality Assurance of Chemical Measurements in the Baltic Sea

Request

Item 3 of the 1994 requests from the Helsinki Commission.

Source of the information presented

The 1994 report of the Steering Group on Quality Assurance of Chemical Measurements in the Baltic Sea.

Status/background information

The ACME reviewed the report of the Steering Group on Quality Assurance of Chemical Measurements in the Baltic Sea (SGQAC) and was pleased to note that further progress has been made in the development and implementation of quality assurance (QA) activities.

One of the activities under this Steering Group, the ICES/HELCOM Workshop on Quality Assurance of Chemical Analytical Procedures for the Baltic Monitoring Programme (BMP), was held from 5 to 8 October 1993 in Hamburg. This Workshop focused on the following topics:

1) the importance and design of sampling strategies;

2) a description of collection procedures which assure that representative and uncontaminated samples are obtained;

3) the need for, and a description of, storage and pretreatment procedures which maintain the integrity of samples prior to their analysis;

4) appropriate instrumental procedures which provide measurements of the required accuracy and precision;

5) the design and implementation of in-house (i.e., within the laboratory) quality control procedures;

6) the need for, and a description of, documented procedures;

7) the role and use of certified reference materials and the preparation and use of uncertified reference materials;

8) quality assurance aspects of measurements of nutrients in sea water and metals and organic contaminants in biota.

It was further noted that the coordinating committee for the Workshop had arranged lectures at the Workshop, and that the written presentations, prepared in advance of the Workshop, addressed and provided practical advice on problems encountered by laboratories in the process of developing experience in their field and laboratory work.

Need for further research

The ACME noted with appreciation the progress that has been made in chemical quality assurance in the BMP laboratories, and agreed that further efforts are still needed in the Baltic Sea laboratories.

In particular, the ACME requested the SGQAC, as a task of high priority, to prepare detailed analytical QA guidelines for chemical components to be measured in the next phase of the Baltic Monitoring Programme.

Recommendations

The ACME noted with approval that the papers presented during the Workshop are to be published in the HELCOM *Baltic Sea Environment Proceedings* series.

Quality assurance activities should continue in the Baltic Sea laboratories. However, in view of the confusion caused by having two similar working groups on chemical QA, namely, the ICES Steering Group on Quality Assurance of Chemical Measurements in the Baltic Sea, and the HELCOM *ad hoc* Working Group on Chemical Quality Assurance, the ACME recommended that a joint ICES/HELCOM Working Group on Quality Assurance of Chemical Measurements in the Baltic Sea be established.

6.3 Results of Step 4 of the ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of Chlorobiphenyls in Marine Media

Request

This is part of the continuing ICES work of coordinating quality assurance activities and reporting on the results and their implications for monitoring programmes.

Source of the information presented

The draft report on the results of the ICES/IOC/OSPARCOM Intercomparison Programme on the Determination of Chlorobiphenyl Congeners in Marine Media, Step 4, and the 1994 report of the Marine Chemistry Working Group (MCWG).

Status/background information

At the 1994 meeting of the MCWG, a draft report was presented on the results of the fourth and, in principle, final step of the ICES/IOC/OSPARCOM Intercomparison Programme on the Determination of Chlorobiphenyls (CBs) in Marine Media. Since 1988 three exercises have been carried out using standard solutions of CBs, and cleaned and uncleaned extracts of seal blubber and sediment samples. In step 4, the matrices themselves, a seal oil, a dried sediment, and a sterilized fish tissue, without pretreatment were distributed to the participants. This enabled a study of the extraction of CBs from the different matrices, as well as a study of the overall performance of the participants. Forty-three laboratories participated in this exercise in which the following ten CBs were determined: CB Nos. 28, 31, 52, 101, 105, 118, 138, 153, 156, and 180.

The performance of the participants in analysing an unknown CB solution was comparable to that in previous exercises, generally resulting in standard deviations of log-transformed observations (SRs) of 1.12–1.19. Nevertheless, for some laboratories a suddenly poorer performance was observed. Improvement of quality control on the long-term variance of the analysis is, therefore, recommended.

For seal oil, acceptable results were only obtained for the determination of the major CBs 138, 153 and 180, with SRs of 1.12–1.16. The determination of other CBs, that are present in lower concentrations in seal, is apparently still difficult for the majority of the participants, with SRs of 1.20–4.81, although some individual laboratories produced acceptable results for most CBs.

In comparison with previous exercises, considerable progress was made for the analysis of CBs in dried sediment. SRs of 1.15–1.33 were obtained for all CBs. However, only for CBs 118, 138 and 153, with SRs of 1.15–1.17, would it be possible to detect changes of 50% or more in CB concentrations in sediment. Because analysis of wet sediment could add to the total error, at present the analysis of dried sediment is recommended.

The performance of the participants in analysing a wet cod muscle tissue was disappointing, with SRs of 1.51–3.84. CB concentrations in this sample were low, but not extraordinarily so, given the CB levels in fish reported in several international monitoring programmes. Apart from difficulties with CB extractions from wet tissue, there seems to be no reason why a similar performance as for the sediment could not be obtained. Therefore, participants were recommended to reconsider their extraction methods, including the drying time after grinding fish tissue with Na_2SO_4. The use of saponification, under controlled conditions, is also recommended.

In two optional exercises, participants were requested to determine the extractable and total lipid concentrations in cod muscle tissue and the total organic carbon (TOC) content in dried sediment. A total lipid determination, obtained using a standard method, is recommended for the determination of lipid concentrations in fish. Accordingly, extractable lipid concentrations should not be used for the normalization of CB concentrations. TOC determinations in dried sediment were reasonably comparable, with an SR of 1.41.

Recommendations

It is recommended that a further study on the extraction of CBs from wet fish tissue be conducted.

Total lipid measurements, obtained using a standard method, are recommended for the determination of lipid concentrations in fish.

The ACME recommended that the final report on the results of this exercise be published in the *ICES Cooperative Research Report* series.

Finally, the ACME expressed its appreciation to the Coordinators of this intercomparison programme, Dr J. de Boer (Netherlands Institute for Fishery Investigations) and Dr J. van der Meer (Netherlands Institute for Sea Research), for their excellent work and dedication in coordinating this series of exercises since 1988, and to their respective laboratories for supporting their efforts.

6.4 Intercomparison Exercise on Analyses of non-*ortho* CBs in Fish Oil

Request

This is part of the continuing ICES work of coordinating quality assurance activities and reporting on the results and their implications for monitoring programmes.

Source of the information presented

The 1994 report of the Marine Chemistry Working Group (MCWG).

Status/background information

The MCWG conducted an informal pilot study on the determination of non-*ortho* and mono-*ortho* chlorobiphenyls in biota. Only eight laboratories out of 22 returned results, but despite this limited set of data, the results were quite satisfying and permitted the following conclusions to be made:

1) The results suggested that an additional separation step could be recommended.

2) Distinct differences were observed between a group using saponification and a group using sulphuric acid treatment.

3) The need was recognized for further development and evaluation of the methods and for suitable reference materials. Work in this field is currently being undertaken by the Measurement and Testing Programme of the European Commission.

The MCWG recommended that before undertaking monitoring of non-*ortho* chlorobiphenyls, ICES should undertake an intercomparison exercise to establish the necessary interlaboratory precision.

6.5 Intercomparison Exercise on Measurements of Lipids in Marine Samples

Request

Item 2.3 of the 1994 Work Programme from the Oslo and Paris Commissions.

Source of the information presented

The draft report on the results of the ICES/IOC/OSPARCOM Intercomparison Programme on the Determination of Chlorobiphenyl Congeners in Marine Media, Step 4, and the 1994 report of the Marine Chemistry Working Group (MCWG).

Status/background information

An optional exercise conducted with step 4 of the ICES/IOC/OSPARCOM Intercomparison Programme on the Determination of Chlorobiphenyls in Marine Media involved the determination of extractable and total lipid concentrations in fish tissue. From the results of this exercise, it was concluded that extractable lipid concentrations should not be used for normalization of CB concentrations in fish. Total lipid determinations by the method of Bligh and Dyer were therefore recommended for normalization purposes. However, a proposed ban in several countries on the use of chlorinated solvents may be a hindrance to the use of this method. Nevertheless, the use of a standard method is important because the definition of lipids is, in principle, method-dependent.

At the 1994 meeting of the MCWG, highly relevant information was presented on the advantages and disadvantages of the various methods in use for the extraction of lipids and for the extraction of hydrophobic organic compounds. On this basis, the MCWG decided that a thorough literature survey of methods in use for the determination of lipid classes is necessary before any further intercalibration exercise on this subject would be feasible. Furthermore, until the problems of lipid determinations are solved, the current practice of expressing contaminant data on a wet weight basis in geographical distribution and temporal trend monitoring programmes should be maintained. The lipid content of the tissues analysed can be reported in addition when the analytical method used is clearly specified.

6.6 Fifth Intercomparison Exercise on the Analysis of Nutrients in Sea Water and Implications for Laboratories reporting to OSPARCOM

Request

Item 2.1 on the 1994 Work Programme from the Oslo and Paris Commissions.

Source of the information presented

The report of the Fifth ICES Intercomparison Exercise on the Analysis of Nutrients in Sea Water, and the 1994 report of the Marine Chemistry Working Group (MCWG).

Status/background information

The ACME reviewed the results of the Fifth ICES Intercomparison Exercise on the Analysis of Nutrients in Sea Water (NUTS 5). It was conducted concurrently with the QUASIMEME nutrients intercomparison exercise and participation in ICES NUTS 5 was made a precondition for 'nutrients laboratories' to join the QUASIMEME project. In November 1992, 142 sets of samples were distributed to laboratories in 31 countries. Results of analyses were returned by 132 laboratories, 61 of which had participated in the Fourth ICES Intercomparison Exercise on the Analysis of Nutrients in Sea Water (NUTS 4) in 1989/1990, and 56 of which were participating in QUASIMEME.

Six samples of sea water were distributed for the exercise containing four primary determinands, nitrate, nitrite, ammonia and phosphate, at three concentration levels, low, medium and high.

The following conclusions were drawn from the results of the exercise:

- Nitrate analyses showed good reproducibility (3%), comparable to earlier exercises including NUTS 4.
- Nitrite analyses showed a reproducibility of 5-10%.
- Phosphate analyses showed a reproducibility of 5-15%, similar to earlier exercises including NUTS 4.
- Ammonia analyses showed a reproducibility of more than 20%. This was disappointing and indicates a general need to improve laboratory techniques and procedures for this determination.
- A study of individual errors indicates that substantial improvements can be expected, because systematic errors represent the major contribution to the inaccuracy.
- The laboratories with the poorest performance in the present round had not participated in earlier exercises.
- The laboratories showing the poorest performance in the previous exercise have improved.
- There is evidence that rapid staff turnover has a deleterious effect on results.
- Through this exercise, laboratories showing good performance have been identified, as well as a number of laboratories that need to examine their techniques in order to improve their performance.

The implications of the results of NUTS 5 for laboratories reporting data under, e.g., OSPARCOM programmes can be summarized as follows:

. Laboratories should be strongly encouraged to join intercalibration exercises since such participation helps in identifying poor performance.

. Laboratories that have been identified as poor performers should try to identify sources of weaknesses in their procedures and correct them.

. The proper training and motivation of laboratory staff is more important than buying state-of-the-art equipment.

Recommendations

The ACME recommended that the report on the results of this intercomparison exercise be published in the *ICES Cooperative Research Report* series.

The ACME expressed its appreciation to the Coordinators of this exercise, Dr A. Aminot (IFREMER, Brest) and Dr D. Kirkwood (MAFF, Lowestoft), for their excellent work in coordinating this exercise, and to their respective laboratories for supporting their efforts.

6.7 Phase 2 of the Intercomparison Exercise on the Analysis of Trace Metals in Suspended Particulate Matter

Request

This is part of the continuing ICES work of coordinating quality assurance activities and reporting on the results and their implications for monitoring programmes.

Source of the information presented

The draft report on the Results of Phase 2 of the Intercomparison Exercise on the Analysis of Trace Metals in Suspended Particulate Matter (SPM), and the 1994 report of the Working Group on Marine Sediments in Relation to Pollution (WGMS).

Status/background information

A draft report on the results of this exercise was discussed by the WGMS at their 1994 meeting. Phase 2 involved the determination of the trace metals Cu, Pb, Zn, Cd, Al, Li, Fe, Mn, Li, and Co in natural suspended particulate matter and also addressed the chemical analysis of blank filters. It was recommended that a common method be used for the total digestion of the SPM samples. The method is based on dissolution using a mixture of hydrofluoric acid and aqua regia. Seven laboratories used this method, while the other participants applied a modification of this method or their own routine method for the preparation of the samples.

Four filter samples containing ca. 2 mg SPM filtered from a bulk sample of natural Baltic Sea water and four blank filters were sent to participants; results were received from 15 laboratories. The results of the intercomparison (summarized in the table below) showed that it is possible for the participating laboratories to analyse very small amounts of SPM for trace metal concentrations by different techniques with very good precision.

Summary of the analytical results of Phase 2 of the Intercomparison Exercise on the Analysis of Trace Metals in Suspended Particulate Matter.

Metal	Number of laboratories	Interlaboratory grand mean	Relative standard deviation (%)	Blank as % of sample concentration
Al	8	67.5 mg/g	8.3	<10
Fe	12	51.7 mg/g	10.9	<10
Cd	12	1.76 μg/g	50.4	<10
Cu	13	46.8 μg/g	70.2	<10
Pb	12	41.4 μg/g	41.9	<10
Mn	14	1057.0 μg/g	13.0	<10
Ni	12	49.2 μg/g	28.9	<10
Zn	12	182.0 μg/g	32.5	<10
Li	8	52.8 μg/g	26.1	<10
Co (tentative)	10	15.4 μg/g	23.6	<10

Recommendations

The ACME recommended that the final report on the results of this intercomparison exercise be published in the *ICES Cooperative Research Report* series.

The ACME expressed its appreciation to the Coordinator of this intercomparison exercise, Dr C. Pohl (Institute of Baltic Sea Research, Warnemünde, Germany), for her excellent work and dedication in coordinating this exercise, and to her laboratory for supporting her efforts.

6.8 Level of Comparability of Analyses Among Laboratories Participating in the JMP, by Analyte

Request

Item 2.2 of the 1994 Work Programme from the Oslo and Paris Commissions.

Source of the information presented

The 1994 report of the Marine Chemistry Working Group, the report on the ICES Fifth Intercomparison Exercise on the Analysis of Nutrients in Sea Water, and the report on the results of Step 4 of the ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of Chlorobiphenyls in Marine Media.

Status/background information

ICES serves as the data centre for the OSPARCOM JMP data on contaminants in marine media. In assessing these data, the relevant OSPARCOM working group has identified a number of problems related to perceived or suspected insufficient quality of the data. As a result, ICES has been requested to include in the database an ever increasing amount of quality assurance information and to make that information available to the assessment experts.

In the assessment work, a continuous concern has been both the comparability of results from a single laboratory over time (temporal trend monitoring) and the intercomparability of results from different laboratories (mainly for baseline studies). At any given time, the information available on quality assurance has not been sufficient to resolve all relevant questions. Therefore, the JMG requested ICES to provide information on the degree of comparability of analyses among laboratories participating in the JMP. Furthermore, in 1994 the JMG requested ICES to provide information concerning which organic contaminants could be monitored in biota and sediment on a routine basis, taking into account their environmental relevance and the state of the art in analytical chemistry and quality assurance. This latter task was immediately directed to the Marine Chemistry Working Group (MCWG) and the Working Group on Biological Effects of Contaminants (WGBEC).

In parallel with these processes, ICES has been conducting a number of intercomparison exercises on analyses of nutrients in sea water and contaminants in sediments and biota, often at the direct request of the Commissions.

Relevant information concerning organic contaminants is contained in the following table.

Organic Contaminant	Recent intercomparison data available	Quality control material available	Laboratory capability
1. Chlorobiphenyls CBs 28, 52, 101, 118, 138, 180 plus CBs 31, 105 and 156	Yes - sediment Yes - fatty tissue ? - lean tissue	CRMs (SRMs) and LRMs. Certified standards available	Most
2. Toxic CBs 77, 126 and 169	Yes - fatty tissue	Yes - in the near future	Some specialist laboratories
3. Organochlorine pesticides	Yes - fatty tissue Yes - sediment	CRMs (SRMs) available for some pesticides	Most
4. PAHs (ICES list of 10)*	Yes - sediment	CRMs in sediment	Many, for sediments and shellfish
5. Dioxin/Furans	Yes (WHO)	Yes	Good for specialist laboratories
6. Chlorinated bornanes (CHBs) (toxaphene)	Validated methods required	RMs required	A few specialist laboratories
7. Organotin	Validated methods required	CRM for biota	A few specialist laboratories
8. Methyl mercury	Validated methods required		A few specialist laboratories
9. Polychlorinated naphthalenes	Validated methods required	CRMs needed	A few specialist laboratories
10. Chlorinated paraffins	Validated methods required	CRMs needed	A few specialist laboratories

* The ten polycyclic aromatic hydrocarbons (PAHs) are: phenanthrene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*e*]pyrene, benzo[*a*]pyrene, benzo[*b*]fluoranthene, benzo[*ghi*]perylene, and indeno[123*cd*]pyrene.

Abbreviations:
- CRMs - certified reference materials
- SRMs - standard reference materials
- LRMs - laboratory reference materials
- RMs - reference materials

Additional comments to the table by the coordinator of the CB intercomparison exercise include the following:

1) State-of-the-art of CB analysis

After the final Step 4 of the ICES/IOC/OSPARCOM intercomparison programme on CB analyses, the following can be concluded on the state-of-the-art of CB analysis of the 43 participating laboratories in this study:

a) Marine sediments

The group of participating laboratories is able to detect 50% differences between two samples for the CB congeners 118, 138 and 153. This refers to the analytical error and does not consider natural variations.

A number of individual laboratories are able to detect smaller differences and are also able to detect 50% differences between two samples for the CBs 28, 31, 52, 101, 105, 156 and 180.

b) Seal oil

The group of participating laboratories is able to detect 50% differences between two samples for the CB congeners 138, 153 and 180. This refers to the analytical error and does not consider natural variations. A number of individual laboratories are able to detect smaller differences and are also able to detect 50% differences between two samples for the CBs 52, 101, 105, 156 and 180. No laboratories are able to determine accurately the CBs 28 and 31. This is due to the high degree of metabolism of these CBs in seal tissues.

c) Wet lean fish tissue

Although some individual laboratories seem to be able to produce acceptable results for the analysis of the CBs 28, 31, 52, 101, 105, 118, 138, 153, 156 and 180 in wet lean fish tissue, the group of laboratories is not able to do so. The problems in the analysis of this type of matrix are related to the extraction. Solutions to this problem are likely to be found in the near future. For more fatty fish tissue, the situation is expected to be better, but exact figures cannot be given because information on the extraction of wet fatty tissue is not available.

2) Degree of comparability of CB analysis

Standard deviations of the log-transformed intercomparison results (SRs), indicating the reproducibility, obtained in the fourth step of the ICES/IOC/OSPARCOM intercomparison programme on CB analysis are as follows:

a) Marine sediment

CBs 118,138,153	1.15 - 1.17*
CBs 28,31,52,101,105,156,180	1.21 - 1.33

b) Seal oil

CBs 138,153,180	1.12 - 1.16
CBs 52,101,105,118,156	1.20 - 1.65
CBs 28,31	2.28 - 4.81

c) Wet lean fish tissue

CBs 101,118,138,153,180	1.51 - 1.68
CBs 28,31,52,105,156	1.93 - 3.84

1.17*: standard deviation of the log-transformed observations (SR) can roughly be read as 17%; an SR of 1.17 corresponds to a reproducibility (R) of 1.53 (roughly 53%).

Information on the analysis of nutrients in sea water, obtained from the Fifth Intercomparison Exercise on the Analysis of Nutrients in Sea Water, can be summarized as follows:

- Nitrate analyses showed good reproducibility (3%);
- Nitrite analyses showed a reproducibility of 5-10%;
- Phosphate analyses showed a reproducibility of 5-15%;
- Ammonia analyses showed a reproducibility of more than 20%. This indicates a general need for improving laboratory techniques and procedures for this determination;
- A study of individual errors indicates that substantial improvements can be expected since systematic errors represent the major contribution to the inaccuracy.

Implications of these results for laboratories reporting data under OSPARCOM programmes can be summarized as follows:

- Laboratories should be strongly encouraged to join intercalibration exercises because such participation helps in identifying poor performance.
- Laboratories who have been identified as poor performers should try to identify weaknesses in their methods and correct them.
- The proper training and motivation of staff is more important than buying state-of-the-art equipment.

Need for further research

Recent relevant information needs to be collected particularly on intercomparison results concerning the analysis of trace metals, as ICES has not conducted intercomparison exercises on trace metals (except for SPM) since 1985.

Recommendations

The above information has been provided in order to facilitate the assessment process for OSPARCOM JMP data. The OSPARCOM is also encouraged to urge the laboratories of the OSPARCOM Contracting Parties participating in the JMP to report to ICES any relevant information on their results in intercomparison exercises on nutrients in sea water and contaminants, **particularly trace metals**, in biota and sediments obtained in other programmes such as the QUASIMEME programme. It should be noted that detailed information on individual laboratory performance in intercomparison programmes not coordinated by ICES can only be made available by each monitoring laboratory releasing such information. This can be done by submitting the results of the analysis of intercomparison samples to the ICES Environmental Data Centre.

6.9 The Use and Availability of Suitable Reference Materials for Inorganic and Organic Contaminants in Marine and Coastal Sediments

Request

This is part of the continuing ICES work to provide information and advice on quality assurance procedures for marine environmental monitoring and research.

Source of the information presented

The 1994 report of the Working Group on Marine Sediments in Relation to Pollution.

Status/background information

The use of reference materials must be considered as part of the broad quality assurance work necessary to ensure that a laboratory is reporting data of adequate quality to meet the objectives of the particular monitoring programme. The quality assurance process can be divided into quality control procedures, which maintain measurements within an acceptable level of accuracy and precision, and quality assessment procedures, which provide documented evidence that quality control is being achieved (Topping, 1992).

Reference materials have three general areas of application (Taylor, 1989). Firstly, they are used in the development and evaluation of analytical methods. The development of methods is, however, outside the scope of these guidelines.

Secondly, there is a need to establish the traceability of measurements to standards of known quality, and to the primary units of measurement. This procedure is required to establish the accuracy of measurements, and this can be achieved through the use of certified standards. In the case of contaminant measurements in sediments, it may be possible to associate directly analyses of unknown samples with accompanying analyses of Certified Reference Materials (CRMs). In other cases, Laboratory Reference Materials (LRMs) may be used, provided that the relationship between the LRMs and relevant CRMs has previously been established. In cases where no suitable CRMs are available, other procedures, probably involving the preparation of standard solutions from 'pure' substances of known specification, will need to be adopted, for example, for use in standard addition procedures. These are fundamentally less satisfactory than the use of CRMs, as they cannot include all phases of the analytical process or provide the necessary match of matrices between standard and samples.

In the interest of obtaining data traceable to appropriate standards of recognized and uniform quality, the organizers of a coordinated monitoring programme should, wherever possible, recommend appropriate CRMs that should be used by all laboratories, both in establishing analytical performance prior to the programme and during the main analytical phase of the programme. The accuracy of a method can be checked through the analysis of CRMs, or LRMs well-characterized by reference to one or more relevant CRMs. The reference materials specified by the coordinator should, therefore, wherever possible be CRMs. They should be of marine origin and have matrices which match as closely as possible those of the samples to be collected during the programme. The concentrations of the contaminants concerned should be similar to those in the field samples. If the concentrations in field samples vary by more than a factor of about 10, two RMs should be specified to cover the upper and lower ranges of concentrations.

A third use of reference materials is in the maintenance of analytical performance, through both quality control and quality assessment procedures (Topping *et al.*, 1993). Other procedures, for example, comparison with independent laboratories using methods known to be under control, and the analysis of blind samples in proficiency testing schemes, can also be used.

Quality control

The main elements of effective quality control in coordinated monitoring programmes are as follows:

- Using experienced and reliable analysts; using an analytical procedure which has been demonstrated to give adequate performance and has been tested and is under control; ensuring that instrumentation is serviced regularly and routinely adjusted to give optimum operating characteristics;

- Supervision of all stages of analysis by qualified and experienced personnel;

- Analysing CRMs or LRMs with each batch of environmental samples to check that analytical data are falling within acceptable limits of accuracy and precision, both in relation to the individual laboratory's performance and the defined needs of the programme;

- Participation in interlaboratory checks of analytical performance as required by the programme coordinator.

Quality assessment

Each analytical batch should include an LRM, or CRM specified by the coordinator, one blank, and one duplicate sample. Where the coordinator has not specified a reference material, the analyst should select an appropriate CRM or LRM. If the expected range of concentrations is large, two appropriate reference materials to cover the upper and lower ranges of concentration should be included. The analytical data for reference materials should be plotted on an analytical quality control chart (AQCC), which incorporates guidelines that allow an objective decision to be made on whether or not the data are of acceptable quality. The use of CRMs for routine quality control is normally both wasteful and expensive. Once a method has been validated with CRMs, a well-characterized LRM can be used routinely, with an occasional check by CRM.

1) Establishing an AQCC: The prerequisite for the AQCC is that the method has been validated.

   a) Select the RM to be routinely analysed with the environmental samples.

   b) Analyse the RM at least ten times for each determinand. These measurements should be made at different times using different calibrations to determine the full between-batch variance of the method.

   c) Calculate the mean value (X), the standard deviation (s), and the following values: $X+2s$, $X+3s$, $X-2s$, and $X-3s$. Use these data to produce the initial control values.

2) If the analytical data for the RM are under control, 95% of them should fall within $X \pm 2s$, i.e., the area between the UWL (upper warning limit) and the LWL (lower warning limit). Similarly, 99.7% of the results should fall within $X \pm 3s$, i.e., the area between the UCL (upper control limit) and the LCL (lower control limit). The relationship between these limits and the requirements of the coordinated programme should be established, but in general no data should be submitted if the method was out of control when they were obtained.

3) The analyst should plot the results of subsequent analyses of reference materials on completion of each batch of analyses of environmental samples to check that the data lie within the acceptable limits. These trends are best determined by cusum analysis, which is more sensitive than simple Schewart charts.

4) The following guidelines can be used to assess whether the data for the reference materials and, consequently, the data for the environmental samples are of acceptable quality, i.e., the analyses are under control.

   a) If one result falls outside the warning limits, the analyst need not doubt the result or take any action, provided that the next result falls within the warning limits.

   b) If the results fall outside the warning limits too frequently, particularly if the same warning limit has been crossed more than once on consecutive results, then the analyst needs to assess the source of this systematic error.

   c) If the results on more than seven successive occasions fall on the same side of the X line (either between X and UWL, or X and LWL), then the analyst needs to check the analytical procedure to determine the source of this systematic error.

   d) If the result falls outside the UCL or LCL lines, then the analyst should check the analytical procedure to determine the source of error.

   e) If any of the above cases occur, the results of the analysis of the particular batch of environmental samples should be rejected. The analyst should not carry out any further routine analyses until the source(s) of the errors have been identified and the analyses are again under control.

   f) Control charts are ideally used when analyses are done routinely on a day-to-day basis. Under these conditions, analysts become familiar with, and gain confidence in the use of, the analytical procedures thus minimizing the variability of the measurements. If batches of analyses are separated by significant periods of time, the analyst should demonstrate that the routine procedure is still under control before field samples are analysed.

g) Even if the analyst rigorously pursues analytical quality control work, the data produced may not be accurate if the original sediment sample was contaminated before the analysis began. Therefore, an important component of the quality assessment procedure is the scrutiny of the data, by comparing new measurements with previous ones and/or by comparing them with data produced by a reference laboratory.

