

COOPERATIVE RESEARCH REPORT

NO. 172

**REPORT OF THE ICES ADVISORY COMMITTEE ON
MARINE POLLUTION, 1990**

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

The ACMP consists of a number of scientists acting - when they work as Committee members - in their personal capacity as scientists, responsible only to the Council. The membership of the Committee is such that it covers a wide range of expertise related to studies of marine pollution. The members do not act as national representatives. The 1990 membership of the Committee is found on page 1.

TABLE OF CONTENTS

Section	Page
LIST OF MEMBERS	1
OVERVIEW OF THE 1989 ACMP REPORT	2
EXECUTIVE SUMMARY	4
1. INTRODUCTION	9
2. REQUESTS FROM THE OSLO AND PARIS COMMISSIONS	10
3. REQUESTS FROM THE HELSINKI COMMISSION	15
4. NORTH SEA TASK FORCE ACTIVITIES	18
5. GUIDELINES ON REGIONAL ASSESSMENTS	21
6. MONITORING ISSUES	23
6.1 Matrix Tables for Some Contaminants of Interest to NSTF and JMP ...	23
6.2 Guidelines for Monitoring Contaminants Using Fish (JMP)	28
6.3 Guidelines for Monitoring Contaminants in Fish and Shellfish	29
6.4 Guidance for the Sampling and Analysis of Nutrients in Sea Water ..	29
6.5 Report on the Analysis of the CMP Trend Data on Contaminants in Fish Liver Tissue and <u>Mytilus edulis</u>	29
6.6 Temporal Trend Monitoring for Contaminants in Sea Water	30
6.7 Pooling of Specimens before Chemical Analysis	31
6.8 Use of Seaweeds for Monitoring Marine Contaminants	32
7. BASELINE STUDY OF TRACE METALS IN COASTAL AND SHELF SEA WATERS	33
8. BIOLOGICAL EFFECTS OF CONTAMINANTS	42
8.1 Bremerhaven Workshop	42
8.2 Leaflets on Biological Effects Techniques	43
9. BENTHOS ISSUES	44
9.1 Results of the 1986 North Sea Benthos Survey	44
9.2 Impacts on Benthos of Physical Disturbance of the Sea Bed	44
9.3 North Sea Task Force (NSTF) Monitoring Master Plan: Comments on Proposals for Benthos Studies	45
10. FISH DISEASE ISSUES	48
11. ENVIRONMENTAL IMPACTS OF MARICULTURE	49
11.1 Production Trends	49
11.2 Chemical Usage in Mariculture	49
11.3 Nutrient Inputs from Baltic Fish Farms	51
12. ALGAL BLOOMS AND RELATED ISSUES	52
12.1 Standard Method for the Measurement of Primary Production	52
12.2 Factors Responsible for the Initiation of Exceptional Algal Blooms	52
12.3 Algal Toxins and Methods for their Determination	55
13. NUTRIENT TRENDS IN THE NORTH ATLANTIC	56

Section	Page
14. INTERCOMPARISON EXERCISES AND QUALITY ASSURANCE ACTIVITIES	58
14.1 Intercomparison Exercise on the Analysis of Nutrients in Sea Water	58
14.2 Intercomparison Programme on Analyses of Polycyclic Aromatic Hydrocarbons	58
14.3 ICES/IOC/OSPARCOM Intercomparison Programme on Analyses of Chlorobiphenyls	59
14.4 Intercomparison Exercise on the Determination of Trace Metals in Suspended Particulate Matter	60
14.5 Plans for the Intercomparison of Dissolved Oxygen Measurements in Baltic Sea Water	61
14.6 Quality Assurance Aspects for the Sampling of Sea Water	62
14.7 Other Quality Assurance Activities	62
15. STUDIES OF CONTAMINANTS IN SEDIMENTS	64
15.1 Critical Review of Contaminants in Baltic Sediments	64
15.2 Development of Sediment Quality Criteria	66
16. EFFECTS OF EXTRACTION OF MARINE SEDIMENTS	67
17. STUDIES IN THE BALTIC SEA AREA	68
17.1 Working Group on the Baltic Marine Environment	68
17.2 Baltic Fish Chapter of the Second Periodic Assessment of the Baltic Marine Environment	68
17.3 Joint International Investigation of the Skagerrak (SKAGEX)	69
18. SEAL ISSUES	70
18.1 Final Report on the 1988 Seal Epidemic and its Impact on Seal Stocks	70
18.1.1 History of the Epidemic	70
18.1.2 Source of the disease	74
18.1.3 Impact of the disease on seal populations	74
18.1.4 Status of other North Sea and Baltic Seal stocks	76
18.1.5 Vulnerable populations and causes for concern	76
18.2 Relationship between Contaminant Burden and the Health of Seal Stocks	76
19. CLASSIFICATION OF SUBSTANCES IN THE CONTEXT OF THEIR HAZARDS	79
20. OVERVIEWS OF CONTAMINANTS IN THE MARINE ENVIRONMENT	81
20.1 Overview on Hexachlorobenzene and Lindane in the Marine Environment	81
20.1.1 Introduction	81
20.1.2 Hexachlorobenzene (HCB)	82
20.1.3 Lindane (γ -HCH)	84
20.1.4 The Value of Detailed Analysis of HCB and γ -HCH	85
20.1.5 References and Bibliography	85
20.2 Progress on other Overviews	99
21. GESAMP STATEMENT ON PRINCIPLES FOR THE PROTECTION AND MANAGEMENT OF THE MARINE ENVIRONMENT	100
22. AUTOMATIC DATA PROCESSING ISSUES	101

Section	Page
ANNEX 1: MONITORING ISSUES	102
ANNEX 2: AN EXAMPLE OF THE CONSEQUENCES OF APPLYING THE GUIDELINES FOR THE THREE PURPOSES OF MONITORING AT DIFFERENT SAMPLING LOCATIONS	111
ANNEX 3: FISH/SHELLFISH MONITORING GUIDELINES INCORPORATING REVISED GUIDE- LINES FOR SAMPLING AND HANDLING OF MUSSELS FOR TEMPORAL TREND MONITORING PURPOSES	115
ANNEX 4: BASIC GUIDANCE FOR THE SAMPLING AND ANALYSIS OF NUTRIENTS IN SEA WATER	121
ANNEX 5: POOLING MAY ECONOMIZE A SAMPLING PROGRAMME	126
ANNEX 6: NORWEGIAN CONTROL SYSTEM FOR DRUG USE IN FISH FARMS	135
ANNEX 7: PROTECTING AND MANAGING THE OCEANS	137
ANNEX 8: RELEVANT DOCUMENTS AVAILABLE FROM OTHER ORGANIZATIONS	143
ANNEX 9: OVERVIEW OF INTERCALIBRATION/INTERCOMPARISON EXERCISES CO- ORDINATED BY ICES	144
ANNEX 10: RECENTLY PUBLISHED RELEVANT COOPERATIVE RESEARCH REPORTS	153

REPORT OF THE ADVISORY COMMITTEE ON MARINE POLLUTION, 1990

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

OVERVIEW OF THE 1990 ACMP REPORT

The ACMP report is addressed mainly to the questions posed to ICES by the regulatory Commissions of the Helsinki, Oslo and Paris Conventions. The Executive Summary that follows this overview provides an outline of the content of the report in respect to work requested by the regulatory Commissions, under three sub-headings for the Oslo and Paris Commissions broadly corresponding with the groupings under which they record their requests, and a single sub-heading relating to the requests specifically raised by the Helsinki Commission.

The Executive Summary is followed by a more detailed report on the progress made in relation to the specific questions raised by the three Commissions. This is intended to direct the reader to the sections of the report likely to be of most interest in relation to a particular question.

It will be noted that in a number of cases the advice or information provided goes beyond that specifically requested by the Commissions. This additional material is provided, in part, simply for the sake of completing the picture so far as it is practicable at this point in time. As such, it will be of benefit to the wider audience within ICES that ACMP is also expected to advise. It is, however, hoped that the regulatory Commissions will find this material of interest, since it is directly related to the questions they have raised. Examples of such topics are issues related to algal blooms and trends in concentrations of nutrients in sea water and the advice provided on sampling and analysis for monitoring purposes, especially that related to monitoring for temporal trend assessment purposes.

In addition to providing advice in direct response to the Commissions' requests, the ACMP has also included information on a number of other issues of environmental concern. Since these are not mentioned in the Executive Summary, particular attention is drawn to them here.

Section 12.3 of the report refers to the progress being made in the development of chemical methods for the quantification of various algal toxins. It is anticipated that in many countries the routine use of rat or mouse bioassays will be restricted within the next few years. Whilst it seems likely that chemical methods will be available for the toxins presently identifiable, the detection of new toxins may cause difficulties. Attention needs to be paid to the provision of facilities for the identification of such toxins and the definition of the critical dose limit to humans. Whilst the occurrence of toxic algal blooms may not be related directly to pollution, the frequency of their occurrence may be. Thus, the imminent lack of animal testing facilities in many ICES countries, due to restrictions on the use of laboratory animals, is a matter of concern to ACMP and is drawn to the attention of Council and the Commissions.

In both the 1988 and 1989 reports of ACMP, attention has been drawn to the fact that the scale of extraction of marine sediments is increasing in several ICES countries. The material is used for beach replenishment, coastal protection, and in the construction industry. A detailed report of the possible impacts is now almost complete, as is a code of practice designed to mini-

mise the conflict of interests between the marine aggregate (e.g., sand and gravel) extraction industry and other users of the marine environment, particularly the fishing industry. An outline of the content of these two documents is provided in Section 16 of the report.

Several sections of this report deal with issues related to the collection of monitoring data and the assessment of the results of monitoring programmes and other information relevant to the state of the marine environment. The ACMP has noted that many programmes appear to be initiated with inadequate specification of detailed objectives or attention to statistical design. Similarly, where assessments are undertaken, they often do not appear to be linked to clearly defined environmental objectives or related information on inputs and/or known effect concentrations. As a consequence, undue effort appears to be deployed on routine observations and too little on research into understanding the sources, fate, and causes of observed effects. Reference to this type of concern will be found in several sections of this report, see for example Sections 4, 5, 6, and 9.

DEFINITIONS OF TERMS USED IN THIS REPORT

The following terms, used repeatedly throughout this report, are often interpreted in other documents in different ways. For the sake of clarification, in this report the terms should be interpreted as follows:

Pollution - means the introduction by Man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water and reduction of amenities.

Contamination - is used to describe the situation which exists where either the concentration of a natural substance (e.g., a metal) is clearly above normal, or the concentration of a purely man-made substance (e.g., DDT) is readily detectable, but that either no value judgement is passed as to the existence of pollution (i.e., adverse effects) or most people would agree that pollution does not occur.

Monitoring - is the repeated measurement of an activity or of a contaminant or of its effects, whether direct or indirect, in the marine environment. It may be undertaken either for compliance purposes or with the objective of establishing patterns and trends or for research purposes.

Eutrophication - sensu stricto means nutrient enrichment and ACMP uses the term in this context. However, it should be noted that a number of potential effects of eutrophication (for example, increased primary production) are often popularly referred to as "eutrophication".

A full list of acronyms, other than those for the working groups, which are given on the first page of the Executive Summary, is given on the final page of this report.

EXECUTIVE SUMMARY

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

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

At its 1990 meeting, the ACMP considered, inter alia, the most recent reports of the following ICES groups:

Marine Chemistry Working Group (MCWG)

Working Group on the Baltic Marine Environment (WGBME) and its Sub-Group on Sediments

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

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

Working Group on Biological Effects of Contaminants (WGBEC)

Working Group on Environmental Assessments and Monitoring Strategies (WGEAMS)

Working Group on Phytoplankton and the Management of their Effects (WGPME)

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

Benthos Ecology Working Group (BEWG)

Working Group on the Effects of Extraction of Marine Sediments on Fisheries

Working Group on Environmental Impacts of Mariculture (WGEIM)

Study Group on SKAGEX

Joint Meeting of the Working Group on Baltic Seals and the Study Group on the Effects of Contaminants on Marine Mammals

Working Group on Shelf Seas Oceanography

Working Group on Oceanic Hydrography

Working Group on the Assessment of Demersal Stocks in the Baltic

Working Group on the Assessment of Pelagic Stocks in the Baltic

Division IIIa Demersal Stocks Working Group

Working Group on Nephrops Stocks

Working Group on Marine Data Management.

WORK REQUESTS FROM THE OSLO AND PARIS COMMISSIONS

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

General Monitoring Issues

Work has continued under the remit of the WGSATM on a range of issues related to the assessment of temporal trends in the concentrations of contaminants in a variety of biological tissues, in particular, fish livers and mussels. A report reviewing the available data is nearing completion and should be published late in 1990. The analysis undertaken takes account of purely statistical considerations. No attempt is made to relate the findings to environmental trends or management actions, since such assessments require, *inter alia*, feed-back from the data originators, information on inputs, and insight into biological and other variability. In many cases, the time series are still quite short and further measurements according to the agreed guidelines must be maintained for the next 5 to 10 years.

The previous guidelines for the use of mussels in temporal trend studies have been revised in the light of findings from recent studies (Section 6.3 and Annex 3). The question of the use of sea water for temporal trend assessment purposes has again been reviewed and the earlier advice that this practice is generally not recommended is reconfirmed. Possible exceptions in particular circumstances are lindane (γ -HCH) and nutrients.

An ICES/IOC sea-going workshop to test the intercomparability of results from a wide variety of biological effects techniques was conducted in March 1990, based at Bremerhaven in the Federal Republic of Germany. Over 70 scientists took part, and it is clear that the Workshop achieved many of its objectives. The final results will not be available for some time, but a brief review of the preliminary findings is provided in Section 8 of this report. The Workshop confirmed the suitability of at least three of the four tests selected by the North Sea Task Force (NSTF) for use in the North Sea monitoring programme; confirmation for the fourth technique is expected when the results of the benthos studies become available. Two leaflets describing biological effects methods have been agreed and are in press. Others are expected to follow, based on the experience gained at the Bremerhaven Workshop. In the final analysis of the Bremerhaven Workshop results, the outcome will be compared with the results of previous workshops (Oslo and Bermuda), conducted with or by IOC, to provide guidance on the further development of the use of biological effects measurements in monitoring programmes.

The results of the 1985-1987 Baseline Study of Trace Metals in Coastal and Shelf Sea Waters will be published in the Cooperative Research Report series in 1991. An advance version will be made available to the Joint Monitoring Group. An outline of the results is provided in Section 7 of this report. As with previous cooperative studies in other marine media, it is apparent that not all participants followed the guidelines for sampling and

analysis. This created problems in assessing the results. The study was only intended to refer to the concentrations of dissolved metals in sea water. Despite the problems of data analysis, it is clear that land-based inputs of most metals have only a limited area of influence, i.e., can be clearly detected only in the inshore zone of lower salinity. The results are encouraging in the sense that they show that a greater than anticipated number of laboratories are capable of producing good quality data on metal concentrations in sea water. However, unless some laboratories have markedly improved the level of their performance, it is apparent that several of them will be unable to produce adequate quality data in the Commissions' proposed 1992 repeat study of metals in sea water. In the light of this fact, the NSTF studies in 1990 and 1991, and the findings of the 1985-1987 ICES Baseline Study, the Commissions may wish to reconsider the merits and certainly the scale of further monitoring of metals in sea water in 1992.

Continuing Responsibilities

In the context of analytical quality control, work continues in the conduct of intercomparison exercises. One exercise that has been completed is on analyses of nutrients in sea water. The full results of this exercise are expected to be published by early 1991, and an outline of the main findings is included in Section 14.1 of this report. The results fully justified the conduct of the exercise, and considerable feed-back has been provided to several laboratories to help them to identify and rectify errors and deficiencies in their techniques. An additional benefit is that the exercise has demonstrated the viability of a method for producing a sea water reference material for quality assurance purposes. The first phase of intercomparison exercises for determinations of polynuclear aromatic hydrocarbons (PAHs) and chlorinated biphenyls (CBs) in several marine media, and for metals in suspended particulate matter, were also completed during the course of the last year. An outline of these exercises and their results is provided in Sections 14.2, 14.3 and 14.4 of this report, along with plans for the subsequent phases of these exercises.

Work has continued on the production of overviews on chemicals of interest in a marine pollution context. An overview is provided in Section 20.1 for lindane (γ -HCH) and hexachlorobenzene (HCB). The report suggests that both compounds continue to enter the marine environment by a variety of routes and that, although neither give special cause for concern, continued regulation of their use is justified. Plans are announced for the production of several more overviews in the course of the next two years.

ICES continues to provide automatic data processing (ADP) services on behalf of the Commissions and this report notes that the demand for and scale of this effort is steadily increasing. The fact that the very considerable effort expended on data collection by member countries is not matched by the (presently low) level of effort applied to overall data interpretation is also noted as a matter requiring attention in the near future.

Specific Issues

Items that will be of particular interest to the Commissions which are covered in this report are: (a) the results of an analysis of the present guidelines for the use of marine organisms in assessing the spatial distribution and temporal trends of contaminants in the marine environment, (b) the possibility of pooling samples before chemical analysis, and (c) trends in nutrient levels and the occurrence of algal blooms.

It is confirmed that the results of analyses of samples of biota collected according to the temporal trend monitoring guidelines can be used for geographical distribution purposes. However, due to the complexity of the procedure required, this would impose a considerable additional analytical workload to a spatial distribution survey. This could only be justified if it were certain that trend monitoring would be required for the area and contaminant concerned. Tables indicating the appropriate marine matrix to sample for the analysis of voluntary NSTF contaminants are provided in response to a direct request from the NSTF and, as previously, are intended to be used in close association with the explanatory text. It must be emphasized, however, that the additional matrix tables, unlike the earlier ones, are not annotated as to the likely cost-effectiveness of the measurements. They are intended simply to indicate that, if measurements of the contaminant in question are undertaken, the most appropriate matrices within which to make measurements are those specified.