Reporting of data

When data are reported to the data centre or programme coordinator, results for field samples must be accompanied by relevant QA documentation, as required under a defined reporting format. It is likely that, as progress is made towards QA schemes tailored to international monitoring programmes, it will be necessary for data centres to be able to accept QA data from such schemes, and also information on analyses of RMs and results from participation in intercomparison exercises.

Relevant certified reference materials for sediment studies are listed in the following table, along with the contaminants certified and source of the material.

Certified reference materials for inorganic and organic contaminants in coastal and marine sediments.

Code	Supplier	Description	Parameters
BCSS-1	NRCC Canada	Marine sediment	Cu, Zn, Cd, Pb, Hg and other elements
MESS-1	NRCC Canada	Marine sediment	Cu, Zn, Cd, Pb, Hg and other elements
PACS-1	NRCC Canada	Marine sediment	Cu, Zn, Cd, Pb, Hg and other elements (including butyltins)
BEST-1	NRCC Canada	Marine sediment	Cu, Zn, Cd, Pb, Hg and other elements
CRM-277	CEC-BCR	Estuarine sediment (Scheldt)	Cr, Ni, Cu, Zn and other elements
HS-3	NRCC Canada	Marine sediment	PAHs
HS-6	NRCC Canada	Marine sediment	PAHs
IAEA-357	IAEA	Venice Lagoon high level	PAHs, PCBs
MAG-1	US Geological Survey	Marine sediment	Wide range of metals
SD-M-2/TM	IAEA	Marine sediment	Wide range of metals
SES-1	NRCC	Estuarine sediment, spiked	PAHs
SRM 1646	NIST	Estuarine sediment	Range of metals
SRM 1941	NIST	Marine sediment	PAHs, OCs, PCBs, metals

CEC-BCR - European Commission, Community Bureau of Standards (now Measurement and Testing Programme)
IAEA - International Atomic Energy Agency
NIST - National Institute for Standards and Testing, USA
NRCC - National Research Council of Canada

Information from: Intergovernmental Oceanographic Commission (IOC), 1993. Standard and Reference Materials for Marine Science. Manuals and Guides 25. Revised edition, 1993. UNESCO.

Taylor, J.K., 1987. Quality assurance of chemical measurements. Lewis, Michigan, 328 pp.

Topping, G., 1992. The role and application of quality assurance in marine environmental protection. Mar. Pollut. Bull., 25: 61-66.

Topping, G., Wells, D.E., and Griepink, B. 1993. Guidelines on quality assurance for marine measurements. BCR, Brussels, Contract No 5340/1/9/000/04-BCR-UK(10).

6.10 Additional Quality Assurance Information to be Included in the ICES Data Bank

Request

The OSPARCOM has requested ICES to extend the types of quality assurance information stored in the ICES Environmental Data Bank in order to facilitate the assessment of the OSPARCOM monitoring data.

Source of the information presented

The 1994 report of the Marine Chemistry Working Group (MCWG).

Status/background information

In response to the above request, the MCWG defined the quality assurance information required as well as some other steps to be considered, as listed below.

1) Monitoring should not be commenced until reference materials (RMs) are available and a proficiency testing programme is in place. Target values for these RMs should be set by a small number of expert laboratories. These RMs should be matrix matched.

2) Participating laboratories should supply information on certified reference materials (CRMs) used (also certified calibration solutions) including target and measured values with all data. It is recommended that certified values for relevant reference materials in the NOAA/IOC compendium be included in the ICES data bank. This is the most comprehensive and up-to-date listing of RMs available.

3) Organizations coordinating monitoring programmes should supply participating laboratories with blind samples and the laboratories should make data on long-term precision available.

4) Laboratory data should include traceability of any internal reference material to a certified reference material or to a recent intercomparison exercise.

5) Information on and the results of recent relevant intercomparison exercises (e.g., ICES, QUASIMEME, NOAA) should be listed in the data bank.

6) Quality assurance information should include data on analyses of normalizing parameters and on sampling and storage procedures.

7) Information should be presented on the sample work-up (digestion, extraction, etc.) and the detection method.

8) Copies of relevant quality control charts are not needed if all the other QA data are submitted.

9) ICES should not accept results expressed as technical mixtures or the sum of CB congeners.

10) Laboratories should maintain adequate storage and retrieval systems for QA and monitoring data.

11) Organizations coordinating monitoring programmes should provide clear guidelines for QA assessments of monitoring data.

7 ENVIRONMENTAL STUDIES IN THE BALTIC SEA

7.1 Baseline Study of Contaminants in Baltic Sea Sediments

Request

Item 5 of the 1994 requests from the Helsinki Commission.

Source of the information presented

The 1994 report of the Steering Group for the Coordination of the Baseline Study of Contaminants in Baltic Sea Sediments and a paper by M. Perttilä and L. Niemistö, "Selection and characterization of net sedimentation stations for reference use – First results of the 1993 Baltic Sea Sediment Baseline Study" (ICES, Doc. C.M.1993/E:30).

Status/background information

The ACME took note of the following initial observations from the Baseline Study of Contaminants in Baltic Sea Sediments.

General conduct of the study

The Sediment Baseline Study expedition was carried out on board the R/V "Aranda" in June–July 1993, covering the entire Baltic Sea. The stations sampled are shown in Figure 7.1. Differential GPS was used for the positioning, with an accuracy of ±50 m or better. At each preselected site, a grid was run in order to facilitate the selection of the exact position for sampling. 10 KHz and 110 KHz echo-sounding equipment were used for the inspection of the layer structure of the bottom sediments. Depth measurements from the echo sounding during the grid were combined with the ship's navigational data and, at each station, a three-dimensional picture of the bottom was made. A side-scan sonar was also applied at most stations. The final selection of the sampling position was made on the basis of an inspection of these three sources of information.

The sediment surface was recorded with a video camera system. In order to study the inner structure of the sediments, a penetrating sediment camera system was also applied, which photographed the vertical structure. For this purpose, one core was also taken for X-ray analysis. The detailed results of these characterizations will be published later.

For samples intended for chemical analyses, a new type of gravity corer was used throughout the study. This corer consists of a double core system, producing two identical cores at a time. The functioning of this corer type was found to be very reliable, and the sampler was shown to strike the sediment surface nearly always in an upright position, contrary to the conventional single-tube gravity corers. The sediment cores were cut to 1 cm thick slices (0.8 cm for redox measurements) and deep-frozen. Redox and preliminary Cs-137 measurements were carried out on board the research vessel.

The Cs-137 measurement gives an energy dispersion pattern, in which the caesium band is easily recognizable. It is assumed that a major part of this element originates from the Chernobyl accident in 1986. The Cs-137 activity can be followed down in the sediment core. At most of the stations, the topmost sediment layers showed high activity, with a peak at a depth of 3–10 cm. In sediment layers below the peak, the Cs-137 activity decreased rapidly to background values. It is assumed that the sediment layer with the activity peak corresponds to the immediate Chernobyl fallout, thus giving a rough estimate of the net sedimentation rate.

Preliminary results of the characterization of the sedimentation basins

The preliminary measurements of gamma-emitting radionuclides indicate that the sediments chosen are in sedimentation basins. This is confirmed at least partly by the depth at which the Chernobyl fallout of Cs-137 now seems to be buried. The clear echo-sounding records of dune-like formations and in some cases the direct video images of the sediment surface indicate that in some areas the present understanding of the sedimentation process has to be reconsidered.

On two stations in the Gulf of Finland it could be observed that a relatively strong (ca. 15–20 cm/s) near-bottom current detached particles and aggregates from the sediment surface. Particles were then transported along the sediment surface, and sometimes the sediment surface seemed to be rolled along by the current. On some other sampling stations, the macroscopic benthic animals were seen to dig into the sediment surface, and even very faint water movements transported clouds of material away. All this must influence the depth of the Chernobyl maximum fallout of Cs-137 and other properties of the sediments.

It appears that in most of the shallower basins with depths around 60 m or less, regardless of location in the Baltic Sea (Arkona and Mecklenburg Basins in the south, the Gulf of Finland and the Gulf of Bothnia in the north), sediment particles have not descended to their final places. The visually observed reworking of the sediment surface described above makes the vertical time scales uncertain and uncontinuous. These types of sedi-

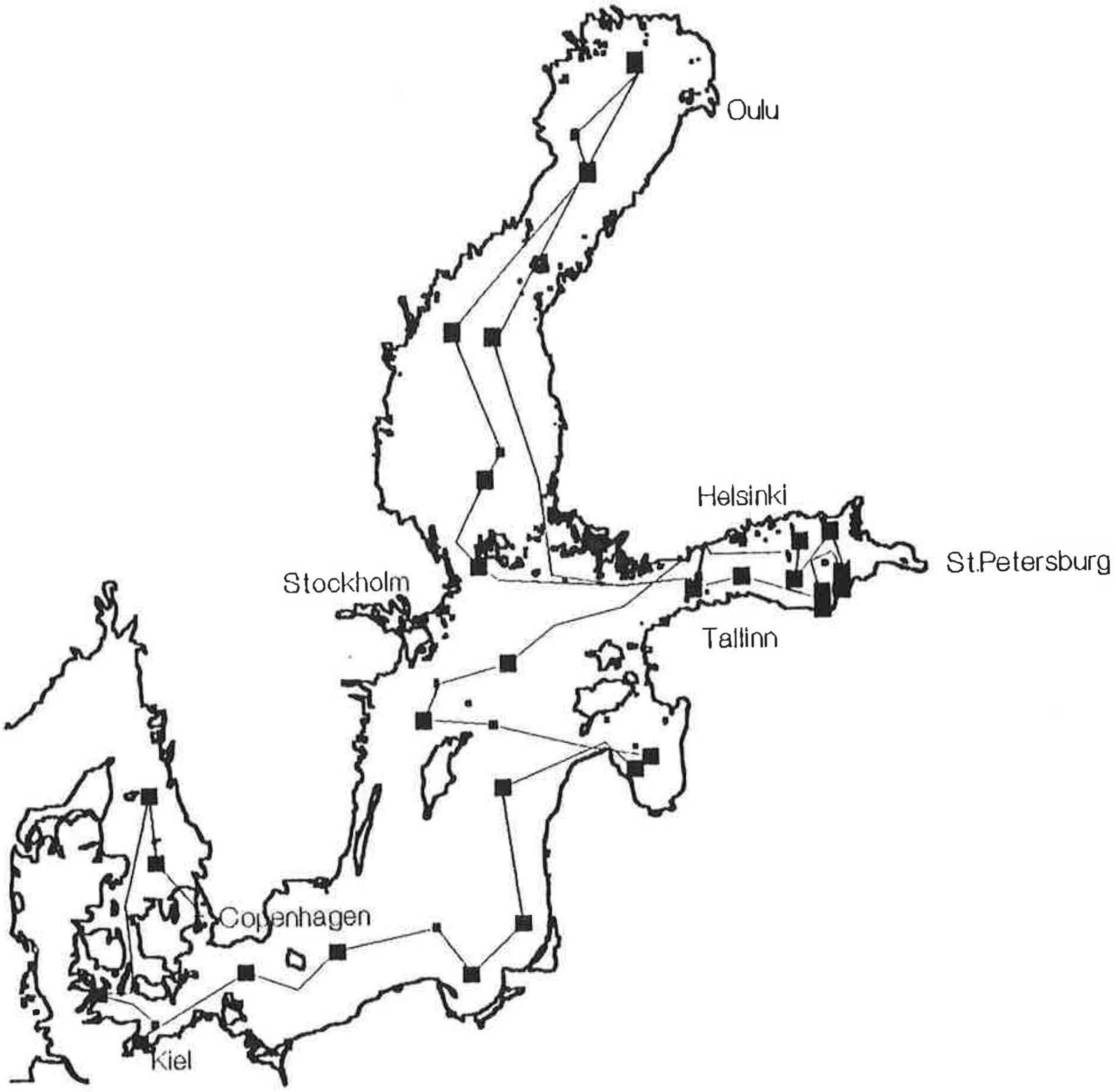

Figure 7.1 Stations sampled for the Baseline Study of Contaminants in Baltic Sea Sediments during the cruise of the R/V "Aranda" from 13 June to 9 July 1993. Source: Finnish Institute of Marine Research.

ment are probably less suitable even for low frequency monitoring.

The deeper basins often show massive sedimentary packages of soft sediments of recent character, as observed by echo sounding. In these basins, stagnant dead bottom periods alternate with non-stagnant periods characterized by a recolonization of benthic fauna and thus a return of water movement. This alternation may govern the vertical sedimentary record, rendering age determination meaningless. Only the deepest parts of the Baltic Sea seem to act as final sinks for particles to form continuous packages of layers.

The Gotland Deep, however, shows striking differences in the depth, thickness and structure of varve. The samples were of a totally different character than expected. On the top of the samples, there was a 10 cm thick fluffy homogeneous-looking layer of very watery, loose greyish sediment. In 1992, a similar, but thinner, layer had been observed. No layers were visible, but the preliminary X-ray images of this fluffy layer revealed three thick separate layers. Below these, the layers were considerably thinner, about 0.5 to 0.2 cm. Deeper down, two white bands were found. The gamma spectrometric analysis of Cs-137 showed a maximum at a depth of only about 9 cm. With the Chernobyl accident having taken place in 1986, this layer is far too near the sediment surface for these layers to be annual.

The ACME noted the further progress that has been made in the conduct of the Baseline Study of Contaminants in Baltic Sea Sediments, including the following activities:

- the freeze drying of samples has been finished;
- further distribution of the samples has continued;
- analyses of sediment samples are under way;
- problems associated with financing the organic analyses have been partly solved;
- all laboratories involved have agreed to complete the analyses by the end of 1995;
- data management is being handled by ICES;
- agreements for the preparation of a report on the results are being made.

7.2 Report of the Steering Group on Fisheries/ Environmental Management Objectives and Supporting Research Programmes in the Baltic Sea

Request

There is no specific request. The ACME reviewed the final report of the Steering Group and considered how this report can be used in the best way.

Source of the information presented

The 1993 report of the Steering Group on Fisheries/Environmental Management Objectives and Supporting Research Programmes in the Baltic Sea (ICES C.M.1993/ J:3).

Status/background information

This Steering Group was established at the 1991 Statutory Meeting as a means of responding to the requirements of managers to obtain scientific information relevant to decision-making in the fields of fisheries management and environmental protection. These requirements had been expressed in particular at the Eighth Dialogue Meeting on "How to use the sea: Management interactions with special reference to the Baltic and its fisheries", which was held in Gdynia, Poland on 13 - 14 September 1991.

The Steering Group identified four major relevant subject areas: fisheries resources/management, stable organic substances, eutrophication, and marine water influx/ exchange, and prepared inventories of research needs for each of them. Thereafter, a further elaboration of research needs was prepared under the headings:

1) The influence of environmental/hydrographic factors on the distribution, abundance, and demography of fish stocks;
2) The influence of biotic factors on the distribution, abundance. and demography of fish stocks, including ecological impacts of the Baltic fisheries on the environment;
3) The influence of factors on the ecosystem which are both natural and anthropogenic;
4) The influence of anthropogenic activities on Baltic fish stocks;
5) The influence of diseases on Baltic fish stocks.

The full text of the final report of this Steering Group is contained in Annex 2.

7.3 Progress in Assessment Activities for the Helsinki Commission

Request

Item 9 of the 1994 requests from the Helsinki Commission.

Status/background information

The ACME took note of progress in the two activities that ICES is coordinating to assist in the preparation of the Third Periodic Assessment of the Baltic Marine Environment under the Helsinki Commission.

In terms of the request to ICES to prepare a chapter on fish and fish diseases for the Third Periodic Assessment, ICES has appointed the Chairman of the Baltic Fish Committee, Dr B. Sjöstrand, to coordinate the work on this chapter, which will comprise three sections. The first section will update the information on commercial species of fish in the Baltic Sea that ICES had provided in a chapter for the Second Periodic Assessment. The second section will provide a compilation of available information on coastal fish species in the various areas of the Baltic Sea. The third section will provide information on the types and prevalences of fish diseases in the Baltic Sea; the Baltic Marine Biologists are coordinating this compilation of fish disease information.

The second contribution that ICES is making to the Third Periodic Assessment is the coordination of an assessment of data for temporal trends in contaminant concentrations in fish and shellfish from the Baltic Sea, using the methodology agreed in Section 5.2.1, above.

To carry out this task, the ICES Environmental Data Bank has received Baltic Monitoring Programme data on contaminants in fish and shellfish from 1979 to 1992 and is presently quality controlling these data sets and returning them to data originators for validation. When the data sets are complete, the scientific quality of the data will be reviewed and the assessment activities prepared. It is anticipated that the assessment of these data will take place in early 1995.

8 DYNAMICS OF HARMFUL ALGAL BLOOMS

Request

There is no specific request; this is part of the continuing ICES work on phytoplankton and phytoplankton-related processes.

Source of the information presented

The report of the 1994 joint meeting of the ICES/IOC Working Group on Harmful Algal Bloom Dynamics and the Working Group on Shelf Seas Oceanography.

Status/background information

The ICES/IOC Working Group on Harmful Algal Bloom Dynamics met together with the ICES Working Group on Shelf Seas Oceanography in Vigo Spain, on 9 – 12 May 1994. The meeting was preceded by a Workshop on Modelling the Population Dynamics of Harmful Algal Blooms.

Modelling of harmful bloom events associated with excessive production of biomass (as opposed to toxin production) is feasible in both a diagnostic and a prognostic mode in specific geographical areas.

Models for specific toxic algal species do not exist and the processes (both biological and physical) involved in the population dynamics are neither enumerated nor understood at present. The lack of knowledge is so great that in many cases even the first order processes cannot be identified. For example, in many cases of toxic blooms, the dynamics are not controlled by nutrient kinetics. The Working Groups reviewed eleven different programmes on harmful algal events covering a variety of different oceanographic regimes. Four pilot programmes (covering the Gulf of Maine, the Skagerrak–Kattegat area, the Iberian Peninsula, and the Baltic Sea) were examined. Although three of the four pilot programmes are still in the planning stage, they have been successful in developing a population dynamics approach to the experimental design.

In situ observations, at appropriate temporal and spatial scales, of toxic algal populations, including their distributions and characteristics in conjunction with the associated physical and chemical processes, are required to elucidate the interactions controlling the population dynamics. Interpretation of these data will require 'species of interest' models which have been useful in general ecology.

9 FISH DISEASES AND RELATED ISSUES

9.1 Occurrence of an Unknown Mortality Factor (M-74) in Salmon Hatcheries in the Baltic Sea

Request

The ACFM requested the ACME to review the available information on the M-74 syndrome and to obtain further information on the causes of mortality in the affected stocks. Accordingly, an ACME Study Group on Occurrence of M-74 in Fish Stocks was established (C.Res. 1993/2:7:9) to assess the effect of M-74 on salmon stocks.

Source of the information presented

The report of the Study Group on Occurrence of M-74 in Fish Stocks and the review of this report contained in the 1994 report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO).

Status/background information

The syndrome termed 'M-74' was first observed in the Swedish compensatory smolt-rearing hatcheries in the early 1970s. Not until 1974, with the implementation of the procedure of incubating the eggs of each female separately, was it noted that the mortality was linked to certain females. Although showing a higher frequency of 'wriggling behaviour' (a balance disturbance of the spawners associated with this syndrome) than females, it was demonstrated that males had no influence on the occurrence of the M-74 syndrome.

The first signs of M-74 in the yolk-sac fry are usually observed 2–3 weeks after hatching, when about 2/3 of the yolk sac has been consumed. When compared to normal yolk-sac fry, those affected by M-74 reveal the following symptoms:

- lethargy and weak avoidance reactions (swimming movements are short, uncoordinated rushes leading to quick exhaustion);
- the yolk-sac fry are greyish in colour;
- fragility of blood vessels, seen as haemorrhages (primarily in the heart region) and precipitates in the yolk sac close to fat droplets;
- the yolk sac may be swollen and exophthalmus is observed, indicating osmoregulatory disturbances;
- the hepatocytes in yolk-sac fry suffering from M-74 show increased vacuolization and lower glycogen content compared to normally developing fry;
- the hepatic cytochrome P-450-dependent 7-ethoxyresorufin-O-deethylase (EROD) activity from M-74 affected yolk-sac fry is very high compared to that of the viable fry from hatchery-reared brood fish and 1.7 times the activity in viable yolk-sac fry from wild spawners.

The death of the entire family group is more or less total within 3 to 5 days after the observation of the first symptoms.

In Sweden, efforts have been made to compensate for the M-74 loss of yolk-sac fry by increasing the amount of eggs in incubation. However, due to the immense increase in M-74 mortalities in 1992 and 1993, this will not be possible in the future and Swedish salmon smolt releases in 1995 will only be about 50% of those in 1994.

In Finland, M-74-like symptoms were observed for the first time during the seasons 1986-1987 and 1987-1988. The first clear cases were found from 1992 onwards and the mean mortality increased in 1993 to over 90%. At the same time, the mortality of fry from hatchery-produced eggs was below 8% during the yolk sac stage and no signs of M-74 could be observed. In the spring of 1993, a massive mortality of yolk-sac fry from wild salmon females was reported.

The situation in other Baltic countries is not clear. In Estonia, the M-74 syndrome has been definitely observed in the Kundo River where the abundance of the 1992 year class was of a standard level but the 1993 year class was totally absent. However, a total lack of year classes has been observed on other occasions during the last few years. In Latvia, there have been slight increases in yolk-sac fry mortality during recent years which could be associated with M-74. The total mortality reached 10.2% in 1992. Information from Lithuania was not available and so far the occurrence of M-74 has not been reported by Poland.

Possible Factors Involved in M-74

There are many factors that may be responsible for the M-74 syndrome and it is necessary to evaluate all of them. However, so far, there are no indications that the rearing environment or other abiotic factors in the rearing environment (such as chemicals used in normal hatchery practice or river water acidification) have any influence.

Nutritional factors seem to be involved in this syndrome. Sprat, along with herring, is the main food of salmon in the main basin of the Baltic Sea. The mortality due to

M-74 recorded in this area correlates significantly with the spawning stock biomass of sprat. As organic contaminants are lipophilic substances, the contaminant uptake will be considerably higher when sprat are eaten instead of herring, particularly during winter when the herring fat content is comparatively low. Also, the average age of herring eaten by salmon is now 1-2 years older than that reported earlier due to a decreased growth rate of herring in recent years. Therefore, the uptake of contaminants in salmon has increased because the level of environmental contaminants in fish increases with age. Another nutritional factor that may be involved is the carotenoid astaxanthin that enhances both the non-specific and the specific immune response systems, and appears to be essential for growth and survival of Atlantic salmon fry.

The occurrence of mild winters may also be important. There seems to be a correlation between the average winter temperature of the surface water in the main basin of the southern Baltic Sea and the occurrence of M-74.

Genetic factors may influence the tolerance of fish to environmental pollutants. A high level of heterozygoty within an animal population seems to be very important for an effective immune defense system. The level of heterozygoty in salmon depends on the effective population size and culturing, and isolation diminishes variation by decreasing the effective population size.

Until now, there have been no indications that infectious agents are involved in the etiology of the M-74 syndrome. Parasitological, bacteriological, and virological examinations performed on affected brood stock and fry in Finland as well as in Sweden have thus far given negative results.

It is still not clear whether chemical substances, endogenous or exogenous, inorganic or organic, are responsible for the development of the M-74 syndrome. However, indications of correlations between the mortality of salmon offspring and the concentrations of several organochlorine compounds have been detected. In Swedish samples, heavy metal concentrations in eggs from M-74-affected and normal females did not demonstrate any significant differences.

Data on the concentrations of dioxins in spawning salmon from rivers discharging into the Baltic Sea are too limited to allow for any conclusions concerning possible correlations between dioxins and salmon offspring mortality.

In recent decades, the Baltic Sea has been heavily influenced by natural and anthropogenic factors which have considerably changed the structure and function of its ecosystem. Many of these changes are of a large-scale character and include both abiotic and biotic changes which may directly or indirectly affect the reproduction of fish populations.

Recommended research efforts

Research efforts on the M-74 syndrome in salmon should be developed as a separate and goal-oriented project aimed at reducing or eliminating the occurrence of the syndrome. The plan of work and recommendations proposed by the Study Group on Occurrence of M-74 in Fish Stocks and the WGPDMO were endorsed by the ACME. The most relevant research needs are:

1) a follow-up of the wild salmon stock status, electrofishing, and confirmation of the relation between the ratio of spawning fish and smolt production;

2) a confirmation of criteria for diagnosis: syndrome symptomology and pathology should be defined;

3) a compilation of environmental factors in the artificial breeding that may influence the occurrence of the syndrome: breeding technology factors, opportunistic infections, pollutants;

4) an epidemiological description of the syndrome: importance of, e.g., sex, age, size, colour, climate, dwelling area in the Baltic Sea;

5) a preliminary search for toxic components, starting in affected yolk-sac fry and going back to the parental fish, followed by an experimental confirmation;

6) the use of biological markers to measure impacts on the reproduction of salmon. Such markers should mirror immunological and/or hormonal functions as well as nutritional status and exposure to environmental pollutants, e.g., via measuring the induction of ethoxyresorufin-O-deethylase (EROD). Examples of possible markers include:

   a) measurements of relevant nutritional factors such as astaxanthin in salmon. Changes in tissue levels should either reflect a changed metabolism in the fish or a more profound influence on the ecosystem where these factors are produced;

   b) induction of drug-metabolizing enzymes in fish. Such changes can reflect the presence of environmental pollutants or be an effect caused by or causing the reproductive disturbance;

   c) changed levels of sex hormones or other hormones, which cause or reflect an observed reproductive disturbance in the fish;

d) the presence of morphological changes associated with reproductive disturbance. Such changes could include reduced organ weights (e.g., gonad weight), histological or ultrastructural changes in critical tissues;

e) development of other relevant markers could, within limited financial resources, provide the possibility for screening for environmentally induced changes in the fish;

7) an investigation to elucidate the possible impact of food items taken up by adult salmon on the viability of the yolk-sac larvae. In this regard, it might be useful to focus on food items ingested 2 – 3 months prior to spawning. As revealed by Canadian studies, most of the transfer of nutritional components from the adult fish into the eggs takes place within this period;

8) a consideration of the possible role of algal toxins.

9.2 The Occurrence of *Ichthyophonus* in Herring

Request

At its May 1993 meeting, the ICES Advisory Committee on Fishery Management (ACFM) requested the ACME to review the available information on this topic.

Source of the information presented

The 1994 report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO), which evaluated additional and new data on *Ichthyophonus*.

Status/background information

Ichthyophonus infection in the spring-spawning herring stock in the western Baltic Sea has decreased significantly and in 1993 only a low level was detected. A low level was also observed in herring in Estonian waters. In the Kattegat and Skagerrak area, there was a decrease in infection prevalence in the larger size class of herring. A notable change in the disease pattern was that in the smaller size class of herring (1+ group) an increasing prevalence was recorded (up to 30%).

Ichthyophonus infection persisted in herring off the area east of the Shetland Islands (ICES Division IVa) at levels similar to those previously found. Herring in the central and southern parts of the North Sea remained uninfected. No new data were available from Norwegian spring-spawning stocks. Overall, there was no apparent decreasing or increasing trend in *Ichthyophonus* prevalence levels in the North Sea. Herring in Icelandic waters again showed *Ichthyophonus* infection, but at a very low prevalence.

Based on very limited data, no *Ichthyophonus* infection was found in herring from the Atlantic coast of North America. However, in cod from Nova Scotia, presumptive *Ichthyophonus* was found in gonads. Dab *(Limanda limanda)* in Icelandic waters exhibited high levels of infection (more than 90% prevalence). In the infected fish, a strong cellular reaction was observed.