On the question of pooling, two aspects were considered: (1) the effects of pooling on the statistical interpretation of data, and (2) the potential use of pooling as a means of economizing a monitoring programme. With respect to the implications of pooled samples for the statistical analysis of data, it must again be emphasized that pooling should only be undertaken in situations where the guidelines permit it and, furthermore, that pooling strategies should be consistently applied, i.e., a sample should preferably comprise the same number of pooled sub-samples and each of these pools must contain the same number of individuals on each sampling occasion (see Section 6.7). This is often not the case at present. Concerning the economies of pooling, it is possible to employ statistical techniques during the design of a sampling programme to determine the most cost-effective sampling strategy in terms of the optimal number and size of pools which should be taken in order to ensure that the programme yields the best possible statistical information in relation to cost constraints. Annex 5 provides more detailed information.

On nutrient trends and trends in the occurrence of algal blooms that cause interference with marine activities, the report suggests that: 1) sufficient effort has been spent on the problem of looking for past nutrient trends in the North Sea and that, while an increase or decrease in anthropogenically derived input may or may not be associated with a concentration change, attention should now be focussed on acquiring good quality data for future temporal trend purposes; 2) problems associated with algal blooms are increasing in frequency; some of this increase is real, but some is probably apparent and due to increased attention and observation. High risk areas can, however, now be identified and, although it may never be possible to predict all algal bloom events, further research into the factors associated with bloom

events, e.g., weather, water stratification, nutrient concentrations, and relative nutrient ratios, is likely to improve that predictive ability. Further advice on this issue will be provided as research progresses and predictive ability improves.

WORK REQUESTS FROM THE HELSINKI COMMISSION

Brief summaries of the progress achieved in answering the questions raised by the Helsinki Commission are presented in Section 3 of this report. Progress has been made on all of the tasks allocated, and a brief outline of the nature of progress on the main topics is given below.

Work is now virtually complete on the preparation of a critical assessment of contaminants in sediments of the Baltic Sea area. This assessment was sufficiently advanced last year to allow ACMP to offer preliminary advice on the maximum frequency of monitoring. That advice is now confirmed. The full report is expected to be published late in 1990, but a brief outline of the contents and the main conclusions are provided in Section 15.1 of this report. The marked differences in data types and quality preclude detailed comparisons, but some patterns are distinguishable and the need for at least one fully coordinated study for selected contaminants is clear.

An intercomparison exercise on analyses of nutrients in sea water has been successfully completed. The need for such an exercise was indicated, in part, by experiences gained in the PEX investigation. The results, which will be published by early 1991, fully justify the conduct of the exercise. Considerable feed-back has been provided to several laboratories to help them to identify and rectify errors and deficiencies in their techniques. An additional benefit is that the exercise has demonstrated the viability of a method for producing a sea water reference material for quality assurance purposes. Advice has been provided on a method for conducting an intercomparison exercise for the determination of oxygen in sea water, and it is understood that this is being used at a Biological Intercalibration Workshop in Visby, Sweden in August 1990.

It is not yet possible to provide quantitative information on the conditions which cause unusual algal blooms in the Baltic Sea area, and such information is unlikely to be available in the near future. It is, however, clear from the many data sets available that inputs of nutrients and their concentrations in sea water have increased in the Baltic Sea area. Additional inputs of nutrients are likely to give rise to more sustained algal production. The available evidence suggests that blooms of algae which cause interference with other uses of the marine environment are increasing in frequency, and it is now possible to identify high risk areas. While it may never be possible to predict all algal bloom events, further research into the factors associated with bloom events, e.g., weather, water stratification, and nutrient concentrations and relative ratios, is likely to improve that predictive ability. Further advice will be provided on this issue as it becomes available.

1 INTRODUCTION

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

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

2 REQUESTS FROM THE OSLO AND PARIS COMMISSIONS

A summary of the progress in the 1990 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 only limited or no progress has been possible, a brief statement is given as to when a response can be expected.

(A) Work which is expected to be undertaken by ICES and reported on in the ACMP Report for 1990.

A1 to report on progress made with the intercomparison exercise for nutrients in sea water and, if possible, provide a preliminary report of the results;

This exercise has now been completed and the results should be published in full by early 1991. A preliminary report on the results is given in Section 14.1 of this report. Those laboratories which experienced difficulties in analysing one or more of the nutrients involved have been provided with advice on how to improve their analytical techniques.

A2 to report on aspects of trend monitoring related to contaminants in sea water;

The ACMP has previously advised on this issue in some detail in its 1989 and earlier reports. The position remains essentially unchanged (see Section 6.6). The analysis of sea water cannot generally be recommended for the purpose of monitoring temporal trends in contaminant concentrations in the marine environment; the only possible exceptions to this are nutrients and, in some situations, lindane (γ -HCH).

A3 to provide advice by means of matrix tables on how most effectively to monitor each contaminant of interest for purposes (c) and (d) as defined by the Commissions;

The detailed advice necessary to meet this request was provided in the 1989 ACMP report. Supplementary matrix tables with respect to the voluntary determinands selected by the North Sea Task Force are provided in Section 6.1 of this report. They cover purposes (a), (c), and (d) of the Commissions' monitoring requirements. However, it must be stressed that, unlike the tables provided with the 1989 report, no attention has been paid to the likely need for, or value of, monitoring these determinands, particularly for purposes (a) and (d), but also on a repeat basis for purpose (c).

A4 to provide revised guidelines for the sampling and analysis of biota for purposes (a), (c), and (d) as defined by the Commissions taking account of the desirability of having a sampling strategy for purposes (c) and (d) that would allow use of only one set of samples;

Advice on this issue is contained in Sections 6.2 and 6.3 of this report. The guidelines for the use of mussels for trend monitoring purposes have been improved. Appropriate revised guidelines are included as Annex 3. Consideration of the present guidelines for fish shows that samples collected for purpose (d) can be used

for purpose (c), but the extra work this entails would only be justified if the subsequent need for purpose (d) work on that determinand at that site is assured.

- A5 to prepare proposals for the 2nd and 3rd phases of the inter-comparison exercise on CBs aimed specifically at CBs in sediments;

Phase 1 of this exercise is now complete and the results are being published. Detailed plans have been drawn up for the conduct of the second, third and fourth phases (see Section 14.3 of this report). Steps have been taken to allow new participants, or participants who failed to achieve adequate performance in phase 1, to join the exercise at phase 2.

- (B) Work which is essentially of a continuing nature and on which it is expected that ICES will submit a progress report in 1990.

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

During the past year, four intercomparison exercises have been carried out:

- 1) An intercomparison exercise on the analysis of nutrients in sea water; this is mentioned under Question A1 (see also Section 14.1).
 - 2) Phase 1 of an intercomparison programme for the determination of PAHs. Section 14.2 provides an outline of the results of this phase and plans for the second phase, which will be directed towards the analysis of PAHs in sediments. A full report on the results of this first phase of the PAH exercise is being prepared for publication in the Cooperative Research Report series.
 - 3) Phase 1 of the ICES/IOC/OSPARCOM intercomparison programme on the determination of chlorobiphenyls (CBs) (see also Question A5); Section 14.3 of this report provides an outline of the results of this exercise. A report on this exercise is expected to be published in the Cooperative Research Report series by early 1991.
 - 4) Phase 1 of an intercomparison programme for the analysis of trace metals in suspended particulate matter and the quantitative determination of suspended particulate matter in sea water. Section 14.4 provides details of the progress in this programme, Phase 1 of which is now complete. Section 14.4 also provides an outline of the plans for further work on suspended particulate matter, which requires advice from the Commissions as to their requirements in this regard.
- B2 To provide copies of relevant descriptions of methods of sampling and analysis as published in the Techniques in Marine Environmental Sciences series;

The titles of the volumes so far published in this series are given below. Copies of each have been provided to the OSPARCOM Secretariat.

- No. 1 - Cadmium and lead: Determination in organic matrices with electrothermal furnace atomic absorption spectrophotometry
- No. 2 - Trace metals in sea water: Sampling and storage methods
- No. 3 - Cadmium in marine sediments: Determination by graphite furnace atomic absorption spectroscopy
- No. 4 - Lipophilic organic material: An apparatus for extracting solids used for their concentration from sea water
- No. 5 - Primary production: Guidelines for measurement by ^{14}C incorporation
- No. 6 - Quality control procedures: Good laboratory practice and quality control

The following leaflets are being published in mid-1990:

- No. 7 - Suspended particulate matter: Collection methods for gravimetric and trace metal analysis
- No. 8 - Soft bottom macrofauna: Collection and treatment of samples
- No. 9 - Sediments and suspended particulate matter: Total and partial methods of digestion (with a videotape)
- No. 10 - Organic halogens: Determination in marine media of adsorbable, volatile, or extractable compound totals

The following leaflets are under preparation, with publication expected prior to the 1991 meeting of ACMP. The titles given are working titles only.