Danish research showed that continuous culture of *Ichthyophonus* could be achieved by changing the pH of the culture medium during the growth of the fungus. No pathological changes were observed after infecting and feeding mice with *Ichthyophonus*, possibly suggesting that there are no harmful effects in mammals.

There are preliminary indications from Canadian research of the presence of at least two morphologically different types of *Ichthyophonus*.

9.3 Studies of Fish Diseases in the Baltic Sea

Request

Item 7 of the 1994 requests from the Helsinki Commission.

Source of the information presented

The 1994 report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO).

Status/background information

The ACME reviewed a progress report by the WGPDMO and noted that there is still a lack of information on fish diseases in the Baltic Sea. During the meeting of the WGPDMO, a report was given by members of the Baltic Marine Biologists (BMB) Working Group 25 'Fish Diseases and Parasites in the Baltic Sea' on activities of that Working Group scheduled for 1994. These include the following:

1) A 'BMB/ICES Symposium on Flounder Diseases and Parasites in the Baltic Sea' will be held on 27–29 October 1994 in Turku, Finland (Convenor: Dr G. Bylund). In addition to scientists from the Baltic countries, specialists from ICES countries outside the Baltic Sea area are invited to participate. The scientific contributions to the symposium will be published in a proceedings volume.

2) A 'BMB/ICES Sea-going Workshop on Fish Diseases and Parasites in the Baltic Sea' will be conducted from 25 November to 6 December 1994 on board the German R/V "Walther Herwig III" (Convenor: Dr T. Lang). It is intended that specialists from different fields of fish pathology and parasitology from all Baltic countries will participate in the Workshop and

that a larger area should be covered. The main objectives of the Workshop are:

- to study the abundance and spatial distribution of diseases and parasites in Baltic flounder and other abundant fish species along a transect from the western (Kiel Bight) to the eastern (Gulf of Finland) Baltic Sea,

- to evaluate the applicability of the ICES standard methodologies for fish disease surveys, developed mainly for the North Sea, under the special conditions in the Baltic Sea,

- if necessary, to develop and recommend new standard methodologies for fish disease monitoring programmes in the Baltic Sea.

Based on the outcome of the symposium and the sea-going workshop, BMB WG 25 will produce a report on fish diseases and parasites in the Baltic Sea and plans for further studies, for submission to ACME through the WGPDMO.

Need for further research

The ACME emphasized that more knowledge about spatial and temporal trends of fish disease prevalences in the Baltic Sea is needed. Research efforts and future disease monitoring programmes should be coordinated between the ICES WGPDMO and the BMB WG 25, and the organizations and scientists involved are encouraged to make use of the WGPDMO's long experience in this field.

9.4 Types of Studies for Elucidation of Possible Relationships between Fish Diseases and Pollution

Request

There is no specific request; this is part of the continuing work of ICES regarding fish diseases and their causes.

Source of the information presented

The 1994 report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO).

Status/background information

The WGPDMO identified three types of approaches to elucidate relationships between fish diseases and pollution:

1) Field studies;

2) Mesocosm and controlled field studies;

3) Laboratory studies.

Field studies

There are two main purposes of field studies:

a) to measure the significance of the direct effects of pollutants (e.g., correlation between gradients of toxic effluents in the water and the occurrence of fish diseases, correlation between concentrations of pollutants in sediments and the formation of liver neoplasms in benthic fish species); and

b) to monitor trends of fish diseases in broad areas where rises or falls in long-term trends can reflect subtle changes caused by environmental stressors, including pollution (e.g., eutrophication-related oxygen deficiencies, global climate changes).

In several cases, field studies have produced circumstantial evidence for a cause-effect relationship between pollution and fish diseases. Field studies are also important because they can identify infectious and non-infectious diseases which might be related to pollution. However, it has to be realized that field studies are only meaningful when they are conducted in a standardized way. Guidelines for standard methodologies of fish disease surveys have been provided by ICES (Anon., 1989).

Mesocosm and controlled field studies

Mesocosm studies are based on creating conditions that closely resemble natural conditions and permit a better understanding and prediction of interactions by manipulation and control of both biotic and abiotic environmental factors with a possible impact on diseases. Mesocosm studies are a good tool for the validation of results derived from laboratory studies or for the validation of developed biomarkers for application in the field. A further approach is to enclose fish in net cages in selected areas in the marine environment and measure changes in their health status.

Laboratory studies

Laboratory studies are important because they provide definite demonstration of cause-effect relationships between pollution and fish diseases in highly controlled environments. They are the ideal tool for research and development of specific techniques such as molecular/cellular biomarkers relevant to disease induction. They can be used to document the multiple steps involved in the development of fish diseases following exposure to toxic substances. For example, it is possible either to expose short-lived surrogate fish species as a model or to conduct *in vitro* tests, and apply a pluralistic approach of cellular biomarkers of exposure which can indicate cellular pathology.

Need for further research

The ACME agreed with the recommendation of the WGPDMO that the best strategy to elucidate relationships between pollution and fish diseases should comprise an integrated approach combining field, mesocosm, and laboratory studies. Due to the large resources and efforts necessary to meet this recommendation, standardized research in this field should be encouraged and integrated between institutes involved. Research should focus on the following issues:

1) a rationalized approach to field and mesocosm studies,

2) the impact of toxicants on the immunocompetence of fish as it relates to disease,

3) causal mechanisms involved in the formation of liver neoplasms and other pollution-associated diseases including reproductive and developmental disorders in fish, and

4) the development and application of biomarkers for a) immunotoxicology in fish, and b) early stages of liver neoplasms.

Anon. 1989. Methodology of fish disease surveys. ICES Coop. Res. Rep. No. 166, 43 pp.

9.5 Statistical Analysis of Fish Disease Data

Request

There is no specific request; this is part of the continuing work of ICES regarding fish diseases.

Source of the information presented

The 1994 report of the WGPDMO Subgroup on Statistical Analysis of Fish Disease Data.

Status/background information

The ACME reviewed the progress report of the WGPDMO Subgroup on Statistical Analysis of Fish Disease Data. A major item of the Subgroup work was the presentation and discussion of the new ICES fish disease data reporting format for the submission of fish disease data to the ICES Environmental Data Bank. The main improvement in the reporting format is that data on individual fish can be submitted instead of data on aggregates of fish. The use of individual fish data has been considered necessary in order to perform a comprehensive statistical evaluation of the data, including an analysis of spatial and temporal correlations between data on disease prevalences and concentrations of contaminants in marine sediments. However, such a comprehensive analysis based on individual data requires the re-submission of all data that have already been submitted to ICES as aggregated data.

10 ISSUES REGARDING MARINE MAMMALS, INCLUDING SEAL POPULATIONS IN THE BALTIC SEA

Request

Item 1 of the 1994 requests from the Helsinki Commission.

Source of the information presented

The 1994 report of the Study Group on Seals and Small Cetaceans in European Seas.

Status/background information

Based on its review of the report of the Study Group on Seals and Small Cetaceans in European Seas, the ACME agreed to present the information below.

10.1 Marine Mammals in the North Sea

The ACME noted the estimate of 4600 harbour porpoises (*Phocoena phocoena*) by-caught annually in the Danish North Sea fisheries for cod and turbot. Furthermore, it noted the plans for a large-scale international sighting survey for small cetaceans in the North Sea, English Channel and western Baltic Sea (SCANS), to be conducted in June–July 1994. The ACME felt it appropriate that information on by-catches of small cetaceans in the North Sea be reviewed when the abundance estimates provided by SCANS become available.

The ACME further noted that there has been a directed take of probably more than 100 harbour seals (*Phoca vitulina*) at the north and east coasts of Scotland in 1993. The ACME felt that a status of the exploited stocks should be provided.

10.2 Status of Seal Populations in the Baltic Sea

With the information available in the Study Group report, the ACME was not in a position to make an in-depth assessment of the impact of contaminants and by-catches on Baltic seal populations. In order to address the request from HELCOM, the ACME recommended that a series of actions be undertaken by ICES Member Countries before such an assessment can be completed. These are listed in the section covering needs for further research, below. The information presently available on the status of Baltic seal populations is summarized in the following paragraphs.

Harbour seals

The numbers of harbour seals in the Baltic Sea are undoubtedly very much lower than they were at the beginning of the century. There are two apparently distinct populations of harbour seals in the Baltic Sea. The population in the main part of the Baltic Sea is small and genetically distinct. This population was not affected by the 1988 phocine distemper epizootic. The population in the Belt Seas and the Øresund suffered 60% mortality during the 1988 epizootic and this population has not recovered from the effects of that epizootic (Helander and Bignert, 1992). Levels of contaminants in all Baltic harbour seals are relatively high (Blomkvist *et al.*, 1992), and there is a by-catch of harbour seals in the Danish and Swedish drift net fisheries for salmon. Although the official statistics suggest that only a few animals are killed each year, these by-catches might be a significant factor in slowing down the recovery of the numerically small Baltic population.

Ringed seals

There is considerable uncertainty about the total numbers of ringed seals (*Phoca hispida*) in the Baltic Sea because no information has been available for the Gulf of Finland, which has held an appreciable part of the population since 1984. However, an aerial survey of the Gulfs of Finland and Riga was scheduled for April 1994. Regular aerial surveys of ringed seals in the Bothnian Bay commenced in 1984. These suggest that numbers have increased, although this may be the result of immigration by seals from the Gulf of Finland in response to the greatly reduced ice cover during the past five winters. At present, there are about 3000 animals in the Bothnian Bay. Durant and Harwood (1986) estimated that there may have been at least 300,000 ringed seals in the Baltic Sea at the beginning of the century, on the basis of catch statistics and an estimate of population size in the 1970s. This analysis needs to be repeated with a wider range of demographic parameter values to provide an estimate of the range of initial population sizes which are consistent with the catch history and recent survey results. Nevertheless, it is clear that the present population size represents only a small fraction of the historic level. Until the 1960s, hunting was the major cause of the marked decline in the numbers of ringed seals in the Baltic Sea. However, the decline continued after hunting pressure was reduced, due to reduced population fecundity which may have been caused by pollution.

There is a by-catch of ringed seals in the fixed-net fishery for salmon. This mortality appears to be low ($<1\%$ per year), but its impact on the recovery of the population should be evaluated.

High levels of contaminants were found in Baltic ringed seals in the 1960s and 1970s. In addition, a large proportion of the adult females had uterine occlusions (Helle *et al.*, 1976), resulting in reduced fecundity (when only one horn was occluded) or sterility (when both horns were occluded). There are signs that the levels of DDTs and PCBs in the blubber of ringed seals are decreasing (Blomkvist *et al.*, 1992) and there has also been a reduction in the incidence of uterine occlusions (Helle, pers. comm.). The proportion of young (ages 1-4) animals taken during the spring hunt for scientific sampling has started to increase, which provides indirect evidence of an increase in population fertility.

Grey seals

1,300 grey seal (*Halichoerus grypus*) pups were counted at colonies in Estonia in 1992. The historic population size was undoubtedly much larger. A figure of 100,000 has been proposed in the literature (Almkvist, 1978; Almkvist, 1982), but the basis for this is unclear. However, catch statistics are available and an estimate of numbers at the beginning of the century could be back-calculated using the approach described by Durant and Harwood (1986). The reported by-catch for the last three years has averaged 90 animals. This represents an annual mortality of 2 - 3%.

High levels of contaminants were found in Baltic grey seals in the 1960s and 1970s. Uterine occlusions were also common, although the incidence was only about half that recorded for ringed seals. There has been a reduction in the levels of DDTs in grey seal blubber, but PCB levels have not changed significantly (Blomkvist *et al.*, 1992). PCB levels in grey seals may have remained relatively high if there has been a shift in the diet of the seals from white fish in response to recent changes in prey availability.

Need for further research or more data

In order to assess the impact of by-catches and contaminants on seal populations in the Baltic Sea, the ACME proposed that the following actions be taken:

1) the reporting of by-catches of marine mammals should be made mandatory in Baltic Sea fisheries, and complete statistics should be provided to ICES on an annual basis;

2) by-caught seals should be made available for *post mortem* examinations to monitor contaminant levels and to show the reproductive status of individual seals and the fertility of the population;

3) modelling studies of the population dynamics of all three seal species in the Baltic Sea should be continued. These should include the effect of current reported by-catches and the impact of contaminants on the recovery of the populations, and back calculations of population sizes at the beginning of the century. For the harbour seal, the modelling should take account of the short- and long-term effects of the 1988 epizootic;

4) studies of interactions between seals and fisheries should be conducted with the aim of reducing by-catch levels by modifying fishing gear and fishing operations;

5) surveys to estimate abundance should be continued, with collaboration among countries in the Baltic region being continued and augmented to increase the geographical coverage of the surveys.

References

Almkvist, L. 1978. Seal stock sizes along the Swedish coast in 1976. Finnish Game Res., 37: 22–24.

Almkvist, L. 1982. Baltic marine mammals — A status report. ICES, Doc. C.M.1982/N:16. 19 pp.

Blomkvist, G., Roos, A., Jensen, S., Bignert, A., and Olsson, M. 1992. Concentrations of SDDT and PCB in seals from Swedish and Scottish waters. Ambio, 21(8): 539–545.

Durant, S., and Harwood, J. 1986. The effect of hunting on ringed seals (*Phoca hispida*) in the Baltic. ICES, Doc. C.M.1986/N:10.

Helander, B., and Bignert, A. 1992. Harbor seal (*Phoca vitulina*) on the Swedish Baltic coast: Population trends and reproduction. Ambio, 21(8): 504–510.

Helle, E., Olsson, M., and Jensen, S. 1976. PCB levels correlated with pathological changes in seal uteri. Ambio, 5: 261–263.

11 BENTHOS ISSUES

Request

There is no specific request; this is part of continuing ICES work on the study of benthic communities and anthropogenic influences on them.

Source of the information presented

The 1994 report of the Benthos Ecology Working Group.

Status/background information

The ACME reviewed the material provided by the Benthos Ecology Working Group and agreed to present the information that follows.

11.1 Indicator Species with Reference to Physical Disturbance of the Seabed

'Physical disturbance' is defined by the Benthos Ecology Working Group as "any discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability, or the physical environment".

This definition covers natural events such as storms, hurricanes, sedimentation or erosion processes, high river runoff, as well as anthropogenic activities such as aggregate extraction, dredging, fishing effects, management of coastal areas, and mariculture operations.

The Benthos Ecology Working Group as well as the Working Group on Ecosystem Effects of Fishing Activities prefer to use the term 'vulnerable' species rather than 'indicator' species, which has a wider sense and because the concept of 'indicator' species for marine waters is not well defined as opposed to that for fresh waters.

Physical disturbance of the seabed (substratum) can include the following:

1) the substratum may be removed to leave an inhospitable habitat (e.g., sediment removed down to the clay level, consolidated/stable substrata removed to mobile substrata including substrata likely to cause scouring);

2) hard substrata having fragile slow-growing species may be broken up, abraded or overturned;

3) reefs of slow-growing species providing a biological substratum for other species may be destroyed;

4) biological reefs or consolidated hard substrata may be overturned or destroyed but be capable of rapid recolonization after the disturbance ceases;

5) (re)suspension of silt may occur, followed by sedimentation nearby or at a distance;

6) sediment compaction (below heavy gear) may occur;

7) substratum structure and composition may be changed producing a 'new' habitat (e.g., topography may be changed, buried cobbles exposed, coarse shell material broken up or exposed).

When considering the potential effect of physical disturbance on benthic fauna, it is important to consider the scale, frequency, and intensity of any disturbance event.

Species characteristics which make them vulnerable

The vulnerability of benthic species should be assessed on the basis of their life history characteristics, physical fragility, habitat and behavioural characteristics (epifauna, infauna, burrowing, etc.). The vulnerability of a species is partly dependent on its structure, size, behaviour, life strategy, etc., and on the environment/habitat that the animal lives in. The geographical distribution of the species also has to be considered – species at the extreme edge of their distribution are likely to be more vulnerable.

The fragility of a species will, in the first instance, determine whether it is easily damaged or not. This fragility is determined by morphology (size and shape), whereas vulnerability is determined by the depth at which it lives in the sediment (i.e., within or outside the reach of the physical disturbance) and its mobility. The nature of the sediment is also important, e.g., fishing gear may penetrate different sediments to different depths, and disturbance of large gravel or cobbles themselves will have a very different impact on species than, for instance, disturbance to sand.

After being subjected to physical disturbance, the recovery process of an individual organism depends on its ability to regenerate, to repair damage, or to relocate itself. Low abilities of these attributes may make a species vulnerable to indirect effects of physical disturbance, in particular predation.

Sediment resuspension, interfering with filter feeding and/or respiration, may have a negative effect on growth and, ultimately, reproduction and recolonization.

In addition to effects at the individual organism level, a long-term effect at the population level may be present. Factors determining long-term effects include the longevity of a species, growth rate, reproduction and settlement success. Potential recruitment is thereby determined not only by the standing stock of the parent population, but may also be affected by the changes in the physical characteristics of the habitat, for instance, changes in sediment grain size, as well as the absence/presence of a parent population. For some sessile organisms, it has been shown that juveniles only settle in the vicinity of an older population releasing chemical stimuli, which promote settlement. Thus, to assess the vulnerability of a species, detailed knowledge of its life cycle, regeneration, growth, and other parameters is required.

The ACME recognized the following criteria of classification, proposed by the working group, to identify the vulnerability of species:

- Fragile long-lived species with infrequent recruitment - unlikely to recover within a foreseeable future;
- Fragile long-lived species with good prospects of recruitment/regrowth (but after several years);
- Fragile but fast growing/recruiting species - likely to be damaged but recover rapidly;
- Robust or deep-burrowing species - unlikely to be damaged;
- Species likely to thrive in disturbed situations (e.g., predators, opportunist species).

Need for further research

A common strategy for the definition of a protocol of research should be identified to assess the impact of different anthropogenic activities disturbing the seabed at a species level but also at a benthos community structure level. These studies must be conducted on a multidisciplinary basis covering the physical processes, the geological aspects, and including recruitment population dynamics, density dependence and biodiversity concepts.

11.2 Feasibility of Establishing a Benthos Data Bank within ICES

Request

In 1993 the ICES Benthos Ecology Working Group (BEWG) recommended that ICES establish a benthos database. Subsequently, the OSPARCOM requested ICES to study the feasibility of integrating benthos data into the ICES database (second data handling request on the 1994 work programme from the Oslo and Paris Commissions).

Source of the information presented

The ACME reviewed a document prepared by the ICES Secretariat on this subject and the results of the consideration of this document by the Benthos Ecology Working Group.

Status/background information

The 1986 ICES North Sea Benthos Survey was initiated and conducted by the Benthos Ecology Working Group. The results of this survey were entered into a database at the Netherlands Institute of Ecology, Centre for Estuarine and Coastal Ecology. In addition to the data from the North Sea Benthos Survey, the present version of the database contains data from several other surveys and now comprises more than 130,000 records. Most of the data pertain to macrobenthic infauna and include numbers per sample by species as well as biomass by major taxonomic groups, but for some surveys, data on meiobenthos and/or sediment characteristics are also included.

The data are presently organized in a relational database using the PC database program Paradox. The software allows the user to extract data on density and biomass based on a selection of either species, sample or position. Additional software allows the data to be presented in the form of circles on maps, with the area of the circles being proportional to the abundance of individual species.

Over the years the data have been used by several ICES working and study groups and in connection with the preparation of the *North Sea Quality Status Report*, 1993.

Establishment of an ICES Benthos Database

To establish an ICES Benthos Database will require carrying out the following different activities:

a) Transferring and integrating the present database into the ICES Environmental Data Bank;

b) Receiving and integrating additional historic benthos data sets;

c) Defining and implementing a reporting protocol for the results of future studies;

d) Receiving and integrating data submitted according to the new protocol;

e) Maintaining the data bank;

f) Producing output products;

g) Participating in meetings.

In addition to the costs associated with these activities, there will be additional expenses connected with the purchase of additional computing power and software. The ICES Secretariat will provide an estimate of the overall costs associated with the establishment and maintenance of the database. The general level of costs are indicated, along with further details of the work to be conducted, in the complete feasibility study which is attached as Annex 4.

Feasibility of transferring the current database

Several deficiencies in the setup of the current database need to be rectified if it will be transferred to ICES. In general, the database contains very little documentation on the data included and suffers from the lack of an agreed reporting protocol. To ensure comparability of results among participating laboratories, quality assurance information should be an integral part of the data submitted. A new database should include options for the evaluation of this information.

Conclusion

Provided that priority is given by ICES to the establishment of this database and that the necessary financial and manpower resources are made available, the ACME considers the problems associated with the establishment of a Benthos Database at ICES to be minor.

Request

Item 2 of the 1994 requests from the Helsinki Commission; this has also previously been on work programmes for the Oslo and Paris Commissions.

Source of the information presented

The Marine Chemistry Working Group (MCWG) coordinates the preparation of these overviews, with review of toxicological and biological effects information by the Working Group on Biological Effects of Contaminants. Papers that have passed their review are transmitted to the ACME for further consideration.

Status/background information

The ACME reviewed the papers and material provided by the MCWG and agreed on the summary information presented in the following sections.

12.1 Atrazine in the Estuarine Environment

The ACME considered a paper prepared by J. Tronczynski, "An Overview of Atrazine in the Estuarine Environment", which had been presented at the 1993 ICES Statutory Meeting in Dublin (ICES, Doc. C.M.1993/E:21).

Atrazine is a synthetic organic compound with selective herbicidal properties; it is widely used in agricultural as well as non-agricultural practices. The main environmental concerns regarding atrazine are focused on its moderate persistence, its mobility in aquatic ecosystems, and its mode of action as an inhibitor of photosynthesis. Recent data provide evidence that estuarine waters in Europe are contaminated by atrazine and this contamination can extend into full salinity waters. Sediment deposits do not appear to be a major reservoir of atrazine in estuarine ecosystems, either due to chemical and/or microbial degradation or to geochemical factors that favour the partitioning of atrazine in the dissolved phase. Ambient concentrations range from <0.001 μg/l to <1 μg/l in estuarine waters and 0.1 to 30 μg/l in surface and sub-surface freshwater systems. Higher concentrations have been detected in areas receiving direct inputs from agricultural sources or runoff, but they are localized and highly transient. Acute toxic effects on marine algae have been observed at high concentrations (EC_{50} 60–460 mg/l). Little is known about chronic effects of low levels of atrazine or the effects of its metabolites on aquatic species.

There are many unanswered questions concerning the transport, fate, and effects of atrazine in estuarine and marine environments and more detailed studies of local estuarine systems are warranted. Given the incomplete information on the present status of atrazine as a contaminant in the marine environment, it should not be included in broad-scale monitoring programmes for contaminants. However, studies in the vicinity of local discharges may yield important information on the processes affecting its transport, fate, and effects in coastal and estuarine ecosystems.

12.2 3,3′-Dichlorobenzidine

The Marine Chemistry Working Group considered a review note prepared by R. Law on 3,3′-dichlorobenzidine at its 1994 meeting and approved it for transmission to ACME.

3,3′-Dichlorobenzidine (DCB) is a synthetic organic compound used as an intermediate in the manufacture of dyes and pigments and as a curing agent for isocyanate-terminated resins for urethane plastics. High concentrations of DCB have not been detected in waters downstream of dye plants and it has not been found in fish tissues from similar locations. The production and discharge of DCB are both small and the potential for bioaccumulation is low. The effects of DCB appear to be minimal and restricted to the vicinity of local discharges. Therefore, it seems unlikely that DCB would be a contaminant of concern in the marine environment and DCB should not be included in routine monitoring programmes.

12.3 Toxaphene in the Marine Environment

At its 1994 meeting, the Marine Chemistry Working Group reviewed a paper authored by D. Muir and J. de Boer on "Toxaphene in the Marine Environment: Analysis, Distribution, and Possible Biological Impacts". This paper will be submitted for publication in the open literature. A special issue of Chemosphere (Vol. 27, No. 10) has recently been published on toxaphene.

Toxaphene is a complex mixture of polychlorinated camphenes or, more correctly, chlorinated bornanes (CHBs). Prior to its ban in the United States in 1982, toxaphene was the most widely used pesticide in the US and in many parts of the world. Although no longer manufactured in the United States, toxaphene is still used in Central and South America, Mexico, Africa, Germany, Hungary, Poland, Romania, regions of the former USSR, and India. Concern for toxaphene distribution in the marine environment is focused on the atmospheric transport of toxaphene and elevated levels in fish and marine mammals.

Toxaphene is synthesized by controlled chlorination of camphene. Technical toxaphene consists mainly of C_7 to C_9 CHBs and there can be at least 6,840 congeners. Analytical problems, including resolution and identification of individual congeners, are similar to those associated with polychlorinated biphenyls (PCBs) but far more complex due to the greater number of potential individual congeners and the paucity of synthesized standards of individual CHBs. There are also great variations in composition between environmental samples and technical grade toxaphene. Atmospheric transport and deposition appear to be the major route of toxaphene delivery to the oceans, especially at low temperatures. Concentrations of toxaphene in fish and marine mammals, especially among populations in polar regions, appear to be high enough to cause concern for long-term or chronic effects of toxaphene exposure. Although limited information on the toxicity of technical grade toxaphene is available, relatively little is known about the toxic effects of highly transformed environmental residues. The development of a GABA-receptor (γ-amino-butyric acid) assay for toxaphene screening provides a possible monitoring tool of both environmentally relevant concentrations and potential effects on neurotransmission.

12.4 Marine Phycotoxins

The ACME noted that the MCWG had reviewed a paper on chemical methods developed to replace the use of animal bioassays for the detection of shellfish toxins, specifically Amnesic Shellfish Poison (ASP), Diarrheic Shellfish Poison (DSP), and Paralytic Shellfish Poison (PSP). The MCWG concluded that the high-performance liquid chromatography (HPLC) method for the analysis of domoic acid (ASP) described by Quilliam *et al.* (1989) is well developed and is currently being used in monitoring programmes as a first-line control. However, HPLC methods developed for DSP and PSP detection are slow and not very robust and, while useful as research and confirmatory tools, are not suitable for use as first-line control methods.

Based on the serious human health implications and the difficulties in the area of animal testing, reliable and robust chemical methods of analysis are urgently required particularly when large numbers of analyses must be conducted during toxic events.

Quilliam, M.A. *et al.*, 1989. High-performance liquid chromoatography of domoic acid, a marine neurotoxin. Inter. J. Environ. Anal Chem.. 36: 139–154.

13 ENVIRONMENTAL INTERACTIONS OF MARICULTURE

13.1 New Approaches to Environmental Assessment and Monitoring of Mariculture Operations

Request

There is no specific request; however, the assessment and monitoring of mariculture operations are topics of interest to ICES, particularly as marine finfish operations continue to develop. New ways are actively being explored within ICES Member Countries to regulate the industry and to control adverse environmental impacts relative to pre-defined standards and the holding capacity of the site. Monitoring methods are becoming directly integrated with simulation models and these reflect farm production and impacts that are easy to measure and quantify. Benthic organic enrichment is the impact most commonly addressed.

Source of the information presented

The 1994 report of the Working Group on Environmental Interactions of Mariculture.

Status/background information

A programme for the monitoring and modelling of the environmental impacts of mariculture for regulatory purposes has been developed which incorporates modelling, monitoring, and fish production. The modelling component consists of four modules: a fish module, a water quality module, a dispersion module, and a sediment module; these are used to simulate the impact of a specific fish farming operation and to determine the size of farm that may be permitted at a particular site without exceeding given impact criteria. The fish module simulates the actual effluent characteristics; the water quality module simulates dissolved compounds and oxygen; the dispersion module takes into account the farm area, and water depth and current conditions; and the sediment module simulates the accumulation and decay of the waste. This model, called MOM (Modellering, Overvåkning, Matfishanlegg), will be tried out in Norway in 1995. The results will be published following scientific review.