- Determination of some organochlorine compounds in biological material
- Determination of organic and total tin in sea water by extraction and graphite furnace atomic absorption spectroscopy
- An introduction to the study of temporal and spatial trends in contaminant levels in the marine environment, in particular, marine biota
- Oyster embryo bioassay
- Measurements of ethoxyresorufin-O-deethylase (EROD).

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

Section 22 of the report gives a brief resumé of the position regarding automatic data processing (ADP) handling of the JMP data. Some improvements have followed last year's appeal for data to be submitted according to agreed formats and deadlines. Actual data handling and processing proceeds smoothly, but more attention needs to be given to data interpretation by data users.

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

Section 20.1 of this report contains an overview on lindane (γ -HCH) and hexachlorobenzene. The material provided is intended to supplement that published elsewhere in earlier reviews, but it does cover briefly all the main topics of interest with recent information. Plans for the production of future overviews are announced in Section 20.2 of the report.

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

This work is continuing on a routine basis and Section 10 of this report provides details of the current position. A more complete report can be expected when experimental studies in the Netherlands, the United Kingdom and elsewhere are completed and reported to the Working Group on Pathology and Diseases of Marine Organisms.

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

Information on this topic was provided in Section 17 of the 1986 ACMP Report (Coop. Res. Rep., No.142); it is expected that an update on the available information will be provided in the 1991 ACMP report. Several ICES working groups are addressing this question, but at this stage it seems unlikely that much new information is available and the advice is likely to be on the nature of research work required to improve the understanding on this issue. In view of this fact, ICES intends to establish a study group to conduct a comprehensive review of knowledge, and gaps in knowledge, and to recommend the best approaches for research investigations.

(C) Special topics on which it is expected that ICES will carry out an in-depth study.

No such tasks are currently outstanding.

(D) Work already underway on which it is expected that ICES will report in the ACMP report of 1989.

- D1 to report on the experience gained from trend monitoring studies, including the results of studies using organs other than fish muscles and liver, and including cases where fish tissues or shellfish have been pooled prior to analysis;

Results of work relating to fish muscle were published in Cooperative Research Report No. 162 in 1989. The available data on contaminants in fish livers and in mussels have recently been assessed from a statistical standpoint; this assessment will be published in a Cooperative Research Report within the next year. Some trends are apparent, but interpretation of their significance will depend on information not available to the members of the Working Group on the Statistical Aspects of Trend Monitoring responsible for the statistical analysis of the data. What is apparent, however, is that data should continue to be collected and with stricter adherence to the agreed guidelines.

- D2 to report on all aspects of trend monitoring related to sediments; to supply advice on the value and the use of normalization methods for interpreting contaminant levels in sediments, including dredged materials;

Advice on this question was provided in the 1989 Report of ACMP (Coop. Res. Rep., No. 167). The guidance and information provided previously needs to be studied carefully, as it appears to be widely misinterpreted in relation to earlier guidelines.

- D3 to provide examples of case studies of monitoring the composition of benthic communities illustrating the use of the guidelines provided in the 1988 report;

These examples were provided in Annex 1 of the 1989 Report of ACMP.

- D4 to review evidence of trends in nutrient concentrations in sea water by examining data sets already available to ICES including those provided by the Netherlands and France;

It is apparent that the quality of nutrient data and the frequency and timing of measurements in the North Sea are such that further attempts to identify trends in past data will be unlikely to provide unequivocal results (see Section 13). Apparent trends can be found in data sets for coastal waters of the southeastern North Sea. Attention now needs to be paid to the collection of good quality data over the coming years to assess the impact of measures taken to reduce nutrient inputs.

- D5 to review the proposals (made by the Netherlands in paper JMG 14/Info.17) for quality assurance of metals in sea water analyses in time for any amendments to be incorporated for use in the 1992 baseline survey.

Work on this task is well underway and a number of amendments to the proposal have been suggested. These will be completed before ACMP meets in 1991 and will be provided directly to the Commissions in time for them to be adopted for the 1992 survey (see, however, the response to Question A2 and Section 6.6 of this report).

3 REQUESTS FROM THE HELSINKI COMMISSION

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

Continuing responsibilities

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

Work has continued on this subject, with particular reference to the influence contaminants might have had in the 1988 outbreak of disease among seals. Section 18 of this report provides a summary of the impact the disease outbreak has had on stocks generally and describes the present position in relation to contaminants. The only populations of seals in Northern Europe presently considered to be vulnerable are those in the Baltic Sea. It should be noted, however, that the estimate of the total stock of Baltic grey seals has recently been raised from 2000 seals to between 2500 and 3000, following the submission of new data from Soviet scientists.

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

This report includes an overview on hexachlorobenzene and lindane (γ -HCH) (Section 20.1). The ACMP is continuing to promote the production of these types of overviews, and it is anticipated that in future years they will cover a mixture of the traditional and "new" contaminants.

Special studies

3. To conduct a specific assessment of contaminants in sediments and prepare guidelines for the conduct of "repeat extensive baseline studies" of contaminants in sediments;

Section 15.1 of the report provides an outline of the main findings of a critical review of contaminants in Baltic sediments. The full report is expected to be published late in 1990 in the Cooperative Research Report series. The review clearly shows that a properly designed coordinated baseline survey of contaminants in sediments is justified and should be conducted in 1993, but that such surveys should not be undertaken with a frequency of more than once every 5 years. A steering group will be established to develop the detailed plans for this survey and these will be passed on in a future report of ACMP.

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

This information has previously been adopted for publication in the form of a leaflet in the Techniques in Marine Environmental Sciences series entitled "Suspended particulate matter: Collection methods for gravimetric and trace metal analysis". This is

being published in mid-1990. The first phase of an intercomparison exercise on analysis of metals in suspended matter has just been completed and plans are underway for follow-up exercises (see Section 14.4 of this report).

5. To study the problem of the intercomparability of nutrient analyses and coordinate intercalibration exercises on analyses of nutrients and oxygen;

The PEX experiment in 1986 suggested that there was a need for an intercomparison exercise on the analysis of nutrients in sea water. Such an exercise was conducted in 1989, with the participation of 22 laboratories from the Baltic Sea area. Section 14.1 of this report outlines the main findings. The exercise confirmed that a number of laboratories needed to improve their techniques for one or more of the nutrients. Considerable feed-back has been provided to those laboratories.

Advice from ACMP on a method for conducting an intercomparison exercise for the determination of oxygen in sea water was passed directly to relevant scientists in the Baltic Sea area in 1989. Further advice was developed at the 1990 ACMP meeting and will be conveyed directly to the organizers for use in an intercomparison exercise being conducted as part of the Biological Intercalibration Workshop being held in Visby in August 1990.

6. To provide information on progress in the intercomparison work on determinations of specific hydrocarbons in marine samples;

The first phase of an intercomparison exercise for the determination of specific polynuclear aromatic hydrocarbons (PAHs) was completed in 1989. Section 14.2 of this report provides an outline of the results and plans for the second phase, which will be directed towards the determination of PAHs in marine sediments.

7. To provide in 1991 as detailed information as possible on the environmental impact of mariculture in the Baltic Sea area, including amounts and impacts of nutrients and organic matter;

Information on this topic relating to the scale of inputs of nutrients via the mariculture industry relative to other sources was provided in the 1989 report of ACMP (Coop. Res. Rep., No. 167). It is intended to provide a comprehensive update of this information in 1992, by which time the appropriate ICES working group will have been able to collect and assess data from most, if not all, of the Baltic Sea countries. In the interim, if the Helsinki Commission requires information, it should be possible to obtain an estimate of inputs by gathering data on the number and scale of mariculture units and to calculate the inputs of nutrients in the same way as used by ACMP in its 1989 report.

8. To provide information on as quantitative a basis as possible on conditions (physical, chemical, and biological) relevant to the potential development of unusual algal blooms in the Baltic Sea area;

Information on this subject is provided in Section 12.2 of this report. Whilst it is now possible to predict areas of high risk and it is apparent that elevated levels of nutrients are implicated in some bloom incidents, it will probably never be possible to predict all bloom events with complete certainty. However, investigation of the factors involved in future incidents will certainly improve predictive capability.

9. To develop a general scheme for identification of chemical substances that might be of concern to the marine environment based on toxicity, chemical properties, etc., and provide guidance for its use relevant to the Baltic Sea.

This topic is currently being examined by a number of ICES working groups, and Section 19 presents some initial advice from ACMP on this issue.