The incorporation of modelling activities within the monitoring and surveillance strategy for mariculture provides definite benefits, such as supplying information on the holding and carrying capacity of mariculture development areas in the coastal zone, improving husbandry practices and advice on site management practices, designing appropriate monitoring strategies which allow assessment of regulatory thresholds and risks, and providing socio-economic advice on macroeconomic issues within the coastal zone. Modelling can include the development of 'expert systems' and can couple site-specific databases (e.g., GIS systems) to decision-support tools to assist planners and managers in addressing regulatory, monitoring, and socio-economic issues.

Combined with the modelling and monitoring regime will be a surveillance component to ensure that the environmental impact does not exceed pre-determined environmental quality standards. The level of surveillance (frequency) will be directly related to fish production.

The Working Group on Environmental Interactions of Mariculture (WGEIM) compiled information on ongoing monitoring programmes related to the assessment of aquaculture impacts and interactions. Monitoring regimes for mariculture were discussed based on Irish, Scottish, and Norwegian experience and this information is now being prepared for incorporation into a Technical Report on the Management of the Environmental Impacts of Mariculture, which will be annexed to the WGEIM report. The overall objective of monitoring mariculture operations is to meet the biological requirements of the cultured organisms and, at the same time, achieve the environmental quality objectives within coastal waters set by regulatory authorities. In practical terms, one must concentrate on regulating the major impacts by placing emphasis on those that can be controlled. The long-term use of the site must be safeguarded and the accumulation of organic wastes must not exceed pre-defined levels. A diverse assemblage of benthic macrofauna must continue to be present under sea cages. In some cases, baseline surveys prior to production would assist in the development of simulation models and in the determination of appropriate locations where benthic sampling stations should be positioned. The use of underwater photography is advocated in the assessment of mariculture effects as it provides a permanent visible record of benthic conditions over time. Likewise, the incorporation of Sediment Profile Imagery (SPI) techniques is recommended as a cost-effective method in the mapping and monitoring of the benthic impacts of finfish cultivation.

The effectiveness of monitoring finfish operations depends on the quality of farm records concerning biomass, mortalities, feed conversion, etc., and such records should be included as part of a routine monitoring and assessment programme.

Approaches to the monitoring and assessment of mariculture operations are rapidly evolving within ICES. The WGEIM has established a monitoring sub-group to address these issues and will report on new developments, such as the MOM strategy in Norway. In the interim, the strategy for the monitoring of mariculture operations, appended to the WGEIM report, should be distributed within ICES to assist Member Countries in their development of monitoring programmes related to mariculture operations.

13.2 NASCO Request for Advice on the Impact of Salmon Aquaculture on Wild Stocks

The North Atlantic Salmon Conservation Organization (NASCO) requested ICES for advice on potential environmental impacts of salmon aquaculture on the wild stocks of Atlantic salmon. The WGEIM was asked for its advice concerning improvements in the containment of farmed fish. There was general agreement that the best approach to minimizing losses of salmon from sea cages was to improve the standard of cage design and to carry out routine maintenance of structures and moorings. An inspection programme in Norway on sea cage structures has resulted in a 75% reduction in the number of escaped salmon.

In addition, improvements in antipredator controls are essential and the ecological implications of the use of acoustic systems merit consideration. The WGEIM should address such issues and a study group on mariculture technology should be established to evaluate existing knowledge and new technology for predator control in mariculture, in addition to other topics of a technological nature.

Many farmed salmon escape during routine handling over protracted periods. The reduction of minor escapement must be addressed by raising the awareness of fish farmers, educating operators, maintaining good stock records and taking immediate remedial action when problems occur.

The recapture of escaped salmon was considered impractical as was the tagging of farmed fish. A suggestion that the escaped salmon problem could be solved through the use of land-based sea water systems was not perceived as being economically viable.

Experiments on the use of exclusive areas for the protection of wild salmon were initiated in Norway in 1989 and the results will be evaluated by the WGEIM in 1995. The strategy of using sterile fish for salmon mariculture, notwithstanding the growth, deformity and consumer resistance concerns, also raises questions concerning the ecological implications of the escape of large non-spawning fish, particularly with respect to competition for available food sources in the marine environment. The issue of the interactions of escaped salmon with wild stocks and progress in research on this topic will be reviewed by the WGEIM at its next meeting.

In addition, the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) considered the question of the disease implications of escaped cultured salmon on wild populations. The following points were noted:

a) information on interactions of disease between wild and reared salmon is scarce. Available reports contain mostly circumstantial evidence for interactions of disease between wild and farmed fish.

b) a number of research projects are being conducted in ICES Member Countries:

  - in Scotland, a project on the association between sea lice, Infectious Pancreatic Necrosis (IPN), Pancreatic Disease (PD), and furunculosis in sea trout,

  - also in Scotland, a project on diseases in wrasse (Labridae) (cleaner fish) and cultivated salmon to identify whether either species acts as a reservoir of infection for the other,

  - in England, a project on epizootics of wild freshwater fish (including salmonids),

  - in Norway, projects on the interaction of sea lice in cultivated salmon and wild salmon and sea trout,

  - in Norway, a project on the interaction of typical furunculosis in wild and cultivated salmon,

  - especially in Norway, as well as in some other countries, there are a number of studies on the spread of *Gyrodactylus salaris* in wild salmonid stocks,

  - in Ireland, investigations on mortalities associated with disease, particularly lice, in sea trout,

  - in the USA, it has been reported that significant losses of Pacific salmon were associated with the Erythrocyte Inclusion Body Syndrome (EIBS) virus,

  - European Union countries with wild and farmed salmonid stocks routinely conduct monitoring programmes for diseases listed in EC Directive 91/67.

In conclusion, the WGPDMO observed that most of the above projects were under-resourced and, with additional funding, could be fruitfully expanded. Furthermore, the WGPDMO drew attention to relevant conclusions in its 1992 report that, from a disease point of view, the interaction between farmed and wild fish is a complex two-way process with opportunities for spread in both directions, but on the evidence available it would seem that, if anything, wild fish pose a greater disease threat to farmed fish than *vice versa*. A review of published information did not provide evidence of a significant detrimental effect on wild fish stocks as a consequence of the occurrence of disease in mariculture, but this needs to be kept under review. These conclusions from 1992 are still valid as the situation has not changed significantly since then. The WGPDMO's opinion was that most disease organisms present in farmed fish were also present in wild fish stocks. Furthermore, it was considered that wild fish were more likely to act as reservoirs of disease for farmed fish than *vice versa*.

13.3 Guidelines on the Assessment of the Environmental Impact of Therapeutants

One of the public concerns frequently voiced with respect to finfish mariculture is the use of therapeutants in fish farming and the distribution and fate of these agents in the ecosystem. The WGEIM paid considerable attention to this topic at its 1994 meeting.

An important issue is the development and use of ecotoxicological guidelines for the assessment of a candidate therapeutant for potential environmental impact. Generally, a three-tiered approach is taken, whereby Tier 1 consists of determining basic physio-chemical parameters of the therapeutic compound; Tier 2 takes into account the fate of the product including chemical and physical routes of breakdown, toxicological studies, bioavailability and bioaccumulation, etc.; and Tier 3 considers dispersion studies in natural water bodies with defined hydrographic characteristics.

The factors influencing the fate of anti-microbial agents in the marine environment are primarily related to the association of these chemicals with particulate matter and their distribution between faeces and uneaten feed pellets. Uneaten feed pellets will sediment rapidly, accumulate under the cages, and be present in wild fish and shellfish in the vicinity of the farm. In contrast, the faeces leave the farm site as a well-dispersed cloud; faecally associated anti-microbial agents are much less likely to accumulate in fish, and are primarily important in the water column. Feed-associated anti-microbial agents are primarily important in the sediments and benthic fauna. Overfeeding, especially of medicated feeds, is not only uneconomical to the fish farmer, but will also result in unacceptable accumulations of organically enriched material under the cage. There is evidence that organically enriched sediments will select for a high frequency of non-specific, low level, multiple resistant strains even in the absence of antibacterial agents.

The question of the bioavailability, bioactivity, and binding of therapeutants is an essential part of the therapeutant approval process, however, the development of chemical methods to investigate the presence of these substances, in the environment and in animal tissues, has been dominant in the research and development agenda. The bioactivity and binding of therapeutants is mediated by water quality and factors such as the presence of humic substances and other particulate matter. The consequence of these chemical analyses, and the interpretation of the results, shows that the chemically based methods currently in use, although specific and sensitive, are capable of yielding an overestimation of the biological significance of the data. There is a need to develop assays that enable a valid quantification of the bioactivity of these therapeutants.

Another aspect of the problem is that medicated feeds, although they might appear to have adequate amounts of an anti-microbial agent present for absorption by the fish, contain complexing factors so that, in fact, most of the drug is not available biologically to the fish and passes straight through as faeces. Alternate methods of application of the therapeutants, including the development of alternate oral matrices by which medication is presented to the fish, will have to be developed. The basic concept which must not be ignored is that the chemical presence and the biological presence of therapeutic agents are not the same.

The increase in the frequency of resistant bacteria is potentially the most sensitive indicator of the biological activity of anti-microbial agents in the environment. No studies have yet reported a clear relationship between drug levels (as detected by HPLC) and the frequencies of resistance in the microflora. In fact, the data suggest that resistance frequencies are elevated in farm effluents whether or not the farms have used anti-microbial therapy. There is a critical requirement for wide-scale standardization and validation of the methods used in detecting resistance frequencies in environmental samples.

These issues are presented and discussed in the report on the Use of Chemicals in Mariculture, which has been published as *ICES Cooperative Research Report* No. 202.

13.4 Coastal Zone Management for Sustainable Mariculture Development

Increased emphasis on the multiple use of renewable coastal resources to optimize economic and social benefits is a priority of many countries. It is recognized within ICES that major improvements are required in the way development in the coastal zone is planned and managed. The opportunities for promoting sustainable growth and the diversification of mariculture in the coastal zone are not being fully realized and many options for future development are being foreclosed.

The WGEIM has given attention to the topic of the role of mariculture in integrated coastal zone management and has reviewed the relevant principles and the opportunities mariculture can have in this regard. Mariculture is relatively new and its development, especially in some sectors such as salmon farming, has coincided with a large increase in public awareness. This has often led to competing interests with other users and conflicts which will undoubtedly increase unless more attention is focused on this issue.

On the positive side, mariculture produces a prime product in demand by consumers and provides a new source of socio-economic activity in rural areas. Furthermore, the very presence of mariculture helps to discourage pollution from less environmentally friendly industries. On the negative side, many mariculture projects have resulted in pollution, often due to poor management.

A number of initiatives within ICES on integrating mariculture within coastal waters have furthered the process of coastal zone planning. The LENKA planning programme in Norway aimed at providing an efficient and standardized tool for coastal planning and took into account the environmental requirements for farmed fish, environmental quality standards, existing users and infrastructure. This programme served to initiate the process of coastal zone planning in Norway. In France, there have been many schemes to plan for mariculture, particularly for shellfish culture in the coastal zone. In British Columbia, Canada, there have been initiatives to designate special areas for tourism, recreation, reserved areas (parks), and preferred development areas where aquaculture is given priority status. Coastal resource planning initiatives are also under way in eastern Canada.

14 ISSUES REGARDING INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

Request

ICES Member Countries may request ICES to review proposed introductions or transfers of marine organisms for mariculture purposes. These proposals receive in-depth review by the Working Group on Introductions and Transfers of Marine Organisms, with ultimate review by ACME. Two requests have been considered below, one from the United States concerning the use of sterile triploid Japanese oysters in open field trials, and another from Ireland concerning the introduction and development of a high-intensity land-based culture system for striped bass, white bass, and their hybrids.

Source of the information presented

The 1994 report of the Working Group on Introductions and Transfers of Marine Organisms (WGITMO).

Status/background information

The ACME reviewed the WGITMO report and agreed to present the information and advice contained in the following sections.

14.1 1994 Code of Practice on Introductions and Transfers of Marine Organisms

The ACME noted that the Code of Practice on Introductions and Transfers of Marine Organisms had been substantially revised in 1994, taking into account suggestions and recommendations provided by the ACME and the Mariculture Committee. The main changes include the simplification of the title of the code and the expansion of the preamble to broaden the scope of the code to emphasize ecological concerns about organisms other than pests and disease agents. The code now also includes consideration of genetically modified organisms and refers to non-ecological impacts as well as potential economic impacts. Furthermore, the code makes provision for periodic inspection (including microscopic examination) of material prior to exportation to confirm freedom from introducible pests and diseases.

Under the revised ICES Code of Practice, any proposed introduction of a marine organism would require the preparation of a detailed prospectus on the potential impacts on the ecosystem, which would include reviews of the ecological, genetic, and disease relationships of the candidate species in both its natural environment and at the proposed release site. Based on this information, ICES will be able to consider the possible outcome of the proposed introduction and offer advice on the acceptability of the choice.

After the 1994 Code of Practice on Introductions and Transfers of Marine Organisms has been adopted, the WGITMO will prepare a new report for publication in the *ICES Cooperative Research Report* series to update the current guidelines and manual of procedures for implementing the Code of Practice.

After review, the ACME accepted the 1994 Code of Practice on Introductions and Transfers of Marine Organisms for use by ICES. The Code is attached as Annex 3.

14.2 Accidental Transfers of Aquatic Organisms, Including the Problem of Ballast Water

The ACME noted the very serious threats posed by the accidental introduction of pest species through the release of ballast water from ships in distant waters. Several case studies are presented here to illustrate these threats.

The occurrence of *Mnemiopsis*, a ctenophore of western Atlantic origin, in the Black/Azov Seas and the Mediterranean Sea has been under investigation. The introduction of this species, through ballast water discharges, has been identified as being responsible for the collapse of the anchovy fishery in the Black Sea. This example demonstrates the potential threat of ballast water introductions and their potentially major implications on large marine ecosystems. Furthermore, it emphasizes the need for better control procedures. A proposal for the biological control of *Mnemiopsis* through the introduction of a fish predator is under consideration by the United Nations.

Ballast water studies are under way in several ICES Member Countries. In Germany, a project was initiated in 1992, and to date 357 samples from 274 ships have been collected and analysed. In the USA, a project funded by the U.S. Coast Guard and the Sea Grant Program is being conducted in Norfolk, Virginia and Baltimore, Maryland, the two major ports on the Chesapeake Bay. Of the vessels sampled, over 90% have had live organisms present in the ballast water and these organisms can remain viable for at least 20 days.

Recommendation

To address the increasing concerns regarding the role of ballast waters in the accidental release of exotic species, the ACME recommended that this issue be addressed in depth at the ICES 1995 Annual Science Conference (formerly Statutory Meeting).

14.3 Introduction of Japanese Kelp, *Undaria pinnatifida*, into France, Including Ecological Considerations and Environmental Impacts

Japanese kelp (*Undaria pinnatifida*) has been cultivated since 1983 in the Rance estuary, France. As of 1990, eight sites were listed as farming areas, yielding 40–75 tonnes (fresh weight) per year. Reports from France have concluded that, several years after its introduction, the alga has only colonized some areas close to the original farming sites near St. Malo and Charente Maritime, while on other sites small and fluctuating populations have developed. These studies have concluded that *Undaria* does not have a detrimental impact on the environment.

In their review of the data provided, the WGITMO noted that *Undaria pinnatifida* has spread from the farming sites, as anticipated earlier, but that its effects on the ecosystem so far do not seem to be detrimental, although large populations may develop. A further spread in Europe seems likely considering that it has occurred since 1990 in Spain.

14.4 Risk of the Use of Sterile Triploid Japanese Oysters in Open Field Trials

The presence of "MSX" disease, caused by the sporozoan *Haplosporidium nelsoni*, and Dermo disease, *Perkinsus marinus*, have seriously reduced the native populations of the resident American oyster, *Crassostrea virginica*, in Chesapeake Bay, USA. For the Dermo disease, it has been demonstrated experimentally that the Pacific oyster, *Crassostrea gigas*, is resistant to this disease agent. There was an interest in determining whether this oyster species would also be resistant to the MSX disease agent under natural conditions, as the only way to conduct the study. *C. gigas* is resistant to the two diseases even if it is contaminated by MSX. Dr S. Allen, Rutgers University, New Jersey, was permitted, in accordance with the guidelines for the ICES Code of Practice on Introductions and Transfers, to place F4 generation *C. gigas* in experimental trays in both Chesapeake and Delaware Bays, provided that all oysters were individually pre-tested by flow cytometry and confirmed to be triploid. After six months, of the 83 oysters examined from a Chesapeake Bay site, 61 (73.5%) were still triploid, 17 (20.5%) were found to be mosaics (that is, possessing both triploid and diploid cells), and 5 (6%) were found to be diploid. This reversion from a triploid to a diploid state is unprecedented in bivalve molluscs. Nonetheless, even if there is no reversion, triploid systems are not sterile; they can reproduce, but at a very low rate (0.1%).

Given these findings, the question that had been addressed to ICES by the States of New Jersey and Delaware had essentially been answered, that is, that the species should <u>not</u> be introduced unless it fulfils the requirements of the ICES Code of Practice and that, in this particular circumstance, complete reproductive sterility would be assured. The WGITMO concluded that the holding of non-indigenous oysters in Delaware and Chesapeake Bays constituted an "introduction" within the context of the ICES Code of Practice on Introductions and Transfers of Marine Organisms.

In addition, the WGITMO believed that ICES should address the broader issue of the application of sterilization techniques of test organisms (such as triploidy) when there is a desire to conduct field trials and experiments with an introduced species, or in consideration of policies under development to impose sterilization, by triploidy, of species used in mariculture as a means of protecting wild stocks. The Working Group on Applications of Genetics in Fisheries and Mariculture should take this question under further consideration.

14.5 Proposed Introduction of Striped and White Bass by Ireland

The ACME noted that the WGITMO had examined a proposal by Ireland to introduce and develop a high-intensity, land-based, contained culture system for striped bass (*Morone saxatilis*), white bass (*Morone chrysops*), and their hybrids. The WGITMO acknowledged that either species or their hybrids proposed for importation have the potential to become established and to compete with marine species if a release should occur. However, it was the opinion of the WGITMO that the basic proposal addresses the risk of escapement within the proposed operations by virtue of strict containment and, therefore, a full assessment of the ecological implications was not warranted.

The Working Group made the following recommendation:

On the basis of the considerations of the WGITMO on the importation of bass from the USA to Ireland by a private party, it does not oppose the importation subject to adherence to the ICES Code of Practice, and under the land-based, completely contained culture conditions presented in the proposal, and further subject to the following conditions:

a) An assessment should be carried out which addresses the operational and environmental aspects of the disposal of all waste products, including dead fish, waste water, and liquid manure. (The disposal of these products is to meet with the requirements of the relevant Irish authorities.)

b) *The facility should be constructed* so that, in the event of complete tank(s) failure, all fish and water would be physically contained within the facility.

c) *A contingency plan should be prepared* that addresses any and all identifiable potential accidental events that could lead to fish escape (such as the loss of fingerlings during transfer from the port of entry to the culture facility).

d) *Breeding stocks should be established* within the culture facility as soon as possible by importing surface-disinfected (if practicable) eggs from parents that have been lethally sampled for bacteria, viruses, and other potentially vertically transmitted organisms. These breeding stocks should be maintained within the site in isolation from fingerlings in culture.

e) *No live fish or viable gametes will leave the security of the site.*

The ACME endorsed this recommendation.

15 GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENTS OF MARINE AGGREGATES DREDGING

Request

There is no specific request; this is part of continuing ICES work concerning the effects of marine aggregate extraction on fisheries and means of reducing this impact.

Source of the information presented

The 1994 report of the Working Group on the Effects of Extraction of Marine Sediments on Fisheries.

Status/background information

The ACME considered the report of the Working Group on the Effects of Extraction of Marine Sediments on Fisheries and noted with satisfaction that guidelines for the environmental impact assessment of marine aggregate extraction were proposed. The ACME accepted these guidelines, as reproduced below.

GUIDELINES FOR THE PREPARATION OF AN ENVIRONMENTAL IMPACT ASSESSMENT EVALUATING THE EFFECTS OF SEABED AGGREGATE EXTRACTION ON THE MARINE ENVIRONMENT

Introduction

This guidance describes the requirements of an Environmental Impact Assessment (EIA) such as required by the "Code of Practice for the Commercial Extraction of Marine Sediments (Including Minerals and Aggregates)". It forms the basis of the subsequent technical considerations for marine aggregate extraction.

The effects of marine aggregate extraction will be both physical and biological, as shown in a comprehensive literature review on the impacts on fisheries and the marine environment of sand and gravel extraction (ICES, 1992). However, the significance to the wider marine environment of such dredging-induced changes will clearly depend upon the size and location of the licensed areas.

An EIA should normally be prepared for each operation, but in cases where several extraction operations in the same area are proposed, a single impact assessment may be adequate.

A framework for the content of the EIA should be established by early consultation with interested parties, including the licensing authority, on all concerns, both regionally and within the proposed area of extraction.

<u>Environmental Impact Assessment</u>

Nature of the deposit and proposed method of extraction

The resource should be identified by geographical location and local and regional setting, and described in terms of:

- the bathymetry of the area;
- the distance from, and natural processes affecting, the nearest coastline;
- the geological history, including the source of the material, type of material, mean thickness of deposit, evenness of the deposit over the proposed extraction area, the nature of underlying deposits, sediment particle size, as well as the geological stability of the deposit;
- the natural mobility of the sediments.

The total quantity of material in the resource should be estimated along with proposed extraction rates and the expected life of the deposit.

The method of dredging, including the effect of different suction equipment upon the seabed and the need for onboard processing, should be described.

Physical impact

The main physical impacts of marine aggregate extraction include possible changes in sediment topography and type through the removal of material, and suspension and resettlement of fine particles.

To assess the physical impact of aggregate extraction activities, information should be provided on:

- local hydrography, including tidal and residual water movements;
- wind and wave characteristics;
- average number of storm days per year;
- estimates of bedload transport;
- the occurrence of sand waves and topographic features;

- contamination of sediments and possible release of contaminants by dredging;

- natural suspended sediment loads under both tidal currents and wave action;

- transport and settlement of fine sediment suspended by the dredging activity and its impact on normal and maximum suspended sediment load;

- dispersion of an outwash plume resulting from hopper overflow or on-board processing and its impact on normal and maximum suspended sediment load;

- implications of extraction for coastal processes;

- implications for local water circulation resulting from removal or creation of (at least temporarily) topographical features on the seabed;

- regional, as well as local, effects of the above processes should be considered.

When no data can be obtained, estimates may be acceptable.

Biological impact

The principal biological impacts of marine aggregate extraction may include the disturbance and removal of benthos and alteration of the substrate.

To assess the biological impact of aggregate extraction, the following information should be provided:

- a description of the benthic communities (e.g., species and abundance) within the proposed extraction area, including temporal and spatial variations;

- information on the fishery and shellfishery resources, including spawning areas with particular regard to benthic-spawning fish, nursery areas, overwintering grounds for ovigerous crustaceans, and known routes of migration;

- predator/prey relationships between the benthos and demersal fish species;

- the recolonization time for the denuded sediments;

- areas of special scientific or biological interest in or adjacent to the proposed extraction area, such as adjacent sites designated under local or international regulations (e.g., sites designated under the Ramsar Convention, the World Heritage Convention or the UNEP "Man and the Biosphere" programme).

When no data can be obtained, estimates may be acceptable.

Interference with other legitimate uses of the sea

The assessment should consider the following in relation to the proposed programme for exploitation of the resource:

- areas of natural beauty or significant cultural or historical importance in or adjacent to the proposed extraction area;

- commercial fisheries in the area including seasonal fishing patterns, species caught, type of gear used, value of fish, and location and number of boats and fishermen involved;

- shipping lanes;

- military exclusion zones;

- engineering uses of the seabed (e.g., undersea cables and pipelines);

- adjacent areas of the sea designated in the present or past as sites for the disposal of dredged or other materials;

- adjacent current or proposed extraction areas;

- location of wrecks and war-graves in the area and general vicinity.

Evaluation of impact

In evaluating the overall impact, it will be necessary to identify and quantify the marine and coastal environmental consequences of the proposed activity and the basis of a monitoring plan. The EIA should evaluate the extent to which the proposed aggregate extraction operation is likely to affect other interests of acknowledged importance in the area.

The environmental consequences of the aggregate extraction operation should be summarized as an impact hypothesis.

The impact hypothesis should include consideration of the steps that might be taken to mitigate the effects of extraction activities. These may include:

- the selection of dredging equipment and timing of dredging operations to limit impact upon benthic communities and spawning cycles;

- modification of dredging depth to limit changes to hydrodynamics and sediment transport and to allow future safe use of fishing gear;

- zoning the area to be licensed or scheduling extraction campaigns to protect sensitive fisheries or to respect access to traditional fisheries.

It is also necessary to demonstrate the need to exploit the resource in question through careful, comparative consideration of the local, regional and national need for the material in relation to the identified impacts of the proposal and the relative environmental and social costs of provision of material from other sources, both marine and terrestrial.

The ACME welcomed these guidelines and considered that this information would be very useful.

ICES, 1992. Effects of Extraction of Marine Sediments on Fisheries. ICES Coop. Res. Rep. No. 182. 78 pp.

Request

Item 8 of the 1994 requests from the Helsinki Commission.

The ACME felt strongly that this request for the formulation of guidance for the development of a model for the Baltic Sea cannot be answered given the lack of precise and detailed information on the plans envisaged. However, the ACME agreed that some general information on environmental modelling could be provided based on recent relevant work on this topic.

Source of the information presented

The information presented in this section is mainly drawn from the North Sea Task Force "Testament Document" (NSTF, 1994), the report of the NSTF Modelling Workshop, May, 1992, and the 1992 report of the Advisory Committee on Marine Pollution (ICES, 1992).

Status/background information

Environmental modelling will be of increasing importance as a tool for the management of the marine environment. Models are presently used directly only to a limited extent as a tool in environmental management. Indirectly, however, there is a significant use of models. From a management point of view, models should contribute to the following:

- assessing the possible ecological impacts of specific human activities such as the discharge of contaminants or habitat changes;
- assessing the effects of measures taken to reduce anthropogenic influences on the marine environment;
- increasing the understanding of causal relationships between anthropogenic influences and possible ecological impacts;
- contributing to the optimization of monitoring activities including a cost/benefit evaluation.

A model is, in this connection, a mathematical formulation of the physical, chemical, and biological processes and their interactions required to simulate the transport, transformation, and dispersion of a given substance in the marine environment. A model system consists of a set of model modules which exchange information.

Several modelling approaches may be developed, depending on the precise questions raised. These models range from simulation models such as:

- hydrodynamic/water quality models that take into account changes in hypoxia as well as other parameters associated with reductions in specific inputs;
- primary production models that might suggest research needs (e.g., coupling of physical and biological processes, denitrification processes);
- models that consider changes in the bioavailability of contaminants associated with, *inter alia*, eutrophication and the reduction of specific inputs;

to retrospective analysis models, such as the robust method for the detection and analysis of temporal trends in contaminants in biota, recommended by the ACME in Section 5.2.1, above.

The 1992 ACMP report (ICES, 1992) reviewed the use of models in monitoring and regional assessments, and concluded that models can be used

- to assist in the design of monitoring programmes;
- to assist in the interpretation of results from monitoring programmes;
- to assist in the preparation of regional assessments; and
- within environmental regulatory systems.

It is necessary to design dedicated models for specific issues rather than trying to resolve several complex questions with one complex model. In principle, a model should be as simple as possible and as complex as necessary.