4 NORTH SEA TASK FORCE ACTIVITIES

The Ministerial Declaration of the Second International Conference on the Protection of the North Sea (London, November 1987) endorsed greater harmonization of methods of monitoring, modelling and assessment of conditions in the North Sea. The Declaration also noted that, although a great deal is known about the North Sea, there are still serious shortcomings in the data on the distribution of contaminants. Accordingly, the Declaration requested the development of a coordinated scientific programme for the North Sea to permit links between contaminant inputs, and their concentrations and effects, to be established with greater confidence. This programme is to be conducted under the North Sea Task Force, established by ICES and the Oslo and Paris Commissions in response to a request in this Ministerial Declaration.

The North Sea Task Force (NSTF) found that the existing network of monitoring stations, established under the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions, was inadequate for the purposes of the North Sea Conference process because the JMP does not:

- i) cover all the areas of the North Sea which may be contaminated (e.g., the Skagerrak, northern North Sea, etc.);
- ii) include any offshore North Sea monitoring stations;
- iii) have sufficient breadth of coverage to provide a "snapshot" picture of the spatial distribution of contaminants across the whole of the North Sea; and
- iv) include all the contaminants of interest in a baseline survey context.

For these reasons, it was considered that special measures should be implemented for the North Sea to rectify the shortcomings. The result was the formulation of a NSTF Monitoring Master Plan which, in essence, builds on monitoring carried out under the JMP but overcomes the inadequacies identified above.

The objective of the NSTF Monitoring Master Plan (MMP) is:

"to develop an adequate depth of coverage of data which will provide all the necessary information that is required to assess the condition of the North Sea, and provide a basis for a future programme which will permit an assessment of trends in physical, chemical and biological parameters."

The NSTF Monitoring Master Plan also states:

"In the short term, the monitoring data will be used as a major source of information for the preparation of a new assessment of the North Sea to be included in the Quality Status Report in 1993. The data will be acquired through the conduct of an expanded programme of field measurements to be made during 1990 and 1991. This programme of measurements will aim to fill the gaps in knowledge of the spatial distribution of nutrients and contaminants in the North Sea, especially the open North Sea, and the effects of these substances on its biological status."

The ACMP took note of the outcome of the third and fourth meetings of the North Sea Task Force and the development of the North Sea Monitoring Master Plan on which future monitoring observations throughout the North Sea area would be based. In relation to this Monitoring Master Plan, the ACMP notes that its earlier expressions of concern as to the scale of effort to be deployed on both novel and traditional contaminants have, to some extent, been accommodated in the final version of the Plan. It also notes that in the final Plan it is much more clearly apparent that supplementary measurements will be required, if the results of work in 1990 and 1991 are to be capable of complete interpretation, and that existing suitable data can be used. With regard to future work, it is also clear that decisions as to which sites should be monitored and for which parameters (substances, effects) in a temporal trend context will only be taken in the light of evaluations, in 1993, of the results of the 1990/1991 surveys.

However, whilst the ACMP recognizes that the ICES guidance on monitoring strategies was adopted by the NSTF, it considers that explicit justification for the inclusion of the various determinands in the Monitoring Master Plan would have been advantageous. As the final Plan stands, scientists outside the North Sea Task Force cannot readily discern the rationale. Consequently, there are concerns that similar plans may be imposed over a wider area without proper justification.

Based on its own previous experience of reviewing results from earlier cooperative studies, the ACMP wishes to stress the importance of all participants in the NSTF monitoring programme following the agreed guidelines for the plan. Furthermore, the importance of following sound procedures for establishing good internal analytical and biological quality assurance cannot be over-emphasized. This is especially important as not all the interlaboratory quality assurance procedures will be in place during the programme.

In relation to the preparation of the North Sea Regional Assessment Report (Quality Status Report), the ACMP noted with concern that the fourth meeting of the NSTF had discussed the adoption of a format totally different from that recommended by ICES and previously agreed by the NSTF. The reasons for this proposal were considered and were concluded to be based on a misconception of

the ICES advice and intent. It was agreed that almost all the topics identified by the alternative proposal could readily be accommodated within the anticipated structure of a report written according to the ICES guidelines. Advice on how this could be achieved was prepared for direct transmission to the next meeting of the NSTF. This is summarized briefly in Section 5, below.

The ACMP considers that, once the various sub-regional reports have been prepared, there is a real role for the relevant ICES working groups as well as the ACMP in screening the scientific content of the sub-regional reports, and reviewing the compilation of this scientific information in the disciplinary sections of the holistic North Sea assessment document and the ultimate multi-disciplinary distillation of this information in the overall assessment section. The proposed timetables for the preparation and completion of the various reports should allow this screening to take place. The ACMP further considers that, as it is clearly intended that the holistic North Sea assessment document (Quality Status Report) should form a basis for decisions at the next Conference of North Sea Ministers in 1995, it is important that an additional Part B of the assessment document (see Section 5, below) also be prepared, which discusses the need for action and the type of action required in the light of the findings of the assessment. This will allow the Ministers to take decisions in the light of considered scientific and technical advice as to the significance of the findings. Such advice will serve to minimize action based on perceptions of problem issues and their solutions, which may result in the expenditure of resources on wide-ranging control measures, when what is really required is targeted control, monitoring and research.

5 GUIDELINES ON REGIONAL ASSESSMENTS

In its 1988 report (Section 20, ICES, 1989), the ACMP formulated guidelines for the preparation of regional environmental assessments. The intention of the guidelines was to enhance the presentation of relevant, objective scientific information, with a minimum of value judgements, for the use of responsible managers. The structure of the assessments was designed to facilitate the comparison and collation of information from several individual regional assessments to cover wider geographical areas.

Several reports have recently been published that broadly may be classified as regional assessments. Two in particular have attracted considerable attention: "The Gulf of Maine: Sustaining Our Common Heritage", prepared by three U.S. States and two Canadian Provinces, and the Nordic Council report "Northern Europe's Seas, Northern Europe's Environment". Both of these regional assessments have as their main target audiences senior policy makers and the general public. These reports are very readable, but both also contain many value judgements not strictly based on scientific principles.

The ACMP has considered its position with regard to regional assessment reports which are designed to be broader in scope than those covered by the basic format recommended by the ACMP in its 1988 report. In particular, the ACMP acknowledges that the North Sea Quality Status Report (QSR), to be prepared in 1993 by the North Sea Task Force (NSTF) for the Ministerial Conference in 1995, will be required to include additional elements not specifically covered by the ICES regional assessment report format.

While recognizing the special purposes of the North Sea Quality Status Report, the ACMP nevertheless recommends that the basic structure of the ICES format, whereby the physical, chemical and biological conditions and anthropogenic impacts are treated separately, should be retained. This can readily be accomplished under a series of revised headings which allow for the inclusion of other important topics, such as socio-economic factors, coastal development and physical modifications to the sea bed. An example of an expanded format that caters to these needs is given below.

The ACMP recognizes that there are additional issues which North Sea Ministers will wish to consider, but which would not be appropriate to include in a purely factual regional assessment of the type described above. Accordingly, the ACMP suggests that a second part to the document be prepared, either as an additional Part B or as a separate document. This could cover such issues as recommendations for the future development of the region, management policies, control actions, social and political considerations, etc.

An example of an expanded Regional Environmental Assessment Format is given below. Reference should also be made to the relevant commentary in ICES (1989).

Part A

1. Executive Summary
2. General description of the area
 - 2.1 Physical geography
 - 2.2 Demography
 - 2.3 Socio-economic value
3. Physical conditions
 - 3.1 Physical oceanography and general circulation
 - 3.2 Anthropogenic modifications to coasts, sea-bottom and physical hydrography
4. Marine chemistry
 - 4.1 Qualitative and quantitative aspects
 - 4.2 Contamination profile
5. Marine biology
 - 5.1 Description of major features, including fisheries
 - 5.2 Impacts of anthropogenic activity on marine life
6. Overall assessment

Multi-disciplinary analysis and interpretation of the previous chapters, including, where possible, identification of effects and probable causes

Part B (Optional)

On the basis of the overall assessment in Part A, indicate as appropriate:

- Management options for the region, or particular sub-regions thereof
- Potential control actions
- Recommendations for future development of the region
- Social and political considerations
- Other relevant policy or management considerations.

---ooOoo---

Reference

- ICES, 1989. Report of the ICES Advisory Committee on Marine Pollution, 1988. ICES Cooperative Research Report No. 160, pp. 96-102.

6 MONITORING ISSUES

6.1 Matrix Tables for Some Contaminants of Interest to NSTF and JMP

In response to a specific request from the North Sea Task Force, the ACMP prepared a matrix table based on the report of the Working Group on Environmental Assessments and Monitoring Strategies (WGEAMS), which had used information from the Marine Chemistry Working Group (MCWG). This matrix table (Table 6.1, below) is intended to replace the corresponding table in the NSTF Monitoring Master Plan (MMP) which was subject to confirmation by ICES. It is again stressed that this table must not be considered outside the context of the accompanying text given in Annex 6 of the MMP (Section 6.1 of the 1989 ACMP report, reproduced here as Annex 1) concerning the way the matrices have been selected and the limitations appropriate to their use. The advice given in this matrix table should not be taken as favouring the discontinuation of existing monitoring programmes that are yielding useful information, even if they do not wholly match the selections advocated here.

The matrix table provided here to the NSTF is only suitable for monitoring for the purpose of determining the geographical distribution of contaminants (Purpose (c) of JMP), to which the MMP is initially being directed. However, the ACMP felt that it would be useful to provide to the Commissions the tables dealing with the same suite of contaminants (Tables 6.2 and 6.3, below) for the purposes of human health risk monitoring (Purpose (a) of JMP) and temporal trend monitoring (Purpose (d) of JMP). Obviously, the caveat expressed above must be applied to these two additional tables. In providing these tables, the ACMP has not addressed the question of whether these contaminants should be included in monitoring programmes.

The following details provide clarification of the contaminants included in the tables:

- Chlordanes: Cis-chlordane, trans-nonachlor, trans-chlordane, oxychlordane.
- Planar chlorobiphenyls: CBs-77, 126, and 169.
- DDT: Only the laterally (p,p') substituted forms of DDE, DDD (=TDE), and DDT.
- Polychlorinated dibenzodioxins and dibenzofurans (PCDD/PCDF): All seventeen 2,3,7,8-chlorinated dibenzodioxins and dibenzofurans.
- Drins: Covers the group dieldrin, aldrin, endrin, telodrin, and isodrin. Aldrin is rapidly converted to dieldrin and the other compounds are rarely used; thus, in practice, only dieldrin is likely to be found.

- Polycyclic aromatic hydrocarbons: PAHs selected: Naphthalene and Cl-, C2- and C3-alkyl derivatives; Phenanthrene and Cl- and C2-alkyl derivatives; Anthracene; Dibenzothiophene and Cl- and C2-alkyl derivatives; Fluoranthene; Pyrene; Benz[a]anthracene; Chrysene (+ triphenylene); Benzo[fluoranthene]; Benzo[e]pyrene, Benzo[a]pyrene; Perylene; Benzo[ghi]perylene; Indeno[1,2,3-cd]-pyrene and Dibenz[ah]anthracene.
- Polychlorinated camphenes (PCC): For quantification purposes, it has to be borne in mind that this extremely complex mixture can only be quantified on the basis of technical mixture equivalents (e.g., toxaphene).
- Triazines: Simazine and Atrazine are the major compounds of importance.
- Polybrominated diphenyl ethers (PBDE): 2,4,2',4'-tetrabromodiphenylether and 2,4,5,2',4'-pentabromodiphenylether as representatives of the brominated fire retardants.

Table 6.1 Recommended matrices for voluntary contaminants within the framework of NSTF in order to assess the geographical distribution of these contaminants.

Matrix	Contaminant											
	TBT	MeHg	Chlor- dane	Planar CBs	DDT	PCDD/ PCDF	Drins	PAH	PCC	Tri- azines	PBDE	PBB
Nearshore water	S ¹									P		
Offshore water										P ⁵		
Surficial sediments ²	P	P	P	P	P	P	P	P	P		P	P
Shellfish	P	P	S ³	S ³	S ³	S ³	S ³	S ³	S ³		S ³	S ³
Fish muscle		S ⁴										
Fish liver		S ⁴	S ⁴	S ⁴	S ⁴	S ⁴	S ⁴		S ⁴		S ⁴	S ⁴

P: primary matrix.

S: secondary matrix.

Notes and Qualifications:

¹ Potential addition/alternative to sediment measurements in areas where sediment conditions are not wholly favourable.

² Should be accompanied by total organic carbon measurements, size fractionation (<63 µm), and description of the sediment type. Sampling should be carried out following current ICES guidelines.

³ Could be carried out on an opportunistic basis; may provide additional information on distribution.

⁴ Sedentary species only (e.g., flatfish).

⁵ Only if observations in the nearshore zone identify presence at, or approaching, likely effect levels.

Table 6.2 Recommended matrices for those contaminants adopted as voluntary determinands by the NSTF should it be considered desirable to assess possible hazards to human health.

Matrix	Contaminant											
	MeHg	TBT ²	Chlor- dane ²	Planar CBs	DDT ²	PCDD/ PCDF	Drins	PAH	PCC	Tri- azines ²	PBDE ³	PBB ²
Shellfish	P	P		P		P	P	P	P			P
Fish muscle	P											
Fish liver				S ¹		S ¹	S ¹		S ¹			S ¹

P: primary matrix.

S: secondary matrix.

Notes and Qualifications:

¹ If fish liver is not a consumed fisheries product and there remain human health concerns, transfer attention to fish muscle.

² These contaminants are not currently of concern in respect to the consumption of fisheries products in the North Sea area.

³ Too little is known about the toxicity to assess potential hazard.

Table 6.3 Recommended matrices for those contaminants adopted as voluntary determinands by the NSTF should it be considered desirable to assess temporal trends.

Matrix	Contaminant										
	TBT	MeHg	Chlor- dane	Planar CBs	DDT	PCDD/ PCDF	Drins	PAH	PCC ³	Tri- azines	PBDE PBB
Water	P									P	
Sediment profiles ²			P	P	P	P	P				P P
Shellfish	P	P						P			
Fish muscle		P ¹									
Fish liver			P ¹	P ¹	P ¹	P ¹	P ¹				P ¹ P ¹

P: primary matrix.

Notes and Qualifications:

¹ Considerable care has to be taken with species selection and availability, sampling protocol, and statistical aspects of data analysis. Sedentary species should be selected.

² Care should be taken in selecting favourable areas of high sedimentation rate and limited bioturbation, following the latest ICES guidelines for monitoring contaminants in sediments, including organic carbon measurements and appropriate normalisation procedures. Care should be taken to avoid vertical mixing during the sampling and sub-sampling of sediment cores.

³ No recommendation can yet be made.

6.2 Guidelines for Monitoring Contaminants Using Fish (JMP)

With respect to a request from the Oslo and Paris Commissions, the Working Group on Statistical Aspects of Trend Monitoring (WGSATM) had discussed the possibility of streamlining the existing guidelines such that one sampling scheme can be used for all purposes of monitoring.

The clear conclusion of this work was that, given certain practical considerations, no single sampling scheme based on a streamlining of existing guidelines could meet all the currently defined purposes of monitoring.

However, after examining the present guidelines, the WGSATM did identify certain instances where samples taken for one particular purpose might be appropriate for use under another purpose. In order to facilitate the understanding of their conclusions, the WGSATM prepared a very simple example, included as Annex 2 to this report, to highlight how the application of different guidelines can lead to different interpretations.

The main conclusions concerning the present guidelines are the following:

1. A sample obtained for purpose (a) (human health risk) can be used for purpose (c) (geographical distribution), and vice versa, if the fish tissues used in the pooling are the same under both purposes, and information on the moisture and lipid content of the pooled tissues is available.
2. A sample obtained for purpose (d) (temporal trend) may be applicable to purpose (c) and, subject to the same constraints listed above, to purpose (a).
3. A sample of finfish obtained for purpose (c) cannot be used under any conditions or for any species/parameters for purpose (d). This is because the information obtained using pooled samples of fish is not adequate for trend analysis, which requires a good understanding of the fish stock studied, the use of length-stratified fish samples, and biological characterization and chemical analysis of individual fish.
4. The identification of contaminants for which length-stratified sampling is or is not required cannot yet be done in an unambiguous way. In the past, length-stratified sampling has not always been adhered to by all participants in the monitoring programme; consequently, samples analysed to date for temporal trends have not yielded results which are consistent with regard to the effectiveness of length as a covariate in influencing contaminant concentrations.

On the basis of advice from the WGSATM, the ACMP draws attention to the need to avoid confusion between (i) the use of samples collected under one monitoring purpose for another monitoring purpose (possible under certain conditions, see above) and (ii) the development of a single set of sampling guidelines to cover several monitoring purposes. The development of a single set of sampling guidelines to cover several monitoring purposes is theoretically possible, but generally not recommended. However, if, for example, the guidelines were revised to a common length-stratified sampling procedure with individual fish analysis, this

would be very costly in terms of supplying adequate spatial coverage. In addition, the guidelines for purposes (a) and (c) include the sampling of species which are not appropriate to temporal trend studies (e.g., herring, shrimp).

Nevertheless, it appears that there may be opportunity for improving sampling for monitoring the spatial distribution of contaminants (purpose (c)) and using the results of this improved sampling for obtaining temporal trend estimates (purpose (d)). The WGSATM will continue to work intersessionally on revisions to the present general guidelines, including statements on the need to use species-specific guidelines and to maintain the integrity of the sampling programmes implemented.

Concerning the present temporal trend monitoring programmes, the ACMP endorses the WGSATM advice that the length-stratified sampling technique be continued, along with the need to maintain annual sampling consistency, and that existing trend monitoring programmes be continued under the present guidelines to provide long time-series of comparable data.