Under the framework of the North Sea Task Force (NSTF), there was an attempt to coordinate management-related modelling work in the North Sea countries. The aim of this coordination was to review and compare models describing the behaviour and impact of contaminants in the North Sea and to provide reliable consistent data sets for model validation. It was believed that this work would lead to the identification of key control issues and the development of more cost-effective monitoring programmes.

The NSTF held two workshops on modelling (1990, 1992). The conclusion from the first of these was that a large amount of development work was needed to enable physical and chemical modelling to be used effectively in assessment and decision-making processes. The aim of the second workshop was to compare modelling results on eutrophication and on the dispersion of contaminants in the North Sea. This intercomparison served as the basis for the only contribution to the *North Sea Quality Status Report* based on modelling.

It is likely that more than one approach will be required, depending on the contaminants and the compartment to be considered. For example, changes in contaminant concentrations in sediments and marine biota associated with reductions in inputs of specific contaminants will not be easily assessed using hydrographic or water quality based models due to the long residence time of some contaminants in these compartments.

However, the statistical analysis of trends allowing short-term extrapolation is more readily useable. Guidance for prediction of some contaminant concentrations in sediments and biota may be obtained from an examination of long-term data sets on contaminants in these compartments, the application of statistical models to forecast future trends in the data assuming no reduction in contaminant inputs, continued monitoring, and retrospective analysis of deviations from predicted trends.

Need for further research or more data

Modelling of physical processes is relatively advanced, but there is still a great demand for quality assurance. Modelling of chemical, biological and, particularly, ecological processes is only in the very early stages. More research is needed to provide the basis for further development of such models and thereby make them suitable for decision-making purposes. The NSTF work on modelling showed the necessity for the validation of models and for the coordination of measuring and modelling activities.

ICES. 1992. Report of the ICES Advisory Committee on Marine Pollution, 1992. ICES Coop. Res. Rep. No. 190, pp. 70–75.

North Sea Task Force. 1994. North Sea Task Force: Review and evaluation / The way forward. Oslo and Paris Commissions / International Council for the Exploration of the Sea, North Sea Environment Report No. 5.

17 ECOLOGICAL QUALITY CRITERIA AND OBJECTIVES

The ACME discussed the importance of the development of ecological quality objectives (EcoQOs) if 'ecological management' is to be a reality. It was emphasized, however, that the establishment of EcoQOs requires more than scientific considerations alone. Much of the discussion in international fora (e.g., the North Sea Task Force) has centred upon the principles relating to developing these objectives. Within ICES, work has begun to develop the scientific criteria which can be used to determine whether or not objectives are being met. In particular, the Working Group on Ecosystem Effects of Fishing Activities is working towards defining such criteria *vis à vis* the assessment of the status of the ecosystem in relation to fisheries effects. The ACME will encourage the initiation of this type of work in other working groups within ICES.

18 ECOSYSTEM EFFECTS OF FISHING ACTIVITIES

Request

A request from the European Commission to develop scientific criteria for the establishment of undisturbed areas in the North Sea for scientific purposes was handled jointly by the ACME and the Advisory Committee on Fishery Management. The report prepared in response to this request has been published as *ICES Cooperative Research Report* No. 203. Other issues relevant to ecosystem effects of fishing activities are reviewed in the present section.

Source of the information presented

The 1994 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO).

Status/background information

Discards and offal

The Working Group on Ecosystem Effects of Fishing Activities (WGECO) reviewed recent information on the amounts of discards and offal produced in North Sea fisheries.

A number of studies on amounts discarded from fishing vessels at sea have been carried out in the North Sea. These studies have covered most of the major fisheries, but they have varied considerably both in terms of the time period and area covered and in terms of the recording methods employed. In order to generate an overall picture of discarding, the results of these studies need to be combined. However, most of the data have been made available only in aggregated format. Since many of these formats were found to be incompatible, it proved impossible to generate a wider picture of the overall scale of discarding in the North Sea. The WGECO therefore strongly recommended that disaggregated data be made available for use by ICES.

The ACME noted the lack of a common format for the provision of discard data and recommended that the WGECO continue its work intersessionally to develop a database which will allow further studies on how discard data from various fisheries could be combined into overall estimates.

Studies of the fate of offal and discards have until now focused on the consumption by seabirds. Estimates of the total amounts consumed by seabirds have been made based on information on diet composition, food requirements, and spatial and temporal distributions of scavenging seabirds. These studies have helped to quantify the interactions between seabirds and fisheries, but further progress could be made if additional information were available on the discarding practice at sea. The proportion of the discards taken by seabirds will depend on whether the discards are produced in a continuous stream or whether they are dumped immediately after the haul. It may also depend on whether discarding takes place at night or during the daytime. Depending on the circumstances, a varying proportion is therefore consumed by seabirds. The rest sinks through the water column where it will be available to subsurface scavengers. Almost nothing is known about the importance of discards to this part of the marine community; the WGECO recommended that further studies be conducted on the role of discards for species other than seabirds.

Indicator organisms

The WGECO considered the attributes of indicator species for the evaluation of long-term impacts of fishing. The concept of indicator organisms has a wide usage in environmental studies. Indicator organisms have been defined as organisms "whose characteristics (e.g., presence or absence, population density, dispersion, reproductive success) are used as an index of attributes too difficult, inconvenient or expensive to measure for other species or environmental conditions of interest" (Landres *et al.*, 1988).

Because there are direct measures of fishing activity in the form of time series of effort by major gear types or, for the target species, measures of fishing mortality, the traditional concept of indicator organisms is not particularly useful in a fisheries context. For this reason, the WGECO adopted a more liberal interpretation of the indicator species concept by extending it to cover species which are susceptible to fishing impacts, e.g., species which can sustain only low rates of fishing mortality and/or species which would react to changes in other fishing practices such as discarding.

The WGECO then concentrated on identifying life history characteristics, such as age at first maturity, which would make a given species particularly vulnerable to additional mortality due to fishing. In order to quantify the relative vulnerability to fisheries-generated mortality, the WGECO developed the concept of 'potential jeopardy', which is measured as the level of fishing mortality required to reduce the spawning stock biomass per recruit (SSB/R) to 5% of its unfished level. Because the use of 5% of the unfished SSB/R in the definition of potential jeopardy is arbitrary, this concept can only be used to quantify the relative susceptibility of individual species to fisheries-generated mortality, i.e., to evaluate whether one species would be more susceptible to a given level of fishing mortality than another. It cannot be used to indicate the level of fishing mortality which would bring the stock to extinction. Furthermore, the use of the word 'potential' is meant to indicate that the conclusion will be dependent upon the level of fishing mortality actually experienced by the species. This level will depend on the intensity of fishing relative to the species distribution (probability of encounter) as well as on the proportion of the individuals encountered which will be caught and/or killed by the gear (gear vulnerability). Thus, whether a population is vulnerable to fisheries impacts will depend on the level of fishing mortality it experiences as well as on its ability to withstand this level.

The ACME considered that the development of quantitative indicators of the relative susceptibility of different species to fisheries impacts is important and recommended that the WGECO continue its work on this topic. In this context, the ACME pointed to the need to consider (a) the influence of low fecundity in the evaluation of potential jeopardy, (b) the identification and quantification of factors determining the probability of encounter, and (c) the evaluation of the vulnerability of different species to the gear on encounter.

Summary parameters of species assemblages

The WGECO explored the utility of some of the techniques of analysing patterns in species abundances. These techniques are used to condense information on, e.g., abundance of a large number of species into a few dimensions. Among the techniques applied were Non-Metric Multidimensional Scaling (MDS), diversity indices, and analysis of the overall size composition. Data from bottom trawl surveys in the North Sea over the time period 1979 to 1993 were analysed.

The results from the MDS indicated that, although some weak trends are apparent, there was no grouping of the years that would suggest that the fish community had changed between distinct alternative states over the time period considered. Likewise, several different analyses of the diversity of the fish community showed no directional change and little variance over time. The overall size composition of the fish community changed significantly, however, from the late 1970s to the early 1990s. The slope of the size spectrum steepened, indicating that increases in fishing pressure substantially reduced the numbers and biomass of large fish.

Preliminary results from analyses of bottom trawl surveys in three areas in the northwestern North Sea suggested that a reduction in diversity and a shift towards smaller fish had occurred between 1929–1956 and 1980–1994, but further analyses are needed in order to identify the likely causes of these changes.

The ACME supported the conclusion of the WGECO that further analyses of summary parameters for species assemblages should be undertaken. The ACME strongly supported the attempts made by the WGECO to consider the usefulness of the different parameters and urged the group to consider how the results of such an analysis could eventually be incorporated into management advice.

Landres, P.B., Verner, J., and Thomas, J.W. 1988. Ecological uses of vertebrate indicator species: A critique. Conservation Biology, 2(4): 316-328.

19 SEABIRD/FISH INTERACTIONS

Request

There is no specific request. This issue is of interest to ACME in as much as the interactions between seabirds, shellfish, fish, and aquaculture activities are of considerable scientific interest, and it is the first time that ICES has formally addressed this aspect of biological oceanography.

Source of the information presented

The 1993 report of the Study Group on Seabird/Fish Interactions (SGSFI), which is the first report of this new Study Group.

Status/background information

The ACME felt that this was an excellent first report which provides a clear and detailed analysis of the relationship between seabird populations and their food, specifically with regard to the North Sea. Using simple energetic models combined with data on the biomass of both individual bird and fish species, the SGSFI concluded that sandeels comprise 33%, discards and offal 30%, and other food items 27% of the overall diet of the seabirds in the North Sea, and that their annual overall food requirements are on the order of 600,000 tonnes. Two bird species account for 54% of the total seabird energy demand. Seabirds are responsible for about 8% of the total sandeel consumption (which includes other predators and fisheries). Their overall role as consumers within the ecosystem is, therefore, significant.

On a more localized basis, interactions between seabirds and other components of the ecosystem can be very important. Sandeel consumption by seabirds is highly localized, with 57% (ca. 111,600 tonnes) of the total coming from ICES Area IVa (west). An estimation of total food requirements of eiders in the Wadden Sea indicated that their annual total food intake is on the order of 60,000 tonnes, while the fishery takes 100,000 tonnes. Seabird populations are relatively localized, particularly during breeding, and require access to food of high quality and in large quantities. Several case studies have demonstrated that local fluctuations in fish recruitment and, hence, in prey availability can have a major impact on the breeding success of those species of seabirds which depend on this source of food.

Need for further research or more data

The second meeting of the Study Group on Seabird/Fish Interactions, held in September 1994, will draw together data on seabirds and prey species, as well as associated physical oceanographic data to elucidate spatial and temporal variability in the North Sea ecosystem. On the basis of progress to date, evidenced by this first report, a comprehensive, lucid, and interesting reference document will result, for the North Sea in particular, on the topic of seabird/fish interactions.

Recommendation

The SGSFI should work towards producing an overall report for ultimate publication in the *ICES Cooperative Research Report* series, which will serve as a repository for its amassed data. It should also contemplate mechanisms to publicize the conclusions to the widest possible scientific audience.

Request

There is no specific request. ICES working groups initiate work on topics that they identify as requiring investigation. The ACME chose the results of two such investigations for reporting here.

Source of the information presented

The 1994 report of the Marine Chemistry Working Group (MCWG).

Status/background information

20.1 Relationship between Trace Metal Concentrations and Lipid Content in Biological Tissues

At its 1994 meeting, the Marine Chemistry Working Group reviewed the results of a study on the relationship between trace metal concentrations and lipid content in biological tissues. This study was initiated at the 1992 MCWG meeting to address concerns associated with the determination of trace metals in materials containing high concentrations of lipids.

The MCWG investigation was based on data from the ICES Environmental Data Bank on trace metals and cofactors, and revealed that a strong correlation exists between fat content and the dry matter fraction, and that in fish liver trace metal concentrations on a dry weight basis correlate negatively with the dry matter fraction. On a wet weight basis, the correlation was randomly positive or negative, on average zero. However, these results are preliminary and should be checked using other data. The importance of having a reliable analytical method and measuring the distribution of metals between the water phase and the lipid phases in fish liver were stressed by the MCWG, as well as by the Working Group on Statistical Aspects of Environmental Monitoring at its 1993 meeting, where this matter was also discussed.

20.2 Patterns of Chlorobiphenyls in Marine Species, Including Different Species of Marine Mammals

The MCWG reported on progress in projects investigating similarities in patterns of CBs in marine species and differences in CB patterns between different species of marine mammals. Based on this report, the ACME noted that the project investigating similarities in patterns of CBs in marine species was proceeding well and according to plan. A project report will be finalized during 1994 and will be reviewed at the 1995 MCWG meeting.

Preliminary results of investigations regarding differences in CB patterns among different species of marine mammals revealed that:

- plots of CB ratios between each CB congener and the reference congener CB 153 for more than 200 marine and terrestrial mammals showed a very good correlation in data from the different laboratories;
- metabolic activity of certain CBs, depending on their chemical structure, could be clearly indicated;
- a significant correlation between different CBs and CB 153 that has been observed in fish is not present in marine mammals;
- observations on the metabolic capacity of marine mammals can be useful for information on the condition of the animal as well as for the identification of genetic differences between animals of one species.

The ACME noted that a full report on the results of this study will be presented at the next MCWG meeting.

ANNEX 1

TEMPORAL TREND MONITORING PROGRAMMES FOR CONTAMINANTS IN BIOTA

1 TEMPORAL TREND MONITORING OBJECTIVES

The objectives of temporal trend monitoring of contaminant concentrations in biota have been stated in several different ways by ICES and OSPARCOM, as follows:

Cooperative ICES Monitoring Studies Programme (CMP): *Monitoring, using fish and shellfish as indicator species to provide an analysis of trends over time in pollutant concentrations in selected areas, especially in relation to the assessment of the efficacy of control measures.*

OSPARCOM Joint Monitoring Programme (JMP): *Monitoring, using fish or shellfish as indicator species, for the assessment of the effectiveness of measures taken for the reduction of marine pollution in the framework of the Conventions.*

The CMP and the JMP statements clearly specify the use of contaminant levels in fish and shellfish in temporal trend studies, and that these studies are to be considered in relation to the assessment of the efficacy of control measures. Trend monitoring in relation to control measures, and monitoring for other purposes are considered separately below.

1.1 Trend Monitoring in Relation to Control Measures

Control measures are introduced in response to perceived impacts on the marine environment, and are designed to control (limit or reduce) the scale or occurrence of the impacts. In order to assess the usefulness or success of the control measures, it is necessary to undertake some measurements to determine whether the expected changes have taken place. It is, therefore, normally reasonable to expect that changes in the input of contaminants (as should result from the control measure) may be reflected in the contaminant concentrations in the marine environment, including organisms. Trend monitoring based on biota is therefore a reasonable approach to consider as part of a monitoring and assessment programme, preferably in association with other forms of monitoring, for example, monitoring of inputs or biological effects monitoring.

In the past, control measures have commonly been directed at controlling the releases of particular contaminants to the environment. For example:

- Control measures can affect different contaminants with different physio-chemical properties.
- Control measures can be taken at different times.
- Control measures might be expected to affect local/regional conditions in the immediate vicinity of significant inputs.
- Control measures might be expected to have wider effects if the contaminants are widely distributed in the marine environment, or if the inputs are of a diffuse nature (e.g., if atmospheric deposition is important).

Therefore, within the overall objective of assessing the effectiveness of control measures through trend monitoring, and the desire to use organisms to do this, there needs to be considerable variation in the timing, location, scale, and nature of the monitoring activities so that they might be appropriately matched to particular locations, contaminants, and control measures concerned. The current expressions of the objectives of trend monitoring in relation to control measures indicate the general approach, but need to be supplemented by more detailed, specific and quantified expressions of the objectives behind each series of data. In developing possible formats for these detailed objectives, account must be taken of a range of factors, including the nature of the control measure, the contaminant concerned, the nature and location of the inputs, statistical aspects of sampling and analysis, etc., as outlined below.

1.1.1 The control measure

Trend monitoring programmes in relation to control measures must be clearly linked to the precise control measures being assessed, i.e., the programme definition should include reference to the particular control measure concerned.

1.1.2 Nature of inputs

In cases where the inputs are not predominantly diffuse, near-field responses to control measures are likely to be much stronger than far-field responses. Therefore, near-field sites should be selected to indicate the response to changes in particular, significant inputs which are affected by the control measures.

1.1.3 Monitoring organisms

Not all organisms are equally effective as indicators of all chemicals. Therefore, monitoring organisms should be selected which are particularly appropriate (Section 3) for the measure being assessed. It follows that it should not be expected that one species, or a small number of species, will be appropriate monitoring targets in relation to all control measures. The appropriate target population also needs to be defined, for example, the whole population, organisms within a particular size range, the commercial catch, etc.

1.1.4 Modelling responses to control measures

It should be possible from the control measure being assessed to estimate the magnitude and pattern of change in input that should result from the measure. In order to design an effective monitoring programme, it is necessary to have some concept of the likely change in contaminant concentrations in biota, i.e., estimate the scale of the temporal trend that would be the target for the monitoring programme. The capability of modelling the behaviour of contaminants in the aquatic environment is continually being improved. It is now possible in some cases to predict the response of the environment (in terms of concentrations at particular locations) to changes in contaminant input. The step from this stage to the changes in concentrations in monitoring organisms at those locations is more difficult, but it should be possible to make some estimate. Predictions of the pattern and scale of changes in inputs, and responses by organisms at particular locations, can provide a framework within which to select sampling locations and to undertake statistical assessments of the required power of the programme.

In cases where no prediction is possible from modelling, some assumption would be required as to the likely response of the monitoring organism, perhaps based on the difference between concentrations in the near-field area and in remote areas (background concentrations).

1.1.5 Temporal framework of the programme

In some cases, control measures may produce immediate improvements in the quality of discharges, or in the quality of the environment. In other cases, the changes may occur over a number of years. In either case it is necessary to have a concept of the period over which changes are predicted to occur, so that a review may be made of the possible need for further controls. The temporal framework of both the introduction of control measures, and the response of the environment, should be built into the monitoring programme in terms of the time over which changes are expected to occur.

Provided that there is some knowledge of the likely pattern of changes in inputs, once a number of years of data have been accumulated, it may be possible to make predictions of the likely further changes in concentrations of contaminants in biota, and to assess these, for example in relation to some form of reference values. The review of programmes part way through their intended duration may also provide an opportunity to review the programme, for example taking into account the relationship between the actual changes and those predicted when the programme was designed, or whether the programme appears to have the planned statistical power.

1.1.6 Power of the monitoring programme

Trend monitoring programmes must be designed in such a way that there is an acceptable probability that the quantified objectives will be achieved. These considerations can be brought together in an expression of the power of the programme. The power is a function of a number of factors, including the sources and magnitudes of the variances involved in the field populations and chemical analysis, the sampling and analytical design, etc. Prior to instigating a trend monitoring programme, it is necessary to assess the components of the overall variance, to design the programme and to set analytical performance criteria to ensure that the overall programme has the required power (Section 2).

1.1.7 Far-field areas

In most cases, control measures would be expected to result in improvements in the near-field area. However, there are circumstances in which it is also necessary to consider far-field effects. These include cases where there is concern arising from the accumulation of contaminants in these far-field organisms, or where diffuse (e.g., atmospheric) inputs are important.

If there are no indications of elevated concentrations of the particular contaminant in organisms in the far-field area, then there is no need to monitor the concentrations in these areas with respect to control measures, and effort can be directed to areas closer to concentrations of inputs.

In cases where there is evidence of elevated concentrations in biota in far-field or offshore areas, the above considerations of predicted impact and programme power apply, and programmes should be designed accordingly. It should be noted that programmes to detect large changes close to point source inputs may well not be adequate to detect small changes at near-background levels in more remote areas. Considerably greater effort is likely to be needed in such areas.

1.1.8 Possible formulations of monitoring objectives

The development of a series of detailed monitoring objectives within the broad framework of temporal trend monitoring in relation to control measures, taking into account the preceding discussion, is an integral and essential part of an effective programme, both in relation to the assessment of the efficacy of the control measures, and to the ensuring of value for money to the sponsors of the programme.

Two possible formulations of the detailed objectives of a trend monitoring programme, phrased in the form of hypotheses, are given below. The most appropriate formulation in any particular case will vary with the particular circumstances of the programme.

Example 1

A control measure is designed to restrict inputs to the present level. We might want to ensure that the concentration in the organism does not go up. In Figure 1.1, the solid line (or below) represents what the control measure is designed to achieve and the dotted line (or above) represents what we want to be sure to detect, if it occurs. A quantified objective might then take the form:

> The [Control Measure] will restrict the concentration of [contaminant] in [organism] at [location] to its present level for [number of years] from [starting year]. The programme will detect an increase in concentration of [percentage] per year over [number of years] from [starting year] with [percentage] power.

For example

> The Control Measure will restrict the concentration of CB153 in herring muscle from the Clyde sea area to its present level for 10 years from 1994. The programme will detect an increase in concentration of 10% per year over 10 years from 1994 with 90% power.

Example 2

A control measure is designed to reduce inputs by a certain amount or to a certain level. We might want to ensure that the concentration in the organism has reduced by at least this much, represented by the solid line or below in Figure 1.2. If the improvement is not as good as the dotted line, then we want to know. The quantified objective might then take the form:

Figure 1.1

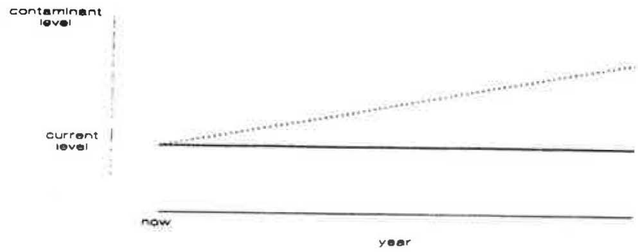

Figure 1.2

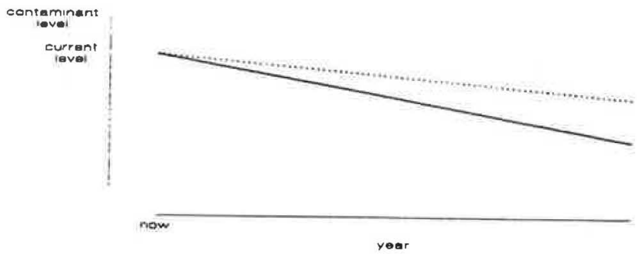

Figure 1 Examples of graphs associated with possible formulations of objectives of temporal trend monitoring programmes. The solid line represents what the control measure is designed to achieve and the dotted line represents what must be detected if it occurs.

> The [Control Measure] will result in a decrease in the concentration of [contaminant] in [organism] at [location] of [target percentage] per year over [number of years] from [starting year]. The programme will distinguish between a decrease in concentration of at least [target percentage] per year and a decrease of [percentage] per year with [percentage] power.

For example

> The Control Measure will result in a decrease in the concentration of CB153 in herring muscle from the Clyde sea area of 10% per year over 10 years from 1994. The programme will distinguish between a decrease in concentration of at least 10% per year and a decrease of 5% per year over this time period with 90% power.

Other formulations could be suggested, but in all cases they would be more specific and quantified expressions of objectives than those given in the outlines for the CMP, or JMP, for example. These detailed, quantified objectives refer to a single series of samples at a single location, and can therefore be seen as supplementary to the broad objectives of the international programmes, and the data generated would be a contribution to the overall aims of the international programmes. A national contribution to the CMP or JMP might therefore consist of data collected in relation to a stated series of such detailed objectives.

1.2 Other Trend Monitoring

In addition to assessment of the efficacy of control measures, there are a number of other general circumstances in which temporal trend monitoring of contaminant levels in biota might be appropriate. On an even broader scale, temporal trend monitoring may be carried out "to assess the development of aspects of the quality of the marine environment". A unifying concept behind all such circumstances is that some degree of change with time is expected, or at least that change, if not expected, would be of significant interest if it occurred.

Examples of circumstances in which trend monitoring of contaminant levels in biota could be considered are:

a) To provide indications of the increasing need for control measures, normally in cases where discharges have increased, or new uses of the chemicals have resulted in a redistribution of inputs. Some of these programmes would be related to target concentrations, the achievement of which would indicate that new control measures were needed.

b) To provide information on changes in the geographical extent of impacts of discharges. Some types of discharge can quickly lead to impacts being observed close to the input, and for the affected area to increase gradually with time. One example would be the gradual increase in hydrocarbon contamination in the northern North Sea arising from the offshore oil industry.

c) To provide information on the response of contaminants to medium-term environmental change, where inputs may not have changed significantly. The gradual changes in hydrography and water chemistry in the Baltic Sea might lead to changes in the availability or concentrations of contaminants.

d) To provide long-term control/background data sets, both as indications of the quality of the wider environment, and as a framework within which to assess changes in areas more likely to be directly impacted by discharges of contaminants.

1.3 Conclusions

Temporal trend monitoring of the marine environment can include other matrices and techniques in addition to the determination of contaminant levels in biota. Sediment, water, community structure, and biological effects monitoring can all be applied in particular cases, and the broad formulation of the objective given above clearly leaves the way open for the incorporation of such procedures into coordinated international monitoring programmes. As for the monitoring of contaminant levels in biota in relation to the efficacy of control measures, the statement of the overall objectives of the programme could sensibly be presented in two parts. The first consists of a broad statement of intent such as the current ICES and OSPARCOM objectives. The second consists of the detailed and quantifiable objectives relating to each component of the overall programme. In this way, the power of the required programme can be defined, and the programme can be designed in such a way that it has the power necessary to meet the objective, or test the hypothesis lying behind the programme.

2 POWER OF TEMPORAL TREND MONITORING PROGRAMMES

2.1 Power

Power measures the effectiveness of a monitoring programme by quantifying the types and magnitudes of changes that are likely to be detected. Specifically, power is the probability that a specified change is detected. If a power study shows that a monitoring programme is unlikely to meet its objectives, i.e., that changes considered to be important are unlikely to be detected, then the monitoring programme should be changed.

Power is described in Cohen (1977). Power studies of the ICES CMP are described in Nicholson and Fryer (1992) and Fryer and Nicholson (1993).

Power depends on many factors, for example:

- the type and magnitude of change that actually occurs;
- the statistical test (choice of model, targeted hypothesis);
- the sampling design (e.g., number of years, samples per year, analyses);
- the components of variation in the population under study and in the data collection process.

2.2 Analytical Noise

The traditional description of the bias and precision of an analytical method (e.g., Nicholson 1994) is extended here to explicitly incorporate information about the time scale applicable to a series of observations. Intuitively, we might, for example, expect precision to improve as determinations are made over progressively shorter time periods. Thus,

bias is the difference between the true concentration and the mean of repeated determinations for a particular sample, made within a specified time interval; and

precision is the standard deviation of repeated determinations for a particular sample, made within a specified time interval.

To demonstrate this, suppose that a method is calibrated daily, that calibration samples are prepared monthly, and that the materials for calibration are purchased yearly. Each of these steps is a possible source of noise contributing a deviation which we can label δ_d, δ_m and δ_y, respectively. Each noise component will have its own mean: m_d, m_m and m_y, and standard deviation σ_d, σ_m and σ_y, respectively. For example, the between-year noise due to different chemical batches might have a mean of 0.5% and a standard deviation of 1%; in a particular year, the deviation due to the particular batch of chemicals might have a value of 1.3%.

There could also be a noise component for periods greater than a year, for example associated with a particular analytical method, which has value m. There will also be a base level of variation within a day, assumed to have a zero mean and standard deviation σ.