6.3 Guidelines for Monitoring Contaminants in Fish and Shellfish

The ACMP reviewed and accepted, with minor modifications, a revised set of guidelines prepared by the WGSATM for the monitoring of contaminants in biota (fish and shellfish) within the context of the Cooperative ICES Monitoring Studies Programme (CMP). These guidelines, included as Annex 3, have been modified specifically in relation to the use of blue mussels (*Mytilus edulis*) in temporal trend monitoring programmes. No changes have been made in relation to the guidelines concerning the use of fish in the monitoring programme; these sections of the guidelines are still under review. To aid in identification of those sections of the existing guidelines where changes have been made, they are marked with a continuous vertical line in the right-hand margin.

6.4 Guidance for the Sampling and Analysis of Nutrients in Sea Water

The ACMP reviewed the draft guidelines for the sampling and analysis of nutrients in sea water, that had been prepared by the Marine Chemistry Working Group. The ACMP accepted an amended version of this paper, as contained in Annex 4.

The ACMP would be interested to learn from the Oslo and Paris Commissions whether this basic guidance meets their requirements.

6.5 Report on the Analysis of the CMP Trend Data on Contaminants in Fish Liver Tissue and *Mytilus edulis*

The ACMP took note of a draft report on the statistical analyses of the Cooperative ICES Monitoring Studies Programme (CMP) data on contaminants in fish liver tissue and blue mussels (*Mytilus edulis*) for the determination of temporal trends, that had been prepared by the Working Group on Statistical Aspects of Trend Monitoring (WGSATM). The report represents a complementary volume to a previously published report concerning analyses of data on contaminants in fish muscle tissue (ICES, 1989).

This report details the results of nearly 250 separate statistical analyses of contaminant levels covering 38 different species-area combinations. Mytilus edulis data from 14 areas are considered and fish liver data are considered for one or more of the following species: cod, dab, flounder, herring, plaice and whiting, from 24 different areas. The results include the analysis of data on 16 contaminants: trace metals (cadmium, chromium, copper, mercury, nickel, lead, and zinc) and organochlorines (Dieldrin; p,p'-DDE; p,p'-DDT; p,p'-TDE; hexachlorobenzene; α - and γ -hexachlorocyclohexane; and polychlorinated biphenyls as PCBs on a formulation basis and as the individual chlorobiphenyl congener no. 153). These data comprise CMP data sets reported by eight countries (Belgium, Denmark, the Federal Republic of Germany, France, the Netherlands, Norway, Sweden, and the United Kingdom) covering the period 1978-1988.

The report describes a statistical analysis of the data which produces yearly-mean contaminant concentration estimates based on geometric mean contaminant levels, and includes tests of significance to investigate possible trends. As with the previously published report on the analysis of the fish muscle tissue data, this report attempts only a statistical evaluation of the data; the ACMP was informed that the final document would be considered by the ad hoc Working Group on Monitoring under the Oslo and Paris Commissions, which will be addressing the wider interpretation of trend monitoring data sets in the context of trends in environmental contaminant levels.

The ACMP agreed that this report should, in principle, be adopted for publication as an ICES Cooperative Research Report, subject to review of a final version of the report by individual members of ACMP prior to the 1990 Statutory Meeting.

Reference

ICES, 1989. Statistical Analysis of the ICES Cooperative Monitoring Programme data on contaminants in fish muscle tissue (1978-1985) for determination of temporal trends. ICES Cooperative Research Report No. 162.

6.6 Temporal Trend Monitoring for Contaminants in Sea Water

With respect to the request from the Oslo and Paris Commissions to report on aspects of trend monitoring related to contaminants in sea water, the ACMP maintains its view that, with the exception of measurements of lindane and nutrients for assessing temporal trends in relation to increased regulatory controls, the use of sea water as a matrix for temporal trend determination is not recommended. This reflects the considerable natural variability in sea water composition, both over time and space, and the associated difficulty of achieving a satisfactory signal-to-noise ratio for temporal trends based on reasonable measurement frequencies.

6.7 Pooling of Specimens before Chemical Analysis

Effects of pooling

In relation to studies of pooling specimens before chemical analysis, the ACMP reviewed the results of work conducted under the WGSATM on the effects of pooling on the statistics of trend determination. For samples of some species taken for some monitoring purposes, it may be appropriate to pool material from a number of animals before chemical analysis. This can aid in the development of a cost-effective sampling programme, but it can lead to systematic biases from year to year unless it is carried out in a consistent fashion, with the same number of animals being pooled into each sample each year.

Briefly, the reason for this is that the geometric mean contaminant concentration of a series of individual samples and that of pooled samples will generally be different. Thus, if the logarithmic mean contaminant concentration of a series of individual samples is taken, this will lead to the logarithm of the geometric mean, while if the individuals were pooled into one sample, the logarithm of the result would be the logarithm of the arithmetic mean contaminant concentration. Intermediate degrees of pooling lead to results intermediate between these levels. Hence, if variable numbers of animals are pooled from year to year, biases in the trend will result. While this might be corrected by a more complicated statistical treatment, it can best be avoided by consistently pooling the same numbers of individual organisms in the pools.

Economies of pooling

Because the costs of analysis are generally higher than the costs of collecting individual animals, pooling of samples before chemical analysis can often be used to improve the cost effectiveness of a monitoring programme. Thus, chemical analysis of a series of pooled samples (which, depending on the relative sizes of biological and analytical variability, could have reduced variability) often represents a better return for a given expenditure of money than analysis of a series of individual samples. Given specific sampling and analytical costs, and the analytical and biological variances, it is relatively straightforward for a statistician to identify an optimal sampling strategy in terms of the number and size of sample pools. Where possible, this should be done as a component of the design of a sampling scheme for monitoring.

A detailed example of how to optimize a particular sampling programme is presented in Annex 5. It should be recognized that the figures provided in the example apply only to the data in question; different relative costs and advantages would apply in different situations.

6.8 Use of Seaweeds for Monitoring Marine Contaminants

The ACMP took note that the Working Group on Environmental Assessments and Monitoring Strategies (WGEAMS) had responded to a request from the Working Group on Statistical Aspects of Trend Monitoring (WGSATM) for advice on the potential use of seaweeds in monitoring marine contaminants, and had discussed the advantages and disadvantages of this matrix. The ACMP recognized the merits of using seaweeds for the monitoring of dissolved metals in sea water. For dissolved copper and zinc, seaweeds are superior to mussels, the use of which is limited by the physiological controls exerted by mussels on these metals. But it should be recognized that the use of seaweeds is mainly applicable to local monitoring in restricted areas. The ACMP considers that it would be premature, given this limited scale of applicability, to recommend the adoption of this additional substrate for routine use in monitoring programmes. Accordingly, detailed advice on procedures is not provided.

Note: In the 1989 ACMP Report (Coop. Res. Rep. No. 167, Section 6.3), an erroneous statement was made (due to a typographical error). The above text must be considered the correct one.

7. BASELINE STUDY OF TRACE METALS IN COASTAL AND SHELF SEA WATERS

The ACMP noted the outcome of a meeting of an ICES ad Hoc Group which had met 5-9 February 1990 to evaluate the data submitted for the ICES Baseline Study of Trace Metals in Coastal and Shelf Sea Waters and to prepare a report on the results. The measurements of trace metals in sea water for this Baseline Study had been done during the 1985-1987 period by ICES and JMG laboratories in association with the 1985 Baseline Study of Contaminants in Fish and Shellfish in the North Atlantic. The ad Hoc Group reviewed the data using the criteria agreed at the 1989 meeting of the Marine Chemistry Working Group (MCWG). These are:

- a) Samples of sea water should have a salinity of >20 in all areas other than the Baltic Sea and the Kattegat.
- b) Only data for filtered samples would be considered unless the concentration of suspended particulate matter (SPM) in unfiltered samples was <1 mg/litre.
- c) Laboratories submitting data should have successfully participated in the recent ICES intercomparison exercises for metals in sea water (i.e., 5/TM/SW and 6/TM/SW).
- d) The comparability of participants' data collected at ICES reference stations must be assured.
- e) In the absence of fulfillment of (c) and (d), above, the data would be assessed by peer review, that is, the ad Hoc Group's knowledge of trace metal levels from publications and recent research papers.

The ad Hoc Group felt, however, that the rigorous application of these criteria would automatically eliminate the data from some laboratories since they were based on measurements on unfiltered samples for which there were no SPM measurements. It was, therefore, decided to screen all measurements on unfiltered samples from areas indicated as having SPM levels <2 mg/litre. Following an examination of the relevant North Sea contour maps for SPM, it was agreed that data for unfiltered samples from all areas other than NS3B, NS4 and NS5 (see Figure 7.1) could be used in the review.

The ACMP also noted that many of the data had been collected without adherence to the guidelines for the baseline study. Some of the data submitted came from surveys undertaken by institutes for other purposes. Such data were inappropriate to the baseline survey and were, as far as possible, excluded. In addition, many of the data submitted were from locations close inshore; thus, comparison with the literature data was rather difficult since the latter data are generally for offshore (even oceanic) waters.