Bias and precision can now be seen to depend upon the time frame within which determinations are made. Two examples will make this clear. In the first example, suppose that a determination is made within a particular day. Then δ_d, δ_m and δ_y will take specific values d_d, d_m, d_y, respectively. The only random variation will be within a day, and hence

$$d_d+d_m+d_y+m = \text{bias(for the particular day)}$$

$$\sigma = \text{precision(for the particular day)}$$

Now consider a second example where a determination is made at any time within a year. Now, δ_d and δ_m are free to vary and we would have

$$d_y+m = \text{bias(for the particular year)}$$

$$\sqrt{\sigma_m^2+\sigma_d^2+\sigma^2} = \text{precision(for the particular year)}$$

A consequence of looking at analytical performance in this way is that bias is also a random variable, having a specific value e.g., in a given month. Hence in the first example, bias is a random variable with mean and variance given by

$$E[\text{bias(for the particular day)}] = m_d+m_m+m_y+m$$

$$V[\text{bias(for the particular day)}] = \sigma_d^2+\sigma_m^2+\sigma_y^2$$

In the second example the mean and variance of the bias are given by

$$E[\text{bias(for the particular year)}] = m_y+m$$

$$V[\text{bias(for the particular year)}] = \sigma_y^2$$

This has important consequences for annual monitoring programmes. The between-year variability in contaminant levels will be inflated by the variability in the biases. If the chemical analyses are all made within a short time period as in the first example, the amount of inflation will be greater than if the analyses are spread throughout the year as in the second example.

The relationship between poor bias and precision and the decreased power of an annual monitoring programme to detect trends can be demonstrated. This relationship could be used to identify targets for analytical accuracy so that a trend detection objective would still be met with sufficient power. An alternative is to use the sampling strategy to reduce the contribution from different components of the variance of the bias. This approach is followed in Section 2.3, in which the contribution of noise from a daily or monthly component has been simplified to the concept of a batch component, e.g., at a weekly level.

The implication, however, is that information about analytical accuracy must be incorporated into the design of monitoring programmes.

2.3 Power, Sampling and Analytical Strategy

2.3.1 Theoretical framework

This is a theoretical framework which allows us to explore how the power of a temporal monitoring programme depends on sampling and analytical strategy and on the components of variation in the data. Full details are given in the report of the Subgroup on Temporal Trend Monitoring Programmes for Contaminants in Biota.

Suppose there is a sampling season each year. Suppose that *R* samples are taken in each of a number of years. In each year, the *R* samples are taken on *E* sampling expeditions, say a week apart and are analysed in *B* batches, again say a week apart. There are therefore *R*/*E* samples taken on each expedition and *R*/*B* samples analysed in each batch.

The measured contaminant level collected in year t can be thought of as follows:

measured contaminant level =

underlying mean contaminant level in year t +
noise due to within-batch analytical variation +
noise due to between-batch analytical variation +
noise due to between-year analytical variation +
noise due to within-expedition sampling variation +
noise due to between-expedition sampling variation +
noise due to between-year sampling variation.

The underlying mean contaminant levels are assumed to represent some smooth underlying trend in contaminant levels.

There are many terms relating to variability in this expression, but they are necessary to understand how the measured contaminant levels arise.

First, consider the analytical noise. This has three components:

- within-batch analytical variation is the variation in the measured concentration of, say, a reference material analysed in the same batch;
- between-batch analytical variation is the additional variability when the reference material is analysed in different batches;
- between-year analytical variation is the additional variability when the reference material is analysed in different years.

Another way of thinking of the between-batch analytical variation is the variation in the within-batch bias between batches (see Section 2.2).

The sampling noise also has three components, analogous to the analytical noise:

- within-expedition sampling variation is the variation in the contaminant levels of individuals collected in an expedition; this arises through the natural variation between organisms;
- between-expedition sampling variation is the additional variation in the contaminant levels of individuals collected on different expeditions (possibly having removed any systematic seasonal trends); this might arise through short-term fluctuations in discharges or environmental variables or through not sampling exactly the same population;
- between-year sampling variation is the additional variation in the contaminant levels of individuals collected in different years (having removed any systematic trends in contaminant levels); this might arise through long-term fluctuations in discharges about some underlying trend.

Let

σ^2 be the within-batch analytical variance + the within-expedition sampling variance

σ_b^2 be the between-batch analytical variance

σ_e^2 be the between-expedition sampling variance

σ_y^2 be the between-year analytical variance + the between-year sampling variance

Then the power of the programme to detect systematic changes in contaminant levels over time depends on a particular combination of the variances and the sampling and analytical design: namely, on

$$\psi^2 = \sigma_y^2 + \sigma_b^2 / B + \sigma_e^2 / E + \sigma^2 / R$$

In fact, this is the yearly residual variance of the sample means about the underlying trend.

Power increases as ψ^2 decreases. Thus, power increases as the number of batches, expeditions and samples increases. Further, power increases if any of the components of variance decrease.

To be more specific about the exact relationship between ψ^2 and power, we need to be more explicit about the type of change, the number of years and the statistical test.

2.3.2 Practical example

Suppose we have a 10-year monitoring programme and we wish to test for a linear change in log-concentration. Then the % yearly increase in concentration detected with 90% power is given by

% yearly increase detected with 90% power =
$100(\exp(0.4087\psi) - 1)$.

Thus, we require a small ψ to achieve good power; for example, 100ψ must be less than 23.3% to detect a % yearly increase of 10% with 90% power.

2.3.3 Design implications

- A monitoring objective should include the desired power of the programme (Section 1). Given any objective, we can calculate the target value of ψ^2 needed to achieve the required power.

- Given estimates of the variance components, we can find values of *E, B, R* that give the target ψ^2. In particular, if we have

  - large within-batch-and-expedition variance σ^2: take more samples (increase *R*);

  - large between-batch variance σ_b^2: analyse samples in more batches (increase *B*);

  - large between-expedition variance σ_e^2: go on more sampling expeditions (increase *E*).

- Alternatively, given constraints on the levels of sampling (i.e., *E, B, R*) and given estimates of the sampling variance components, we can set target values of analytical variance that give the desired ψ^2 (Section 2.4).

- When the between-year variance σ_y^2 is large, we have problems. Often, no matter how large the number of samples, batches or expeditions, the desired ψ^2 cannot be achieved. Sometimes, it might be possible to reduce σ_y^2 by improving sampling procedures or by adjusting for some covariables or by improving the between-year analytical variance. However, at other times, the objectives of the programme cannot be met; it is then important to reassess the objectives.

2.3.4 Data requirements

Good estimates of the variance components are essential to design a programme that will meet its objectives. Obtaining these estimates is often difficult, because the data are often not published, difficult to find or expensive to obtain (e.g., requiring additional fieldwork).

In particular, the present CMP for contaminants in biota is designed so that we can estimate the within-batch-and-expedition variance σ^2, but cannot disentangle the other variance components. Auxiliary analytical quality control data can be used to estimate the between-batch variance. However, the between-expedition variance and the between-year variance still cannot be differentiated. This is a crucial problem. Indications are that the sum of these two variance components is large (Section 2.5). If the between-expedition variance dominates, then power can be improved by going on more expeditions. If the between-year variance dominates, then the power of the CMP to detect trends in most contaminants will be poor, regardless of any changes in design.

2.4 Setting Analytical Targets

The accuracy (defined in terms of precision and bias, cf. Section 2.2) of analytical measurements can affect the ability of monitoring programmes to achieve their objectives. For example, in the context of sampling to monitor the effect of control measures, as accuracy becomes poorer, the probability of identifying a given trend becomes smaller. This effect can be used to set targets for analytical accuracy so that the decrease in the power of the programme is limited. Data sets from the JMP assessments of lead in mussels were used to establish trends that could be detected after 10 years with a power of 90%. Different values of precision and bias were then introduced to identify the point at which the power deteriorated to 80%. This could be used to define an appropriate target for precision and bias. If this is acceptable within the stated objectives of the programme, it provides a simple, quantified target for analytical performance (known to be achievable) for all of the participating laboratories.

Data from an ICES intercalibration exercise on lead were then used to measure the analytical performance for lead determinations achieved by different laboratories. 30% of the laboratories were found to be within this target and so would achieve a power of at least 80%.

Since precision and bias interact with the ability of the programme to achieve its stated objectives, stating the targets for analytical accuracy is an essential part of the analytical quality control underpinning any monitoring programme. Further, these targets for analytical accuracy must be considered when the monitoring programme is being designed.

2.5 Power of the CMP

The random variance of the yearly sample mean log-concentration is given by

$$(1) \quad \psi^2 = \sigma_y^2 + \sigma_e^2/E + \sigma_b^2/B + \sigma^2/R.$$

Starting from the right, the term σ^2/R is the between-sample variance divided by the number of samples (in the CMP, R=25 for fish, R=3 for mussels). The term includes within-batch analytical precision. Data from the CMP have been shown to give a median σ^2 of 0.42^2, 0.23^2, 0.64^2, and 0.27^2 for metals in fish (muscle or liver, 132 data series), metals in mussels (86 data series), organics in fish (86 data series), and organics in mussels (30 data series), respectively.

The term σ_b^2/B is the between-batch analytical variation divided by the number of batches per year. B usually equals 1. σ_b^2 can be estimated from quality assurance (QA) data on heavy metals in reference material relating to 17 data series within the latest JMP assessment. The median is 0.066^2. With samples of fish and mussels, a larger estimate of 0.1^2 may be more realistic. For organics, the estimate is more like 0.2^2.

σ_e^2/E is the between-sampling expedition variance divided by the number of expeditions per year (usually 1). There are no data to make an estimate of the value of this term.

Finally, σ_y^2 is the between-year variance component. This comprises both between-year analytical and sampling variance. The between-year analytical variance can be estimated from QA data on metals from the latest JMP assessment (17 data series), giving a median value of 0.02^2; this is a small component of the total between-year variance.

The total variance, ψ^2, has been estimated from CMP data. The median is 0.25^2, 0.33^2, 0.43^2, and 0.48^2 for metals in fish (muscle or liver, 58 series at least 6 years long), metals in mussels (35 series), organics in fish (52 series), and organics in mussels (10 series), respectively.

From these variance estimates (which are quite uncertain due to the nature of the data material available), the sum $\sigma_y^2 + \sigma_e^2/E$ can be estimated using equation (1). Then equation (1), above, becomes

for metals in fish:	$0.25^2 = 0.21^2 + 0.1^2/1 + 0.42^2/25$
for metals in mussels:	$0.33^2 = 0.29^2 + 0.1^2/1 + 0.23^2/3$
for organics in fish:	$0.43^2 = 0.36^2 + 0.2^2/1 + 0.64^2/25$
for organics in mussels:	$0.48^2 = 0.41^2 + 0.2^2/1 + 0.27^2/3$

The resulting power expressed as the minimum trend detectable over a ten-year period is 11, 14, 19, and 22 percent per year, respectively.

Based on data from the Swedish Environmental Monitoring Programme, herring liver had ψ^2 values in the range 0.08^2–0.45^2 for metals and 0.17^2–0.56^2 for organics. The corresponding detectable trend per year over a ten-year period is 3–20 and 7–26 percent per year. As can be seen, these intervals contain the median values computed from the CMP data.

Even though the above estimates of the variance components are subject to much variation, they indicate that the sum of the between-year and between-expedition components is the most important part of the observed variance, as it accounts for 70-75% of the total variance. The between-sample variance (within batch and expedition) accounts for only 10-15%.

To pursue this, in addition to the CMP data, the more recent data used in the latest JMP assessment were reviewed. First, the median ψ^2 for each combination of species, tissue and contaminant was compared to the corresponding figures for the CMP. Though differences in individual ψ^2 were observed, in general ψ^2 was not smaller in the JMP data. From evaluation of the year-to-year irregularities in sample pooling and/or sample numbers within the individual data series (a data series being data from one station covering one species and one tissue), each series was labelled as consistent, fairly consistent, or inconsistent. Creating three corresponding groups of data series, the residual variance (i.e., the ψ^2) for each data series was compared amongst the groups. Surprisingly at first, no differences were seen. Giving it more thought, it was noted that differences here would mainly arise from variation in the last term in equation (1) and in the preceding paragraph it was concluded that this term, with the current sampling strategy and analytical quality, has little influence on the total between-year variance ψ^2.

In theory, the sum $\sigma_y^2 + \sigma_e^2/E$ could be reduced by going on more sampling expeditions (i.e., increasing E). Unfortunately, we are not able to distinguish these two variance components and estimate the increase of power from going on more expeditions per year.

Some estimate of σ_e^2 might be found in the JMP database if samples in at least some years have been taken at different dates. Further, the impact on ψ^2 might be assessed by grouping the JMP data series depending on the number of sampling dates or periods per year.

Let us equal σ_y^2 and σ_e^2. Then going on a single extra expedition each year would decrease $\sigma_y^2+\sigma_e^2/E$ from an initial value of say $\psi^2 = 0.25^2$ to $\psi^2 = 0.22^2$ (the number of samples analysed is kept constant). Over a ten-year period, the yearly trend detectable would then be reduced from 10.8% to 9.4%.

For organics, the estimate of σ_b^2 amounts to approximately 20% of the total variance. If this is of the correct order, the total variance could be reduced by splitting the analyses into several batches. For example, with the above variance estimates for organics in fish, dividing the 25 samples among 5 batches ($B = 5$) would reduce ψ^2 from 0.43^2 to 0.39^2, thereby reducing the detectable yearly trend from 19.2% to 17.3%.

In conclusion, better estimates of σ_b^2, σ_e^2 and σ_y^2 are needed to make informed judgements about the effect of increasing the number of batches and expeditions.

3 CHOICE OF ORGANISMS AND TISSUE FOR MONITORING TRENDS IN CONTAMINANTS

Assessments of temporal trends in contaminant levels are undertaken regularly to determine whether control measures taken under the Commissions have been effective. The Ad Hoc Working Group on Monitoring of the JMG have statistically analysed time series of contaminant levels in biota collected under the JMP for this purpose and have reported the results to JMG and to the Commissions. However, the main question, to assess the effectiveness of the measures, is not addressed in these reports. It appears to be difficult to link the trends which are found in biota to changes in inputs of contaminants. In the 1993 draft assessment report on temporal trend monitoring data for biota it is stated that ".. whilst it was possible to identify statistical trends in a number of cases, it was as yet not possible to interpret the reasons for such trends". The main reason given for this statement is that no corresponding time series of input data are available.

Simultaneously comparing series of data on contaminant inputs and concentrations in biota would greatly enrich the interpretation of the data and add to the information about the effectiveness of control measures. For example, Alliot and Frenet-Piron (1990) demonstrated a relationship between seasonally elevated levels of metals in sea water with those in shrimps. The input and shrimp time series were highly cross-correlated and, using additional local information, were interpreted in terms of the large increase in activity in the harbour during the summer.

A similar exercise has been attempted here for one example site. For the Western Scheldt, data on inputs, concentrations in sea water and concentrations in biota of cadmium and mercury for the period 1985 to 1990, as presented in the Jaarboek 1991, the 1993 Quality Status Report of Subregion 4, and JMP data, were compared. For cadmium, trend series in mussels and in flounder liver were available. For mercury, data on mussels and flounder muscle were available for small and large fish. (See Figure 3.1).

For cadmium, inputs showed a steady decrease over the period 1985–1990. This decrease was in general reflected in the trends in concentrations of cadmium in water, but neither the mussels nor the flounder liver showed any trend. For mercury, the input data showed a very slight decrease over the years with a peak in 1988. The general pattern does not seem to be reflected directly either in water or biota, though the peak in 1988 seems to be reflected in water, mussels and large fish.

There are several reasons why these data show no great agreement. The time series are very short, and the data were collected from different sources and could be mismatched in both the time and position of sampling. However, a further reason might be that the organism sampled does not reflect input levels in a way that is meaningful for this monitoring programme. In order to detect changes in the environment arising from changes in inputs using the time trends of contaminants in biota, the organism to be monitored must be appropriate, i.e., it should satisfy certain biological and practical requirements. These requirements should be taken into account when designing a monitoring programme, and be considered when interpreting the results.

The aspects which must be considered can be divided into different categories, as follows:

1. Practical considerations, as listed by Philips (1980):
   - The organism should be easy to collect.
   - For an international monitoring programme, the organism should preferably have a wide distribution.
   - The organism should be representative of the area in which it is collected, which means that it should be present in the sampling area for a large period of time within the year.
   - The organism should have a life-span appropriate for the monitoring period.
2. Characteristics of the organism in relation to the kinetics of the uptake and elimination processes:
   - Organisms should have an integrative ability for contaminants, i.e., they should have the capacity to smooth ambient variations of contaminant concentrations as a result of favourable rate constants of uptake and loss processes for the contaminant.
   - Organisms should have a high bioconcentration factor.
   - The uptake and elimination processes should take place at an appropriate rate in relation to the temporal sampling frame of the monitoring programme (cf. Nicholson and Fryer, 1993).
3. Characteristics of the organism in relation to the contaminant:
   - The organism should reflect the environmental response to the changes in inputs.

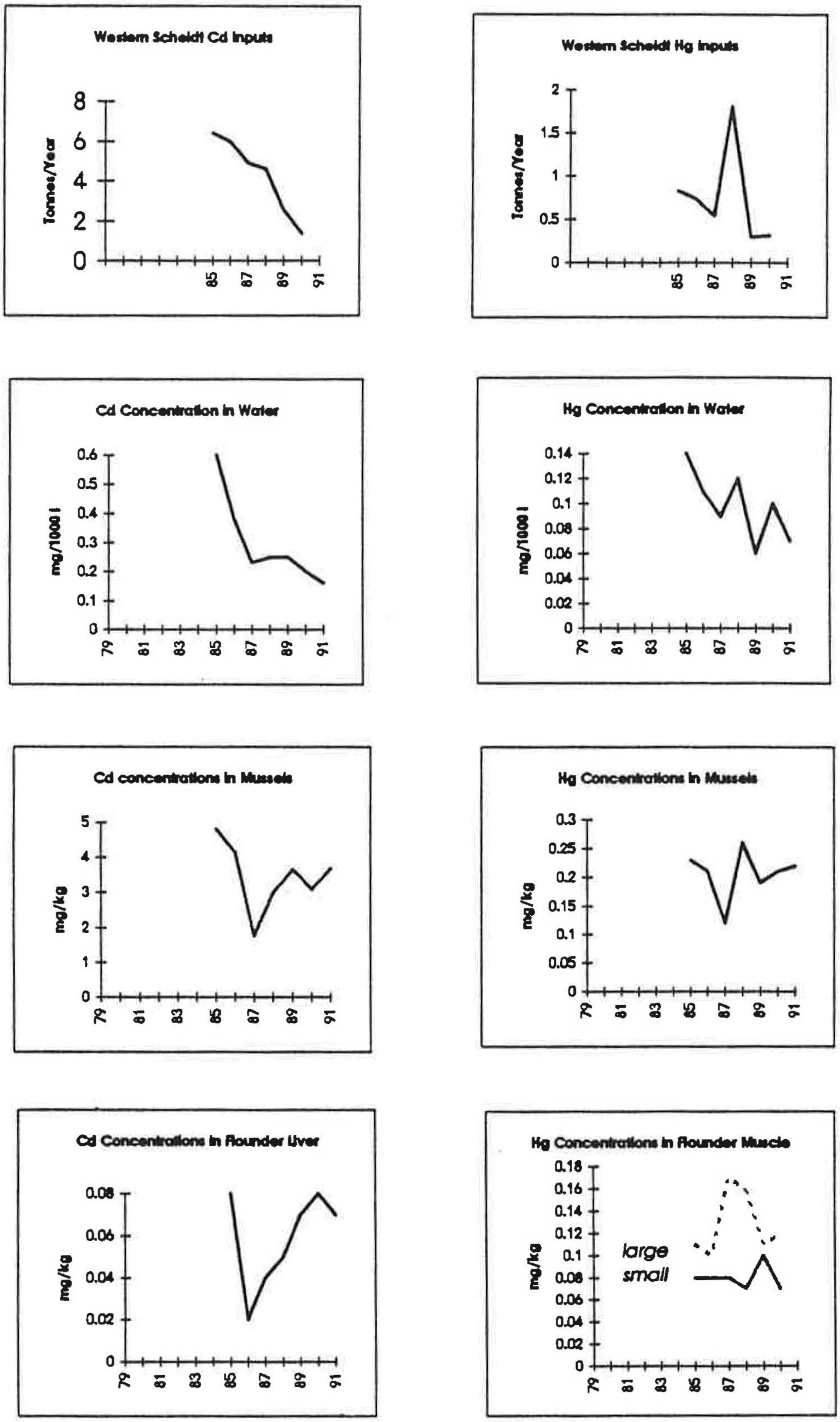

Figure 3.1 Examples of time series data on mercury and cadmium in various media.

4. Information needed for the definition of sampling guidelines and the interpretation of the data:

   - Information on factors affecting the uptake and clearance rate of contaminants such as salinity, water temperature, seasonal variation, interactions between different contaminants in uptake, growth effects, etc., is also required.

As far as possible, an attempt has been made to determine whether the biota sampled under the current JMP meet these considerations. The following comments on the suitability of *Mytilus* as an indicator of trends in contaminant levels are based on the literature available during the meeting:

- *Mytilus* fulfils all the practical considerations.

- No clear examples of time trends in *Mytilus* in comparison with trends in contaminants in the environment were found in the literature. However, a more extensive survey of the literature might provide that information.

- *Mytilus* is able to bioaccumulate a number of contaminants, amongst which are heavy metals, PCBs and PAHs (Philips, 1977; Adema, 1981; de Kock, 1986).

Some quantitative information on uptake and elimination rates of metals was available (Adema, 1981). This information showed that:

- The uptake rate might be influenced slightly by the contaminant concentration.

- The uptake rate for cadmium and chromium might decrease strongly if mussels are exposed to a mixture of heavy metals.

However, the available information on uptake and elimination rates seems quite limited (see Tables 3.1a and 3.1b).

- Experiments with active monitoring show that *Mytilus* seems to respond fairly quickly (a number of weeks) to reach equilibrium with the field concentrations (de Kock, 1986).

As stated earlier by amongst others Philips (1977) and Rainbow *et al.* (1990), it is essential to have some knowledge about the accumulation strategy of a monitoring organism to understand the significance of the levels observed in biota. There seems to be a general lack of this kind of information. A better understanding of the accumulation processes could be provided by laboratory experiments.

Better understanding and more information at all of these levels would improve the effectiveness of probably every monitoring programme.

Table 3.1a. Concentration factors for different contaminants, species and tissue types.

Species/ tissue	Zn-165	Mn-54	Fe-59	Co-58	Cd	Zn	Cu	Cr	Hg
Mussel	154	40	53	11	410	290	340	130	7000
Plaice (muscle)	11	0.4	0.5						
Plaice (liver)	26	4.5							

Table 3.1b. Half life in days for different contaminants, species and tissue types.

Species/tissue	Zn-165	Mn-54	Fe-59	Co-58
Mussel	21	7	14	18
Plaice (muscle)	563	51	40	49
Plaice (liver)	73	10		

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ANNEX 2

FINAL REPORT OF THE STEERING GROUP ON FISHERIES/ENVIRONMENTAL MANAGEMENT OBJECTIVES AND SUPPORTING RESEARCH PROGRAMMES IN THE BALTIC SEA

1 INTRODUCTION

The Steering Group on Fisheries/Environmental Management Objectives and Supporting Research Programmes in the Baltic Sea (Chairman: Dr Z.S. Karnicki, Poland) met at ICES Headquarters from 17-18 June 1993 (C.Res.1992/2:5) with the objective of developing further the proposals for appropriate research programmes aimed at providing the knowledge which was identified by the Steering Group (ICES, Doc. C.M.1992/J:11) as lacking, including detailed time schedules and cost estimates where possible. The proposals should cover the following areas:

a) fisheries resources/management
(Coordinator: Mr B. Sjöstrand, Sweden);

b) stable organic substances
(Coordinator: Dr R. Ferm, Sweden);

c) eutrophication
(Coordinator: Dr H.P. Hansen, Germany);

d) marine water influx/exchange
(Coordinator: Mr H. Dahlin, Sweden).

The membership of the Steering Group includes the Chairmen of the Baltic Fish, Marine Environmental Quality, Hydrography, and Biological Oceanography Committees, the Advisory Committee on Fishery Management (ACFM), and the Advisory Committee on the Marine Environment (ACME), as well as four scientific administrators selected by the Council in consultation with the Baltic Marine Environment Protection Commission (Helsinki Commission) and the International Baltic Sea Fishery Commission (IBSFC). The participants were as follows:

Mr H. Dahlin	Sweden
Dr R. Ferm	Sweden
Dr H.P. Hansen	Germany
Dr Z.S. Karnicki	Poland
Mr P. Niskanen	Finland
Dr I. Olsson	Sweden
Dr T. Osborn	USA
Dr (Ms) J. Pawlak	ICES
Dr (Ms) K. Richardson	Denmark
Dr F. Serchuk	USA
Mr B. Sjöstrand	Sweden

2 BACKGROUND

At its initial meeting in 1992, the Steering Group on Fisheries/Environmental Management Objectives and Supporting Research Programmes in the Baltic Sea recognized two overall objectives in relation to the management of Baltic Sea resources:

1) to maintain sustainable ecosystems based on healthy, balanced populations of naturally occurring species assuring, as far as possible, natural diversity and distribution; and

2) to maintain viable fisheries within sustainable ecosystems.

An ecosystem is defined as sustainable if management actions do not result in irretrievable loss of any component of the system.

The above objectives are almost the same as those adopted by the Advisory Committee on Fishery Management (ACFM).

In framing the research needed to progress towards these goals, the Group identified three different time perspectives in which environmental/fisheries management problems should be addressed:

1) Cleaning-up/acute phase, which covers the immediate research needs resulting primarily from the work of the HELCOM Programme Implementation Task Force, which coordinates the implementation of the Baltic Sea Joint Comprehensive Environmental Action Programme;

2) Preventative phase, which covers the research needs for the next 5 to 10 years; and

3) Sustainability phase, which covers research needs in the time perspective of several decades or longer.

In this list, it is in the cleaning-up phase that the manager will have the most acute need for scientific information. Much of this information already exists and must be made accessible through an extensive dialogue between scientists and managers. At the other extreme, the information requirements (i.e., need for research) for the sustainability phase are very large, but the time frame for dialogue and information acquisition is also considerably longer.

The terms of reference for the Steering Group meeting in 1993 directed the Group to develop proposals for appropriate research programmes in the framework given above for the following areas:

a) fisheries resources/management;

b) stable organic substances;

c) eutrophication;

d) marine water influx/exchange.

However, during the course of the meeting, it became clear that the majority of the Steering Group members felt that the areas identified above do not represent an exhaustive list of environmental/fisheries management problems facing the Baltic Sea. Furthermore, there was a consensus in the Group that the approach of identifying different scientific areas where research is needed was not the most appropriate manner in which to develop the integrated fisheries/environment objectives described above.

Instead, the Steering Group attempted to integrate information from a number of different disciplines in order to identify the most important areas of research needed to address the major fisheries/environmental problems in the Baltic Sea region. In carrying out this "integration", all areas of research were related to the fishery resources of the Baltic Sea. This was done because these resources support important socio-economic activities and because fish are often the most visible integrators and indicators of ecosystem health.

The Steering Group agreed that it is of paramount importance that the impetus which resulted in the creation of this Steering Group be maintained in the future. However, the Steering Group recognized that it lacked sufficient expertise in many areas of research and recommended that the relevant Subject/Area Committees and Working Groups be included in subsequent deliberations. The Steering Group also emphasized that quality assurance mechanisms must be included in the data collection and handling procedures for all of the research areas identified below.

3 RESEARCH NEEDS IN THE BALTIC

3.1 *The Influence of Environmental/Hydrographic Factors on the Distribution, Abundance, and Demography of Fish Stocks*

For the major fish stocks in the Baltic Sea (cod, herring, sprat, and salmon), temporal and spatial distribution patterns are generally well described, and trends in stock abundance are well known. However, the relationships between environmental and hydrographic factors (i.e., temperature, salinity, oxygen, circulation patterns, etc.) and the demographics of fish stocks are poorly known. **More research is needed to assess and evaluate the environmental determinants affecting the distribution of fish stocks in time and space (at all life stages, including eggs, larvae, juveniles and adults), as well as the effects of physical factors on stock dynamics (growth, maturation, spawning, recruitment, etc.). An understanding and parameterization of these interactions will be essential in integrating physical and biological processes within models of the Baltic ecosystem.**

Bottom-living organisms and demersal fish in the Baltic Sea area are frequently affected by oxygen deficiency and the formation of hydrogen sulphide. This problem can be divided into two categories:

1) Annual oxygen deficiency in the bottom layer.

   This is an increasing problem in coastal areas and is closely related to eutrophication.

2) Stagnant bottom waters in deep basins, below the permanent halocline.

   This kind of stagnation has occurred many times over the centuries and is a natural condition within the Baltic Sea. The key process affecting stagnation is the influx (or lack thereof) of high-salinity, oxygen-rich water from the North Sea. The frequency and magnitude of these inflow events affect the duration and extent of stagnation in the deep basins in the Baltic Sea. Other processes, such as river runoff, precipitation, and evaporation, are also important.

Inflows can be categorized either as 'basic events' or 'major events'. Basic inflow events occur on a regular basis (generally on a time scale of days). The impact of these events depends on the density of the inflowing water; normally, these densities are insufficient to permit the inflowing water masses to penetrate down to the bottom and exchange/replace the stagnant water layers. Only major inflows accomplish this, but these events occur only infrequently. In the last 100 years, 92 major inflow events have been identified. Very strong inflows (>100 cubic kilometres) have occurred on only 24 occasions.

Since 1976, major inflows have occurred only twice (in 1983 and 1993). Prior to the 1993 inflow, the stagnation of Baltic bottom waters was the worst in modern times.

Inflowing water is driven by the sea level difference between the Kattegat and the southwestern part of the

Baltic Sea. There is also a baroclinic component, especially in the Great Belt. The flow is strongly oscillatory (on a time scale of days) due to internal waves (i.e., seiches) in the Baltic Sea, and atmospheric conditions over the Baltic Sea and the North Sea. There are also seasonal-scale variations due to changes in evaporation, river runoff, salinity, and temperature.

Water exchange has, in many cases, been calculated using sea levels which are related to volume flow using hydraulic theory. This approach is useful from a modelling perspective, but is less successful in explaining or predicting long-term changes since the meteorological mechanisms affecting sea level variations are not explicitly taken into account.

Several studies have demonstrated the importance of meteorological forcing, and water-exchange models must clearly be developed that account for both large-scale and local atmospheric forcing factors. These models should also include the effects of seiches and river runoff. The models should quantify how the forcing components interact and influence the magnitude of water exchange during both basic and major inflow events.

Investigations need to be initiated regarding process studies of the water exchange forcing in the Great Belt and the Sound. These studies should focus on meteorologic/oceanographic interactions.

Studies of deep-water exchange and mixing processes in the Baltic Proper should be continued in order to be able to predict the effects of inflows within the different basins of the Baltic Sea.

A joint international programme should be designed and planned for implementation during the next major inflow event.

3.2 *The Influence of Biotic Factors on the Distribution, Abundance, and Demography of Fish Stocks, including Ecological Impacts of the Baltic Fisheries on the Environment*

At present, biological interactions (predator/prey interactions) among the major fish stocks in the Baltic have been modelled using multispecies virtual population analysis (MSVPA). In the current model, only one predator (cod) and four prey stocks (cod, sprat and two herring stocks) are considered. To date, only fish of age 1 and older have been included in the model, eggs, larvae and 0-group fish have not.

The model could and should be expanded to include:

a) earlier life stages of both predator and prey species;

b) an increased number of predators (*viz.* seals, birds, other fish species); and

c) a more refined spatial/temporal structure.

In addition, **there are many fish stocks in the Baltic Sea for which few data exist to evaluate the population dynamics of these resources (i.e., flatfish stocks, nearshore/freshwater species, etc.).** Clearly, the influence and role of these species within the Baltic ecosystem will be impossible to characterize until **detailed studies are undertaken on the life history and dynamics of these stocks.**

In all of the Baltic stock assessment work, there is a pressing need to coordinate - and standardize, if possible - sampling programmes and assessment methodologies.

The impacts of fishing activities on the environment of the Baltic Sea are poorly understood and not well documented. Specific concerns have been expressed about the physical impacts of trawling activities on the benthos and benthic productivity, and on 'ghost-fishing' by lost/abandoned gear (e.g., gill-nets). In addition, incidental mortality due to the by-catch of marine mammals, birds, and non-targeted fish species may be significant. **Quantitative evaluations of these impacts are sorely needed.**

3.3 *Influence of Factors on the Ecosystem which are both Natural and Anthropogenic*

Over the past few decades, there has been a marked increase in the amount of nutrients (nitrogen and phosphorus) supplied to the Baltic Sea by riverine discharges and atmospheric deposition. Studies have been conducted to ascertain whether temporal trends can be observed in the nutrient concentrations in the water column. In these efforts to observe whether an increasing flux shows up as an increasing concentration, the clearest case will occur where riverine waters are 'contained' by the circulation patterns during the winter period when there is limited phytoplankton production. During spring, summer, and fall, there is sufficient growth of plant material to reduce the nutrient levels in the water column and, hence, make a trend in nutrient concentrations difficult to discern and, if discerned, even more difficult to relate to the change in inputs.

The flux of nutrients from the land (via rivers and the atmosphere) to the coastal waters does not remain in the water but, rather, a portion continues as a nutrient flux from the water into plant material. Hence, plant biomass may be affected by the increased nutrient flux. However, this again involves relating a rate of supply to a concentration. (Biomass in kg/m^3 is a measure of the nutrients/unit volume that are bound up as plant material, hence biomass is not a flux measurement but a concentration measurement.) The relationships that are seen between biomass and increasing nutrient flux may be due to the fact that phytoplankton production (which is related to the rate of uptake of nutrients) is, to first order in simple cases, a linear function of biomass and light supply. There are many effects that generally make the relationship highly non-linear, time dependent and otherwise very confusing.

In summary, concern about the effects of an increase in the nutrient flux has led to a search for trends in nutrient concentrations in the water column to quantify the effect. The search for nutrient trends has focused on winter data to avoid the impact of biological production. However, it is this biological production that leads to the concern about the nutrient flux in the first place. The simple relationship sought between nutrient fluxes and the degree of eutrophication is elusive because it involves finding a relationship between a flux rate and a concentration.

It is the flux of nutrients that causes the 'problem'. Problems appear in the form of:

a) a large biomass of algae or phytoplankton producing a visual detraction or an oxygen depletion, or

b) a biomass of harmful phytoplankton or algae.

When looking for changes resulting from reduced nutrient fluxes, parameters based on planktonic populations may well show the effects sooner (or more clearly) than the concentrations of the nutrients themselves. **However, both biological and chemical parameters should be monitored.**

As a basis for administrative decisions to counteract eutrophication, information has to be provided on several topics. A review of ongoing research and monitoring programmes suggests that sufficient data are presently being collected on the primary nutrient load to the Baltic Sea from both point and non-point sources. Missing or unsatisfactory information may be provided via minor modifications to existing programmes. **Two main routes of input for which more reliable data are required are atmospheric deposition and diffuse nutrient releases from coastal erosion, surface runoff, etc.**

The first severe gap in knowledge - and maybe the most **important of all - is the missing quantification of the relationship between (anthropogenic) nutrient inputs and trends in these inputs and the response of the Baltic Sea environment.** There are attempts to quantify (model) the input/budget relation of nutrients for the Baltic Sea as a whole. However, nutrient loads are not distributed evenly over the Baltic Sea, but are mainly trapped in the coastal areas. Thus, it is in the coastal areas where the main damage by eutrophication can be expected to be observed. In this connection, anoxia in the deep water, although it resembles effects of eutrophication, is not necessarily related to eutrophication but is a consequence of the hydrographic situation in the Baltic Sea and the historic and natural oxygen demand.

It is necessary to enhance our knowledge as regards:

1. **Quantification of primary loads of nutrients (river discharge, land runoff, atmospheric deposition);**

2. **Quantification of sink capacities in coastal areas (sedimentation, resuspension, processes, fluxes);**

3. **Quantification of (source and) sink capacities in the open Baltic Sea and total nutrient budgets.**

Production and other biological and geochemical processes retain more than 70% of the nutrient inputs. Coastal waters receive the nutrient loads directly, and it is there that the spawning and recruitment areas for many species are found, and thus the most significant effects can be expected, both positive and negative. These are the areas where by quantification and modelling enough insight may ultimately be gained into the eutrophication dynamics that may permit a prediction of the impact of mitigation measures.

Another important research need is the identification of changes in the ecosystem (e.g., changes in the size composition of the plankton community, which may affect energy flow in the food web) which are direct consequences of eutrophication or the contribution of eutrophication to effects based on other causes in (a) near coastal areas, and (b) open Baltic basins.

There are indications that certain negative effects initially considered to be due to eutrophication are instead effects of unbalanced nutrient ratios rather than the mere quantity of nutrient loads. Measures taken to reduce eutrophication have changed the previously parallel inputs of N and P, so that after about 1980, nitrogen loads were still increasing while phosphorus loads decreased, resulting in a drastic change in the N/P ratio. In addition, changes in agricultural techniques have led to enormous local and short-term peaks of nitrogen inputs.

This means that the effects of non-parallel reductions in inputs of phosphorus and nitrogen and changes in the N/P ratio (or other nutrient ratios) in sea water represent another important research need.

3.4 *The Influence of Anthropogenic Activities on Baltic Fish Stocks*

Little knowledge exists of the impacts of anthropogenic influences (e.g., contaminants, nutrient loads, etc.) on Baltic fish stocks. **There is a pressing need to quantify the impact of these factors on life history processes (growth, fecundity, natural mortality, reproduction) of Baltic fish.** In some cases, environmental degradation in coastal regions has adversely affected nursery and spawning habitats. As an example, in some regions nearshore herring spawning areas have been degraded due to the increased abundance of filamentous algae resulting from increased nutrient loadings.

The concentrations and distributions of a number of contaminants (e.g., heavy metals) have been reasonably well studied during recent years. However, **the role that fish play in the transport of contaminants within the Baltic ecosystem (in both a spatial and trophodynamic sense) is not well understood.** Nevertheless, it is clear that high levels of contaminants have been found in top predators (i.e., fish-eating birds, marine mammals, etc.), which suggests that fish play an important role in the bioaccumulation process. **How the fish themselves are affected (either in the short term from acute mortality, or in the long term from sublethal concentrations of these anthropogenic substances) is not quantitatively known.**

Relatively little is known about the concentrations and distributions of organic contaminants in the marine environment. However, a substantial part of the organic compounds produced, intentionally or as by-products, by man ultimately end up in the environment. Some of these substances are degraded very slowly by natural processes and their concentrations in the environment will increase if the rate of their input to the environment is faster than their decomposition rate. In this case, levels at which biological effects appear will ultimately be reached. This is especially important for lipophilic compounds which are accumulated in biota and biomagnified in the food webs.

Most organic compounds that are bioaccumulated are also effectively transported over long distances, resulting in large areas being contaminated before the problem is realized. For compounds which degrade slowly, the problem is, therefore, often extended both in space and in time.

It is, however, difficult to identify the compounds that may cause problems and the length of their persistence in the marine environment; the standard tests used today represent just a few of the chemical and biological breakdown procedures that can take place. For chemicals already in use, the environment itself can be used to test their stability by looking for the substances in samples taken far away from known sources.

The specific conditions of low water exchange and long residence times of water in the Baltic Sea result in high concentrations of a number of persistent organic compounds building up in this environment. It is quite common to find ten times higher concentrations of, e.g., PCBs and DDT, in biota from the southern Baltic Sea than in corresponding samples from the Skagerrak, near the transition area to the entrance to the Baltic Sea. It is also believed that several of the effects observed in Baltic marine mammals and fish are caused by persistent organic compounds. The Helsinki Commission decision to decrease the emissions of some compounds belonging to this group by around 50% is an important managerial action. Since this decision is of a rather general nature, it will need to be followed up by more specific decisions after 1995.

The problems related to persistent organic compounds are very complex due to the great number of combinations of substances and possible effects. Considerably more knowledge is needed but the resources, both the amount of money and the number of good scientists, are limited and a good prioritization is essential. Thus, it is necessary to enhance our knowledge by conducting the following activities:

1. **Development of monitoring methods.** The monitoring analyses become more and more complex and expensive, which means that a great deal of the qualified resources is used for them. All efforts spent on improvements in the monitoring field will, therefore, probably pay off very well. This includes the development of simplified chemical or biological methods or combinations thereof.

2. **Looking for potential persistent organic compounds in the environment.** Several "grey" or "waiting" lists of chemicals in use (some of them in high volumes) have been presented as it is not known whether these compounds pose environmental problems. Those that can be found far away from sources should be followed for some time (or analysed in banked samples) to find out if the levels are increasing.

3. **Identification of "new" persistent organic compounds.** Even if existing and new chemicals are tested, a number of processes, e.g., combustion, form new compounds that are difficult to predict. A

continuous research effort for compounds not yet identified in the environment is, therefore, important, and the Baltic Sea can, as an area in which such compounds appear to concentrate, serve as an "early warning system". This can partly be done in the monitoring programmes where it is essential that all "extra" information be used. The gathering of such information in a central database available to all scientists would be very useful.

4. **Relation between persistent organic compounds and eutrophication.** If part of the decreased levels of some persistent organic compounds in the Baltic Sea observed during recent decades depends on an increased eutrophication, increased concentrations can be expected if the input of nutrients is decreased. A better understanding of the link between these parameters is needed.

3.5 *The Influence of Diseases on Baltic Fish Stocks*

The factors that affect the 'baseline' natural mortality (apart from predation) of fish stocks are normally assumed to be relatively constant over time. However, the outbreak of a disease agent or pathogen can quickly reduce the abundance of fish stocks, affecting both fishery yields and the sustainability of the stocks themselves. **Monitoring programmes are needed to evaluate the 'health' of fish stocks, both in terms of the incidence/prevalence of fish pathogens and in terms of the suitability of affected fish for human consumption (i.e., human health hazards).**

Presently, two diseases affecting Baltic fish stocks (M-74 in salmon and *Ichthyophonus* in southwestern Baltic herring) have the potential to induce catastrophic mortalities within these stocks. Nothing is known about the causes of M-74, although they may be related to persistent organic compounds. Salmon eggs and fry affected by M-74 exhibit very high mortality rates (60-90%). **Research on this disease, a serious threat to the Baltic salmon stocks, is urgently needed.**

For the southwestern Baltic herring stocks, infections by *Ichthyophonus* (a fungal disease) were first noted in summer 1991. ***Ichthyophonus* is lethal to herring** on both acute and chronic time scales. As such, the impacts of this disease could have large implications on the future abundance and management of the affected herring stocks. **Studies are urgently required to: (1) assess the prevalence (by age) of the disease in herring; (2) document the infection rate; and (3) quantify the relationship between disease prevalence and subsequent population mortality rates.**

4 RECOMMENDATIONS AND CLOSURE OF MEETING

The Steering Group recommended that this report be presented at the 19th Session of the International Baltic Sea Fisheries Commission meeting in September 1993. As this meeting will take place before the 1993 ICES Statutory Meeting, the report presented should be described as an unapproved draft.

It was also agreed that a review of this report should be included in the 1994 terms of reference for the following groups: ACME, ACFM, the Working Group on the Baltic Marine Environment, the Working Group on Pelagic Stocks in the Baltic Sea, the Working Group on Demersal Stocks in the Baltic Sea, the Baltic Salmon Working Group, and the Baltic Multispecies Working Group.

After discussion, the Steering Group decided that it had accomplished what it could do with its terms of reference and composition and recommended that it be dissolved at the next Statutory Meeting. It was felt that any feedback from the review of its report could be provided to ACME and ACFM.

The Chairman then thanked all the participants for their active contributions and closed the meeting at 17.00 hrs on 18 June.

ANNEX 3

1994 CODE OF PRACTICE ON THE INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS[1]

The introduction and/or transfer of marine organisms, including genetically modified organisms, carries the risk of introducing not only pests and disease agents but also many other species. Both intentional and unintentional introductions may have undesirable ecological and genetic effects in the receiving ecosystem, as well as potential economic impacts. This Code of Practice provides recommendations for dealing with new intentional introductions, and also recommends procedures for species which are part of existing commercial practice, in order to reduce the risks of adverse effects that could arise from such movements.

I. Recommended procedure for all species prior to reaching a decision regarding new introductions. (A recommended procedure for introduced or transferred species which are part of current commercial practice is given in Section IV; a recommended procedure for the consideration of the release of genetically modified organisms is given in Section V.)

(a) Member Countries contemplating any new introduction should be requested to present to the Council at an early stage a detailed prospectus on the proposed new introduction(s) for evaluation and comment.

(b) The prospectus should include the purpose and objectives of the introduction, the stage(s) in the life cycle proposed for introduction, the area of origin and the target area(s) of release, and a review of the biology and ecology of the species as these pertain to the introduction (such as the physical, chemical, and biological requirements for reproduction and growth, and natural and human-mediated dispersal mechanisms).

(c) The prospectus should also include a detailed analysis of the potential impacts on the aquatic ecosystem of the proposed introduction. This analysis should include a thorough review of:

i) the ecological, genetic, and disease impacts and relationships of the proposed introduction in its natural range and environment;

ii) the potential ecological, genetic, and disease impacts and relationships of the proposed introduction in the proposed release site and environment. These aspects should include but not necessarily be limited to:

- potential habitat breadth,
- prey (including the potential for altered diets and feeding strategies),
- predators,
- competitors,
- hybridization potential and changes in any other genetic attributes, and
- the role played by disease agents and associated organisms and epibiota.

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[1] For further details and procedures see:

ICES, 1984. Guidelines for Implementing the ICES Code of Practice Concerning Introductions and Transfers of Marine Species. ICES Cooperative Research Report No. 130. 20 pp.

ICES, 1988. Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms. ICES Cooperative Research Report No. 159. 44 pp.

Potential predation upon, competition with, disturbance of, and genetic impacts upon, native and previously introduced species should receive the utmost attention. The potential for the proposed introduction and associated disease agents and other organisms to spread beyond the release site and interact with species in other regions should be addressed. The effects of any previous intentional or accidental introductions of the same or similar species in other regions should be carefully evaluated.

(d) The prospectus should conclude with an overall assessment of the issues, problems, and benefits associated with the proposed introduction. Quantitative risk assessments, as far as reasonably practicable, could be included.

(e) The Council should then consider the possible outcome of the proposed introduction, and offer advice on the acceptability of the choice.

II. <u>If the decision is taken to proceed with the introduction, the following action is recommended</u>:

(a) A brood stock should be established in a quarantine situation approved by the country of receipt, in sufficient time to allow adequate evaluation of the stock's health status.

The first generation progeny of the introduced species can be transplanted to the natural environment if no disease agents or parasites become evident in the F_1 progeny, but not the original import. In the case of fish, brood stock should be developed from stocks imported as eggs or juveniles, to allow sufficient time for observation in quarantine.

(b) The F_1 progeny should be placed on a limited scale into open waters to assess ecological interactions with native species.

(c) All effluents from hatcheries or establishments used for quarantine purposes in recipient countries should be sterilized in an approved manner (which should include the killing of all living organisms present in the effluents).

(d) A continuing study should be made of the introduced species in its new environment, and progress reports submitted to the International Council for the Exploration of the Sea.

III. <u>Regulatory agencies of all Member Countries are encouraged to use the strongest possible measures to prevent unauthorized or unapproved introductions</u>.

IV. <u>Recommended procedures for introduced or transferred species which are part of current commercial practice.</u>

(a) Periodic inspection (including microscopic examination) of material prior to exportation to confirm freedom from introducible pests and disease agents. If inspection reveals any undesirable development, importation must be immediately discontinued. Findings and remedial actions should be reported to the International Council for the Exploration of the Sea.

and/or

(b) Quarantining, inspection, and control, whenever possible and where appropriate.

(c) Consider and/or monitor the genetic impact that introductions or transfers have on indigenous species, in order to reduce or prevent detrimental changes to genetic diversity.

It is appreciated that countries will have different requirements toward the selection of the place of inspection and control of the consignment, either in the country of origin or in the country of receipt.

V. Recommended procedure for the consideration of the release of genetically modified organisms (GMOs).

(a) Recognizing that little information exists on the genetic, ecological, and other effects of the release of genetically modified organisms into the natural environment (where such releases may result in the mixing of altered and wild populations of the same species, and in changes to the environment), the Council urges Member Countries to establish strong legal measures[2] to regulate such releases, including the mandatory licensing of physical or juridical persons engaged in genetically modifying, or in importing, using, or releasing any genetically modified organism.

(b) Member Countries contemplating any release of genetically modified organisms into open marine and fresh water environments are requested at an early stage to notify the Council before such releases are made. This notification should include a risk assessment of the effects of this release on the environment and on natural populations.

(c) It is recommended that, whenever feasible, initial releases of GMOs be reproductively sterile in order to minimize impacts on the genetic structure of natural populations.

(d) Research should be undertaken to evaluate the ecological effects of the release of GMOs.

DEFINITIONS

For the application of this Code, the following definitions should be used:

Brood stock
Specimens of a species, either as eggs, juveniles, or adults, from which a first or subsequent generation may be produced for possible introduction to the environment.

Country of origin
The country where the species is native.

Current commercial practice
Established and ongoing cultivation, rearing, or placement of an introduced or transferred species in the environment for economic or recreational purposes, which has been ongoing for a number of years.

Disease Agent
For the purpose of the Code, 'disease agent' is understood to mean all organisms, including parasites, that cause disease. (A list of prescribed disease agents, parasites, and other harmful agents is made for each introduced or transferred species in order that adequate methods for inspection are available. The discovery of other agents, etc., during such inspection should always be recorded and reported.)

Established species
Species with existing reproductive populations.

Exporting country
The country from which a specific consignment of a species (regardless of its native region) is received.

Genetic diversity
All of the genetic variation in an individual, population, or species. (ICES, 1988)

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[2]Such as the European Economic Community "Council Directive of 23 April 1990 on the Deliberate Release into the Environment of Genetically Modified Organisms (90/220/EEC)", Official Journal of European Communities, No. L, 117: 15-27 (1990).

Genetically modified organism (GMO)
An organism in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination. (This definition is from Article 2(2) of EC Directive 90/220, "On the deliberate release into the environment of genetically modified organisms".)

Introduced species (= non-indigenous species, = exotic species)
Any species intentionally or accidentally transported and released by humans into an environment outside its present range.

Maintained species
Species which are reproducing in aquaculture for several generations without artificial spawning.

Marine species
Any aquatic species that does not spend its entire life cycle in fresh water.

Quarantined species
Any species held in a confined or enclosed system that is designed to prevent any possibility of the release of the species, or any of its disease agents or any other associated organisms into the environment.

Transferred species (= transplanted species)
Any species intentionally or accidentally transported and released within its present range.

NOTE:

(a) It is understood that an introduced species is what is also referred to herein as an introduction, a transferred species as a transfer, and a quarantined species as a species in quarantine.

(b) Introduced species are understood to include exotic species, while transferred species include exotic individuals or populations of a species. It is, thus, understood that the general term 'exotic' can include both introduced and transferred species.

(c) It is understood for the purpose of the Code that introduced and transferred species may have the same potential to carry and transmit disease or any other associated organisms into a new locality where the disease or associated organism does not presently occur.

ANNEX 4

FEASIBILITY OF INTEGRATING THE NORTH SEA BENTHOS SURVEY DATA INTO THE ICES ENVIRONMENTAL DATABASE

Introduction

The 18th meeting of the Joint Monitoring Group under the Oslo and Paris Commissions decided to give ICES the task "to calculate the costs of integrating the benthos data currently held in a database in Yerseke (the Netherlands) in the ICES database." This report is the response to this request. It should, however, also be seen in the light of the recommendation from the 1993 meeting of the ICES Benthos Ecology Working Group (BEWG) that ICES establish a proper benthos database (Anon., 1993).

The report consists of four main sections. Section one describes the ICES North Sea Benthos Survey. The survey was conducted in 1986, and the data obtained forms the core of the present North Sea Benthos Database. This database is described in section two. Section three describes anticipated problems associated with the integration of the data into the ICES Environmental Database. This section also calculates the costs associated with this integration. Section four provides references for the literature cited.

1. The North Sea Benthos Survey

The BEWG identified the need for a large-scale benthos survey in the North Sea (Anon., 1985). Basic knowledge on species composition and biomass distribution of benthos in the North Sea did not exist for large areas. The group stated that this type of information is essential in addressing questions regarding the food composition of benthic fish species, effects of eutrophication, pathways of pollutants, etc.

The BEWG proposed, planned and conducted the ICES North Sea Benthos Survey (NSBS). The sampling was done in April/May 1986 through the commitment of several marine institutes. The analysis of the samples comprised identification of organisms to a defined taxonomic level and analyses for associated geochemical parameters.

A list of the stations sampled is given in Anon., 1986.

1.1 Analysis of Samples

The analysis of the NSBS samples was initiated in 1986. The main effort was put into the analysis of epifauna and macro infauna. Estimates of density and biomass were obtained by phyla and by species of molluscs, echinoderms and dominant species of other groups. Determination of the biomass of major taxonomic groups was completed in 1988, and agreement on a final integrated species list was reached in early 1990.

Two workshops were held in 1988 to deal with taxonomic problems arising from analysis of the macrofauna and meiofauna samples. Two further workshops were held in 1989 to agree on the final form of a combined species list for the macrofauna.

Samples were also analysed for concentrations of trace metals, organic matter, proteins, plant pigment, and particle size distribution. This work was completed in 1987, and the results were presented at the 1987 ICES Statutory Meeting.

1.2 Analysis of the Data

The results of the analysis of the NSBS data were reported at the mini-symposium held during the 1990 Statutory Meeting. On this basis, six papers were published in the ICES Journal of Marine Science, Volume 49, nos. 1 and 2, 1992 (Authors: D. Basford, M.J.N. Berman, J. Craeymeersch, J.M. Dewarumez, J. Dorjes, G.G.A. Duineveld, A. Eleftheriou, C. Heip, P. Herman, M. Hup, R. Huys, P. Kingston, A. Künitzer, M.A. Lambert, R.G. Lees, D.S. Limpenny, P. Niermann, U. Rachor, H.L. Rees, S.M. Rowlatt, H. Rumohr, P.K. Soetart, T. Soltwedel, and A.J. de Wilde).

Production estimates based on data from the NSBS were presented by Brey, 1989 (Anon, 1989)

2. The North Sea Benthos Database

The BEWG initiated the discussions about setting up a proper North Sea benthos data bank in 1985 (Anon, 1985). For the NSBS, the BEWG adopted the Helsinki Commission data reporting protocol, based on the GF3 system and used by the Baltic Marine Biologists. A preliminary format for storage and retrieval was outlined in Anon. 1985. A final version of the database was prepared thereafter. It comprises approximately 130,000 records.

2.1 Surveys Included (Geographical Coverage)

In addition to the data from the North Sea Benthos Survey, the present version of the database contains data from several other surveys. The report of the 1993 meeting of the BEWG (Anon., 1993) contains a list of additional data sets which could be included in the database.

2.2 Information Included

Most of the data included are macrobenthic infauna data: numbers, density and biomass of individual species. For some surveys, data on composition and density of meiobenthos are included as well. Additionally, the database contains information identifying and characterizing the sampling location: site name, date of sampling, geographical position, depth, and some sediment characteristics. This information is, however, not complete for all sampling sites.

2.3 Species Coding

In order to keep track of data on individual species in the database, a unique species coding system is necessary. This topic has been discussed several times in the BEWG. Several possibilities have been considered, amongst these the GF3, NODE, MCSSD, and RUBIN code systems.

GF3 was originally adopted. This applies a plain language abbreviation code for species consisting of 6 characters for genus and 6 for species. This was later changed so that an 8-character code was assigned to each species name (Anon., 1989). The present version of the database applies a unique species identification number. For some species the RUBIN and/or the MCSSD codes are known as well. To develop and maintain a proper species coding system is an important task for the data centre responsible for a benthos database (see section 3.1.1).

2.4 Software

The establishment of the database and the development of a management system was funded by the North Sea Directorate and the National Institute for Coastal and Marine Management of the Dutch Ministry of Transport, Public Works and Water Management, the Netherlands Institute of Ecology, Centre for Estuarine and Coastal Ecology, and the North Sea Task Force.

Staff at the Netherlands Institute of Ecology, Centre for Estuarine and Coastal Ecology have developed software for the maintenance and handling of the data. The database is organized as a relational database, structured using the PC database program Paradox. The associated software allows the user to extract data on density and biomass based on a selection of either species, sample or position. Additional software allows presentation of the data in the form of circles on maps, the area of the circles being proportional to the abundances of individual species.

3 Integrating the North Sea Benthos Database into the ICES Environmental Database; Establishing an ICES Benthos Database

3.1 Anticipated Problems Associated with the Incorporation

It is a general problem in the database that very little documentation of the data exists. In most cases, data have been submitted to the database as files with numbers, without any associated explanation on how these numbers should be interpreted. The managers of the present database have put a large effort into 'detective' work to provide the necessary additional information.

3.1.1 Species coding/species information

In the present version of the database, each species is assigned a unique identification number. When available, the species is also assigned a code as defined by either the 'Marine Conservation Society Species Directory Code' (MCSSD) or by the 'RUBIN' code system. In the future, it is desirable that a single coding system is applied.

In the data reported to the database, the same species is sometimes reported under several different systematic names (synonyms). The problem is solved in the present version of the database by maintaining a list of possible synonyms for each species. This work is, however, not finalized and should be continued (see section 3.2.3).

For some species the present version of the database contains information on feeding strategy. This work is, however, not finalized and should be continued (See section 3.2.3).

3.1.2 Raw data vs. derived data

For some of the data stored in the present version of the database there is some inconsistency as to the level of aggregation. This is mainly due to the lack of an agreed data reporting protocol. As an example, data are in some instances reported as density or biomass per m^2, while other data are reported as number of specimens or total weight of specimens found in the sample. The latter is the desired level, for the database to be of scientific value. This level is necessary if the user of the data wants to explore, for instance, between-sample variability or effects of sampling device.

In some instances, only a fraction of a sample has been analysed. Information on this should be retained in the database as well.

3.1.3 Taxonomic level

The present database contains some inconsistency in the reporting of data for various taxonomic levels.

In the analysis of samples, the general problem is that it is usually impossible to identify all specimens to a given taxonomic level (the species level, for instance). The solution usually applied is that the specimens are identified to the agreed taxonomic level whenever possible, the remaining specimens being 'lumped', i.e., identified to some higher level. When the results of the analysis are reported, the data originator does not always specify whether results from the lower taxonomic level are included in the 'lumped' category.

Another problem concerns the definition of macro/meiofauna. For assessment purposes, it is desirable that each observation is referred to as being either macro- or meiofauna. The problem is that the definition differs among workers so that individual species are referred to one group or another depending on the worker/study/survey. An example from the present database is the handling of Nematoda. Some workers apply the definition that specimens passing through the sieve belong to meiofauna, those retained belong to macrofauna. Other workers apply the definition that all Nematoda species should be referred to the meiofauna group.

3.1.4 Quality assurance

To ensure comparability in results between laboratories and workers participating in international programmes, quality assurance should be an integral part of the programme. In this respect, the present database does not include any kind of qualification or evaluation of the data. A new database should include options for such an evaluation.

3.2 Establishing an ICES Benthos Database: Cost Calculations

The establishment of an ICES Benthos Database (IBDB) will require six different types of activities:

a) Transferring and integrating the present North Sea Benthos Database into the IBDB.

b) Receiving and integrating other historic benthos data sets into the IBDB.

c) Defining a reporting protocol for the reporting of results of future studies into the IBDB. Implementing this protocol at the ICES Secretariat.

d) Receiving and integrating data submitted according to the new protocol.

e) Maintaining the IBDB.

f) The production of outputs and software.

Two types of costs will be involved: costs associated with the purchase of hardware and software, and costs associated with manpower.

The costs associated with the purchase of software and hardware will be DKK 5,000 for a Paradox licence and DKK 25,000 for a PC (including the hardware and software necessary for linking the PC to the network at the ICES Secretariat).

The manpower requirements can be broken down into three categories: professional (PR), technical assistance (TA), and programming assistance (PA). These requirements will be described in sections 3.2.1 - 3.2.6.

3.2.1 Transferring and integrating the present North Sea Benthos Database into the IBDB

The present database is organized as a PC-based Paradox database. This is not a convenient basis for the organization of the IBDB, mainly because PC-based systems have general capacity limitations when large amounts of data should be handled. Moreover, it would require all participants in international programmes to have access to PC-based systems with a Paradox licence. The experience from other international programmes is that data handling should not be based on the assumption that the data originators have access to a particular computer system.

The main effort required to transfer the present database is that the data in the database should be converted to comply with a new data reporting protocol (section 3.2.3). The necessary software should be developed to do this.

It is anticipated that, for some historical data sets, it will not be possible to do the conversion because the data are too non-compatible with a new protocol. These data sets will have to be stored 'as is' and handled on an *ad hoc* basis (see section 3.2.2).

The development of the necessary conversion software will require 10 PR days, 10 TA days, and 20 PA days.

3.2.2 Receiving and integrating other historic benthos data sets into the IBDB

The effort required to integrate historic benthos data sets not already included in the Benthos Database will depend on the number of data sets to be included and the condition of the data.

An inventory project will have to be conducted in order to identify the historic data sets to be included. This work could be done by the BEWG.

For data sets already available in digitized form, experience shows that the processing of each data set requires between 1 and 6 weeks. On average, it is anticipated that each data set will require four weeks, i.e., 10 TA days and 10 PA days/data set.

The effort required to convert data sets available only on paper forms will depend on the volume of the data set, and cannot be estimated at this stage.

3.2.3 Defining and implementing a new data reporting protocol

To ensure a proper handling and processing of the data, it is essential that a well-defined data reporting protocol exist. For future submissions of benthos data, a new data reporting protocol should be developed, together with the necessary software to support the protocol.

The protocol should be developed with close cooperation between the BEWG and the ICES staff. This will require 20 PR days and 10 TA days.

The software applied at the ICES Secretariat to handle and check data submissions (the 'screening' and the 'pollfx' programs) should be revised to support the new protocol. This will require 40 PA days.

Experience gained during the North Sea Benthos Survey shows that the best way to ensure that data are reported correctly is to let the data originator apply a designated data entry program. To develop this program will require 40 PA days.

The software developed at the Netherlands Institute of Ecology for management, extraction and mapping of data requires that data available as computer files with a defined structure. The structure of the IBDB will not immediately support this software. If desired, the necessary software could be developed. This will require 15 PA days.

An essential tool in the management of a benthos database is a well-defined species list. As mentioned in section 2.2, this work has been initiated at the Netherlands Institute of Ecology. To complete this task will require 40 PA days.

The costs associated with the establishment of the IBDB will finally include the participation of an ICES staff member in the annual meetings of the BEWG.

3.2.4 Receiving and integrating data submitted to the IBDB

When the IBDB is established and the necessary software developed, experience shows that the effort required to receive and integrate new data sets is approximately 1 TA day per data set.

3.2.5 Maintenance

When established, maintenance of the database will require approximately 10 PR days, 5 TA days, and 15 PA days per year.

3.2.6 The production of output

The costs associated with the production of output will depend on the task, and will have to be estimated from case to case. As a rule of thumb, the production of simple univariate statistics (tables, figures, maps) usually requires 1 PR day per task.

4 References

Anon. 1985. Fourth Report of the Benthos Methodics Working Group. Bremerhaven, 25-29 March 1985. Doc., ICES C.M.1985/L:33.

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Anon. 1993. Report of the Benthos Ecology Working Group. Kiel, Germany, 3-8 May 1993. Doc., ICES C.M.1993/L:3.

Papers from the Mini-Symposium on Benthic Ecology of the North Sea, held in Copenhagen on 9 October 1990. ICES J. mar. Sci. 49(1): 3-64, 49(2): 125-144.

IOC, 1987. GF3: A general formatting system for geo-referenced data.

ANNEX 5

ACME/ACMP ADVICE ON A TOPIC BASIS FOR THE YEARS 1994 - 1983

Numbers in the table refer to sections of the present report and of the ACME or ACMP reports from 1993 to 1984 and to paragraphs in the ACMP reports from 1983.

*Signifies major advice on that topic.

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Monitoring	Strategy	*4 *An.1	5	5.1				*4					
	Multi-purpose					6.2							
	Benthos			8 *An.6	8.1	9	*An.1	*7.1	8				
	NSTF-MMP		5.2			9.3	4						
	Sediments - Guidelines	5.5	6.1 *An.1				*14			15		*An.2	45-49 An.2
	Sed. data normalization	5.5					*14.1	14.1	15.2	16			
	Sensitivity of sediments							14.6 An.2					
	Metals/sediments							12.6					
	Evaluation of programme	4.2											
	Matrix tables - gen. (JMP)					*An.1	*6.1	4					
	" " - organic					6.1							
	Matrix tables - NSTF					6.1							
	Use of seaweeds	5.1				6.8	6.3					4.6	

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Monitoring (ctd.)	Review of CMP												16-19
	JMP Guidelines			13.3						4.5			
	BMP Guidelines		5.3						*12	4.4			90-91
	AMAP		5.4										
	Trend monitor. Guidelines	4 5.2						5.2	6.2 6.3	*4.1 An.1	4.1	4.5	25-26
	" " Data analysis	5.2	6.2	5.2									
	" " Nutrients		6.3					11.1					
	" " Fish - JMP				5.1	6.2				An.1			
	" " Fish - CMP				5.1	6.5	*6.4	5.1	6.1	An.1	4.2	4.1	25-26
	" " Mussels				5.1	*An.3			6.3				
	" " Pooling					6.7 An.5	6.4.3		6.2.1				
	" " Precision	5.2		*An.1			6.4.4						
	" " Sed. Storage							14.2					
	" " Sea water					6.6			6.5	4.2			27-28
	Trend Monitor. Sediments							5.3 An.2	6.5	4.2			
	Sediment quality	5.4	6.4 An.2										
Biological Effects	Monitoring Strategy										5	5.1	33-37
	Concepts						*7.1						
	Methods			6.2	7.2								

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Biological Effects (ctd.)	Pathology									5.1			
	Oslo Workshop									5.2			
	A. Dohrn Workshop											5.2	
	Bremerhaven Workshop			6.1	7.1	8.1	7.2	6					
	Fish egg bioassays									5.3			
	Data analysis			6.3									
	" " EROD			*An.2									
	" " Oyster bioassay			*An.2									
Mariculture	Impacts	13		9.1		*11	10	9	10	10			
	Nutrient inputs Baltic			*9.2		11.1	10.4						
	Drug use control					An.6							
Algal Blooms	Primary production meths.		6.5	11	11.1	12.1		10.2					
	Initiating factors				*11.3	12.2				8			
	Dynamics	8	10										
	Exceptional algal blooms				11.2					8	*8	9	43-44 *An.1
	Phycotoxins/measurements				11.4	12.3		10.1		9			
	C. polylepis bloom						*11.1	10.3					
Regional Assessments	Guidelines					5		*20.1					53-55 An.3
	Preparation plans						5		21.4		10	10	
	Irish Sea								*21.1	24.2			
	Skagerrak/Kattegat								21.2	24.1			

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Regional Assessments (ctd.)	North Sea QSR			4	4	5			21.3	23			
	Baltic Sea	7.3					5						
	Baltic fish	7.3				17.2	17.3						
	Canadian waters				16								
	Nutrient trends - N. Atl.					13	12		16.1				
Baseline Studies	1985 Baseline Fish								*4	4.3.1		4.2 11.4	20-21 86
	" " " Plans											An.9	
	ICES Baseline TM/SW				6	*7	6.5	13	5	4.3.2	7.2.1	4.3	22-24
	Contamns. in Baltic seds.	7.1	8.1	13.2	14.1	15.1			15.1				
	Contaminants in North Sea sediments			13.1									
	HCH in sea water			14									
Fish Diseases	Relation to pollution	9.4			9.1		9.3			5.1	6.2	5.4	
	Survey methods				9.2			8.2				5.3	
	Training guide					10							
	Immunocompetence					10							
	Survey results						9.1	8.1	9	6	6.1		
	Data analysis	9.5	9.4	7									
Quality Assurance	Philosophy				13.6								
	Good lab. practice								13.5	11.5	An.1		
	Reference materials		7.11				13.1	12.8		11.4	7.3		
	Oxygen in water					14.5	13.6						

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Quality Assurance (ctd.)	Hydrocarbons						13.7						
	NSTF					14.7							
	Biological effects techs.		7.1		7.3								
	Sed. quality criteria					15.2	22.2						
	QA of sampling			*12.8									
	QA info. in data bank	6.10											
Intercalibration	Status	An.6	An.5	An.8	An.3	An.9	An.2	An.3					
	Nutrients - sea water	6.6	7.8	12.4		14.1	13.4	11.3	16.2	19			
	Lindane (γ-HCH)									*13			
	Specific hydrocarbons								13.3	11.1	7.1.2		
	Hydrocarbon biol. tissue						13.7				7.1.2	6.5	14-15
	2-3HC/BT											6.5	
	Hydrocarbons in sediments						13.7						
	Hydrocarbons in sea water						13.7			*12	7.1.2		
	PAHs - standards			12.2	13.1	14.2	13.2	12.1					
	PCBs/CBs in biota	6.3 6.4	7.5	12.1	13.2			12.3			7.1.1		
	Organochlorines											6.4	11-13
	5/OC/BT											6.4	
	CBs in sediments	6.3	7.5		13.2				14	14			
	CBs - standards					14.3	13.3	12.2		14			
	TMs in sea water								13.1		7.2.2	6.2	5-8
	5/TM/SW											6.2	5-8

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Intercalibration (ctd.)	6/TM/SW								13.1				
	TMs in sediments							12.5		11.2.1 11.2.2	7.2.4 7.4	6.3	
	1/TM/MS									11.2.1			
	Baltic sediment intercal.										7.4	11.3	52
	TMs in biological tissue								13.2		7.2.1	6.1	9-10
	7/TM/BT								13.2		7.2.1		
	Diss. oxygen in sea water			12.5	13.4	*14.5							
	Methyl Hg in biol. tissue							12.4	13.4				
	TMs in SPM	6.7	7.9	12.3	13.3	14.4	13.5	14.4 An.1		18.2	7.2.3		
	Primary production							10.2					
	Oyster embryo bioassay			An.4									
	EROD			12.6 *An.3									
Marine Mammals	Contaminants/effects								*11.1	7.2			
	Seal epidemic 1988					*18	*18.1						
	Baltic seal stocks	10.2		*18					11.3	*7.1		12 An.8	
	Populations - N. Atl.	10.1	11.1	*18	18								
	Pathogens		11.2 An.3										
Classification	Human health					19							
	Hazardous substances			*15									

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Overviews	Arsenic								*17.2				
	Mercury						*19.1						
	Zinc											*An.7	
	HCB					*20.1							
	Lindane (γ-HCH)					*20.1							
	HCBD												*An.5
	PCDDS and PCDFs						*19.2					An.4	
	PAHs									*20.2			
	Phthalate esters										*13.2		
	Organo-tin and -lead											*An.5	
	Polychlorinated terphenyls											*An.6	
	Octachlorostyrene				20.1								
	Toxaphene	12.3											*An.4
	Atrazine	12.1											
Sand/gravel extraction	Code of Practice					16							
	Effects				15	16	15	15					
	Environ. impact assessment	*15	13										
Methods	SPM in sea water									18.1			
	Trace metals in SPM									18.2			
	Total nitrogen									19.4			
	Nutrients in sea water				13.5	*An.4				19			
	Low DO in sea water						13.6						

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Methods (ctd.)	Sediment normalization	5.5			14.2,3		*14.1	14.1	15.2	16			
	Analysis of total OCs							12.7					
Modelling	Radioactive contaminants in Baltic Sea			*17.1									
	Use in monitoring and assessment	16		17.2									
Special Topics	Context of ACMP advice					An.7	*21		22	25			
	Patchiness in Baltic Sea						17.1	19.1	20.1	22.1	12.1	11.1	84
	Nutr. trends OSPAR area					13	12	11.1	16.1				
	Nutrients & eutrophication		6.3	10	*11.3			10.4					
	Sediments German Bight								An.1			7.4.2	50
	Sediments Kattegat								An.2				
	Sediments Skagerrak											7.4.1	50
	Sediments Baltic	7.1			14.1	15.1	14.2	19.3	15.1	22.2	12.2	7.4.3	51-52
	Bioavailability/sediments	5.4	6.4 An.2		7.4		7.3			17			
	Release of sed. contams.						14.3						
	Oil spill combatting												*An.6
	Effects of low-level HCs										*9		
	Oxidation prods. of HCs											14.6	
	Effects of TiO_2 wastes											*8 *An10	41-42
	Acid rain studies/effects						20	17	19				
	Coastal zone fluxes		8.2										

Topic	Sub-topic	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983
Special Topics (ctd.)	Gross riverine input							16.1	18.2		14	*An.1	
	Inflow to Baltic		8.3										
	Net riverine inputs						16	16.2	18.3	21		*An.1	
	Atmospheric inputs							16.3	18.1 *An.3				96-98
	Capping dredge spoils												99 An.7
	Effs. disturb. on benthos	11.1		8.3	8.2								
	Ecosystem effects fishing	18		*19	19								
	Seabird/fish interactions	19											
	North Sea Benthos Survey			*An.5									
Data banks and Management	Nutrients									19.5			
	Contaminants	2.2	2.2								4.3		
	NSTF			20	*21	22							
	ICES format									4.6		4.7	29-32
	ICES databases		14										
	Benthos database	11.2 An.4											
Introductions and Transfers	Code of Practice	14.1	12.1										
	Accidental transfers	14.2	12.3										
	Genetically modified organisms		12.2										

ANNEX 6

OVERVIEW OF INTERCALIBRATION/INTERCOMPARISON EXERCISES ON CHEMICAL ANALYSES 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 ICES 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. 111 (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).

Seventh ICES Intercalibration Exercise on Trace Metals in Biological Tissue - Part 2
(7/TM/BT-2) 1985

Coordinators	:	S.S. Berman and V.J. Boyko, Canada.
Samples	:	(a) Cod liver, acetone-extracted and freeze dried, (b) dogfish muscle, acetone-extracted and freeze dried, (c) dogfish liver, acetone-extracted and freeze dried, (d) whole dogfish, spray-dried, and (e) Mytilus edulis soft material, freeze dried.
Metals analysed	:	Hg, Cu, Zn, Cd, As and Pb.
Participation	:	49 laboratories from 16 ICES member countries.

Results published in ICES Cooperative Research Report No. 189 (1992).

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

Coordinators	:	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, and (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, 1983.

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).

Trace Metals in Suspended Particulate Matter

First ICES Intercomparison Exercise for Trace Metals in Suspended Particulate Matter (1/TM/SM) 1984

Coordinators	:	Dr P. Yeats and Dr J.A. Dalziel, Canada.
Samples	:	Suspended particulate matter collected on pre-weighed 0.4 μm Nuclepore filters.
Analytes	:	Al, Fe, Mn, Zn, Cu, Pb, Ni, and Cd.
Participation	:	8 selected laboratories from 7 countries.

Results published in J. Cons. int. Explor. Mer, 43: 272-278 (1987).

Second ICES Intercomparison Exercise for Trace Metals in Suspended Particulate Matter (Phase 1) (2/TM/SM-1) 1989

Coordinators	:	H. Hovind and J. Skei, Norway.
Samples	:	Standard reference materials from the National Research Council of Canada: (a) PACS-1, (b) MESS-1, and (c) BCSS-1, from which participants should weigh out 1, 3, and 5 mg samples for analysis.
Analytes	:	Al, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn.
Participation	:	19 laboratories from 11 countries.

Results published in ICES Cooperative Research Report No. 184 (1992).

Second ICES Intercomparison Exercise for Trace Metals in Suspended Particulate Matter (Phase 2) (2/TM/SM-2) 1993

Coordinator	:	Dr C. Pohl, Germany.
Samples	:	Suspended particulate matter collected on pre-weighed 0.4 μm Nuclepore filters.
Analytes	:	Al, Cd, Cu, Fe, Li, Mn, Ni, Pb, Zn.
Participation	:	24 laboratories from 13 countries.

Report on results in preparation.

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 ICES 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 published in ICES Cooperative Research Report No. 183 (1992).

ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of
Chlorobiphenyls in Marine Media - Step 1
(7/OC/BT-1 and 1/OC/MS-1) 1989

Coordinators	:	J. de Boer (Netherlands) (for ICES), J.C. Duinker (Federal Republic of Germany) (for IOC), J. Calder (USA) (for JMG).
Samples	:	(a) Standard solution of 10 CBs in iso-octane, (b) solution of the 10 CBs in iso-octane at unknown concentration, (c) internal standard: octachloronaphthalene in iso-octane, and (d) blank: iso-octane.
Analytes	:	CB Nos. 28, 31, 52, 101, 105, 118, 138, 153, 180, 189.
Participation	:	57 laboratories from 17 countries.

Results published in ICES Cooperative Research Report No. 183 (1992).

ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of
Chlorobiphenyls in Marine Media - Step 2
(7/OC/BT-2 and 1/OC/MS-2) 1990

Coordinators	:	J. de Boer (Netherlands) (for ICES), J.C. Duinker (Federal Republic of Germany) (for IOC), L. Reutergårdh (Sweden), and J.A. Calder (USA) (for JMG).
Samples	:	(a) standard solution of all CBs (in iso-octane) to be analysed; (b) seal blubber extract in iso-octane; (c) sediment extract in iso-octane; (d) internal standard solution in iso-octane; and (e) blank (iso-octane).
Analytes	:	CB Nos. 28, 31, 52, 101, 105, 118, 138, 153, 156, 180.
Participation	:	58 laboratories from 16 countries.

Results will be published in late 1994.

ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of Chlorobiphenyls in Marine Media - Step 3a (7/OC/BT-3a and 1/OC/MS-3a) 1991

Coordinator	:	J. de Boer (Netherlands).
Sample	:	Certified Reference Material CRM 349 cod liver oil (from the Community Bureau of Reference (BCR) of the European Community).
Analytes	:	CB Nos. 52, 153, 156.
Participation	:	45 laboratories from 15 countries.

Report on results to be published in late 1994.

ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of Chlorobiphenyls in Marine Media - Step 3b (7/OC/BT-3b and 1/OC/MS-3b) 1992

Coordinator	:	J. de Boer (Netherlands).
Sample	:	A cleaned and an uncleaned sediment extract; a cleaned and an uncleaned seal blubber extract; a standard solution.
Analytes	:	CB Nos. 28, 31, 52, 101, 105, 118, 138, 153, 156, 180.
Participation	:	46 laboratories from 15 countries.

Report on results to be published in late 1994.

ICES/IOC/OSPARCOM Intercomparison Programme on the Analysis of Chlorobiphenyls in Marine Media - Step 4 (7/OC/BT-4 and 1/OC/MS-4) 1993

Coordinator	:	J. de Boer (Netherlands)
Samples	:	(1) Seal oil (2) Sediment (3) Atlantic cod muscle (4) Standard solution.
Analytes	:	CB Nos. 28, 31, 52, 101, 105, 118, 138, 153, 156, 180.
Participation	:	43 laboratories from 15 countries.

Report on results in preparation.

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 (nC7-nC33), 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 (nC15-nC32) 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).

Fourth ICES Intercomparison Exercise on
Polycyclic Aromatic Hydrocarbons in Marine Media - Stage 1
(2/HC/MS) (4/HC/BT) 1988-1990

Coordinator	:	R.J. Law, United Kingdom.
Samples	:	Solutions of 10 PAHs in acetonitrile (for HPLC analysis), or solutions of 10 PAHs in hexane (for GC analysis).
Analytes	:	Phenanthrene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[e]pyrene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[ghi]perylene, and indeno[123-cd]pyrene.
Participation	:	17 laboratories from 9 countries.

Report on results will be published in early 1994.

Nutrients in Sea Water

Fourth ICES Intercomparison Exercise for Nutrients in Sea Water
(4/NU/SW) 1989

Coordinators	:	D. Kirkwood (United Kingdom), A. Aminot (France), and M. Perttilä (Finland).
Samples	:	(a) Natural oceanic water, with no preservatives or pre-treatment, (b) natural shelf sea water, filtered, bottled in glass and autoclaved, and (c) sea water depleted in nitrate and phosphate, then filtered and bottled (blanks for nitrate and phosphate).
Analytes	:	Nitrate + nitrite, phosphate, silicate, nitrite, ammonia, total nitrogen and total phosphorus.
Participation	:	68 laboratories from all 18 ICES member countries.

Report on the results published in ICES Cooperative Research Report No. 174 (1991).

Fifth ICES Intercomparison Exercise for Nutrients in Sea Water (5/NU/SW) 1993

Coordinators	:	D. Kirkwood (United Kingdom), and A. Aminot (France).
Samples	:	Six samples of sea water (three for nitrate + nitrite determinations and three for ammonium and phosphate determinations).
Analytes	:	Nitrate + nitrite, ammonium, phosphate.
Participation	:	132 laboratories from 31 countries.

Report on the results in preparation.

ANNEX 7

RECENTLY PUBLISHED RELEVANT VOLUMES OF THE ICES COOPERATIVE RESEARCH REPORTS

No.	Title
177	Report of the ICES Advisory Committee on Marine Pollution, 1991
178	A Review of Measurements of Trace Metals in Coastal and Shelf Sea Water Samples Collected by ICES and JMP Laboratories during 1985-1987
180	Review of Contaminants in Baltic Sediments
181	Effects of Harmful Algal Blooms on Mariculture and Marine Fisheries
182	Effects of Extraction of Marine Sediments on Fisheries
183	Report on the Results of the ICES/IOC/OSPARCOM Intercomparison Exercise on the Analysis of Chlorobiphenyl Congeners in Marine Media - Step 1 and the Intercomparison Study of the Determination of CBs in Baltic Herring Oil
184	Report of the Second ICES Intercomparison Exercise on the Determination of Trace Metals in Suspended Particulate Matter
186	Report on the Eighth Dialogue Meeting, 13-14 September 1991
189	ICES Seventh Round Intercalibration for Trace Metals in Biological Tissue, ICES 7/TM/BT (Part 2)
190	Report of the ICES Advisory Committee on Marine Pollution, 1992
194	Atlas of North Sea Fishes
197	Ninth ICES Dialogue Meeting – "Atlantic Salmon: A Dialogue"
198	Report of the ICES Advisory Committee on the Marine Environment
201	Patchiness in the Baltic Sea (Symposium proceedings, Mariehamn, 1991)
202	Chemicals Used in Mariculture
203	Joint Report of the ICES Advisory Committee on Fishery Management and the Advisory Commitee on the Marine Environment, 1994