The ad Hoc Group carried out a statistical analysis of the data and prepared notched box-and-whisker diagrams for each of the core group of metals (copper, cadmium, zinc, lead and mercury) for each area and for three salinity ranges (20-25, 25-30 and >30). An additional set of box-and-whisker plots, which included lower salinity ranges, were prepared for the Kattegat/Baltic Sea areas. An example of this analysis is given in Figure 7.3. Each plot is based on all selected data for samples collected in the depth range 0-10m. For those areas and metals where there were suitable data, plots of dissolved metal concentration against salinity were also produced.

A detailed report on the baseline study will be presented to ACMP in June 1991, following some further intersessional work by the members of the ad Hoc Group. A final report on the study is expected to be published in the ICES Cooperative Research Report series and a paper will be prepared for publication in the open literature. A final draft report will be submitted to JMG in January 1991 to assist in the discussion and planning of its trace metal survey work.

In advance of this report being completed, the ACMP considers it appropriate to present the Commissions with a summary of the main findings of this review. These are:

All metals

- a) Baseline levels of the metals studied can now be established for most of the areas covered in this study.
- b) A number of ICES/JMG laboratories, considered by the MCWG in 1984 as not being sufficiently experienced in trace metal measurements in sea water, have now achieved the capability of producing state-of-the-art measurements. Others will have to improve if they are to participate successfully in the proposed 1992 JMP survey of metals in sea water.
- c) Concentrations of copper, zinc, mercury, cadmium and lead for the salinity range >30 are remarkably uniform throughout the North Sea and other adjacent coastal waters.

Cadmium

- a) Concentrations of dissolved cadmium are higher in inshore waters; levels reported by participants for offshore areas are similar to those reported in the literature.
- b) The highest values for cadmium in inshore areas are found off the western coast of the UK.
- c) Inverse relationships exist between dissolved cadmium and salinity for a number of areas; the slope of the regression line varies from area to area.
- d) The behaviour of cadmium (like zinc) is non-conservative; maximum values are observed in the 20-25 range of salinity values.

Copper

- a) The highest values for salinities >30 are found in inshore areas.
- b) In general, the baseline levels for areas with a salinity >30 are similar to those reported in the recent literature for these areas.
- c) Concentrations in surface waters in offshore areas of the North Sea are higher (x 2) than those for surface waters off the continental shelf.
- d) Dissolved copper versus salinity relationships were defined for most of the areas covered; the slopes of the relationships varied from area to area. The relationships based on results from two laboratories reporting data from the Skagerrak/Belt Sea area were essentially the same (similar values for slope and intercept).

Lead

- a) In the salinity range >30, the highest values are found in offshore areas of the North Sea.
- b) Offshore values of dissolved lead are similar to values for surface waters of the oceanic Northeast Atlantic.
- c) Although an inverse relationship between dissolved lead and salinity appears to exist, there are insufficient data to compare this relationship among different areas.

Mercury

- a) Median values for the salinity range >30 for all areas lie within a very small concentration range.
- b) No strong relationships between dissolved mercury and salinity could be defined.

Zinc

- a) There is a strong relationship between salinity and dissolved zinc for some areas.
- b) Zinc does not behave conservatively throughout the salinity range 0-35, so extrapolation of metal concentrations to zero salinity should be done with caution.

The ACMP draws attention to the following matters to be considered in relation to future sea water monitoring/baseline studies.

In 1984, it was generally agreed that there was a sufficient number of European laboratories with the capability to carry out accurate and precise measurements of trace metals in sea water to participate in an ICES-coordinated Baseline Study of Trace Metals in Coastal and Shelf Sea Waters. In view of this, and the request from ACMP to carry out this task as soon as practicable, proposals were drawn up for a baseline study. These proposals included a quality control mechanism (sampling at reference

stations) and identified the need to measure other parameters, i.e., salinity, temperature, suspended particulate matter, dissolved oxygen, nitrate, phosphate, silicate, in samples collected for trace metal analysis to assist in the assessment of the baseline data.

It was assumed that the adoption of these guidelines by participants would lead to a reasonably comparable data set and that the task of assessing such a data set, in relation to the main aims of the work, would be straightforward.

Unfortunately, for the reasons outlined and discussed below, the task of assessing the baseline data was both difficult and time consuming:

- a) The majority of participants in the baseline study were inexperienced in the collection of sea water samples and their analysis for trace metals. Of the six core institutes and eight reasonably experienced institutes, identified by MCWG in 1984 as potential participants, only two of the first group and two of the second group took part in the baseline study.
- b) Only a few participants (4) conducted measurements on samples collected at one or more of the ICES reference stations. Thus, in the absence of other quality control data (e.g., successful participation in ICES intercomparison exercises), the assessment of data from the majority of the participants had to be based on the knowledge and experience of the ad Hoc Group. A summary of data reported for the reference stations is given in Table 7.1.
- c) Some of the participating laboratories did not comply with all of the guidelines, with the result that a large proportion of the data submitted were from analyses of unfiltered samples with no accompanying data on SPM. In order to judge whether data on unfiltered samples could be included in the assessments, the ad Hoc Group spent considerable time examining the data sets for each individual area, and had to introduce pragmatic criteria such as using SPM information derived from published reports on other studies.

Although a small number of JMG/ICES laboratories have now achieved the capability of producing state-of-the-art measurements of trace metals in sea water, there are others who need to improve their capability if they are to make a positive contribution to the proposed 1992 JMP survey of metals in sea water.

Table 7.1 Measurements of Metals in Sea Water at ICES Reference Stations.

Reference Station: Skagerrak				58° 10' N 09° 30' E	
Contaminant	Laboratory	Date	Depth (m)	Concentration(s) µg/l (ng/l Hg) ¹	Filtered/ Unfiltered
Cadmium	BLUK	19.11.85	640	0.018	F
	DHIG	05.06.86	0	0.017	U
			50	0.014	U
			125	0.019	U
			300	0.010	U
	HFLD	21.08.85	300	0.035/0.031	U
		19.02.86	60	0.018/0.013/0.019	U
		18.02.87	300	0.019/0.017/0.018	U
Copper	HFLD	21.08.85	300	0.200/0.180	U
		19.02.86	60	0.280/0.290/0.340	U
		18.02.87	300	0.143/0.148/0.184	U
Mercury ¹	DHIG	05.06.86	50	3.50	U
			300	2.20	U
	HFLD	21.08.85	50	16.0	U
		19.02.86	60	<8.0	U
		18.02.87	50	17.3	U
Reactive Hg	BLUK	19.11.85	640	<0.1/0.1/0.1	F
Lead	BLUK	19.11.85	640	0.024	F
	DHIG	05.06.86	10	0.043	U
			50	0.051	U
			125	0.042	U
			300	0.010	U

¹ Note: units for mercury concentrations are ng/l.

Laboratory codes:

ALUK - Department of Agriculture and Fisheries Marine Laboratory, Aberdeen, UK.

BLUK - Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Burnham-on-Crouch, UK.

DHIG - German Hydrographic Institute, Hamburg, Federal Republic of Germany.

HFLD - Marine Pollution Laboratory, Charlottenlund, Denmark.

(cont'd)

Table 7.1 (cont'd)

Reference Station: N.W. Scotland				60°30'N 05°00'W	
Contaminant	Laboratory	Date	Depth (m)	Concentration(s) µg/l (ng/l Hg) ¹	Filtered/ Unfiltered
Cadmium	ALUK	26.04.85	1000	0.024/0.018/0.025/ 0.020/0.022/0.020	F
	DHIG	07.05.86	0	0.008	U
			20	0.021	U
			800	0.013	U
	BLUK	25.05.88	2	0.009	F
			50	0.004	F
			100	0.023	F
			200	0.016	F
			500	0.025	F
			950	0.021	F
Copper	BLUK	25.05.88	2	0.052	F
			50	0.180	F
			100	0.340	F
			200	0.350	F
			500	0.180	F
			950	0.170	F
Mercury ¹	DHIG	07.05.86	10	2.90	U
			20	1.80	U
			800	0.50	U
Total Hg	BLUK	25.05.88	2	0.340	U
			100	0.270 : 0.280	F : U
			200	0.300 : 0.280	F : U
			500	0.300 : 0.460	F : U
			950	0.340 : 0.480/0.470	F : U
Reactive Hg	BLUK	25.05.88	2	0.270	F
			100	0.300	F
			200	0.220	F
			500	0.170	F
			950	0.160	F
Lead	ALUK	26.04.85	1000	0.009/0.007/0.010/ 0.010/0.009/0.007	F
	DHIG	07.05.86	10	0.068	U
	BLUK	25.05.88	2	0.035	F
			50	0.040	F
			100	0.085	F
			200	0.027	F
			500	0.020	F
			950	0.013	F

¹ Note: units for mercury concentrations are ng/l.

Figure 7.1 Designation of Areas used in Baseline Study of Trace Metals in Coastal and Shelf Sea waters (Northern European seas).

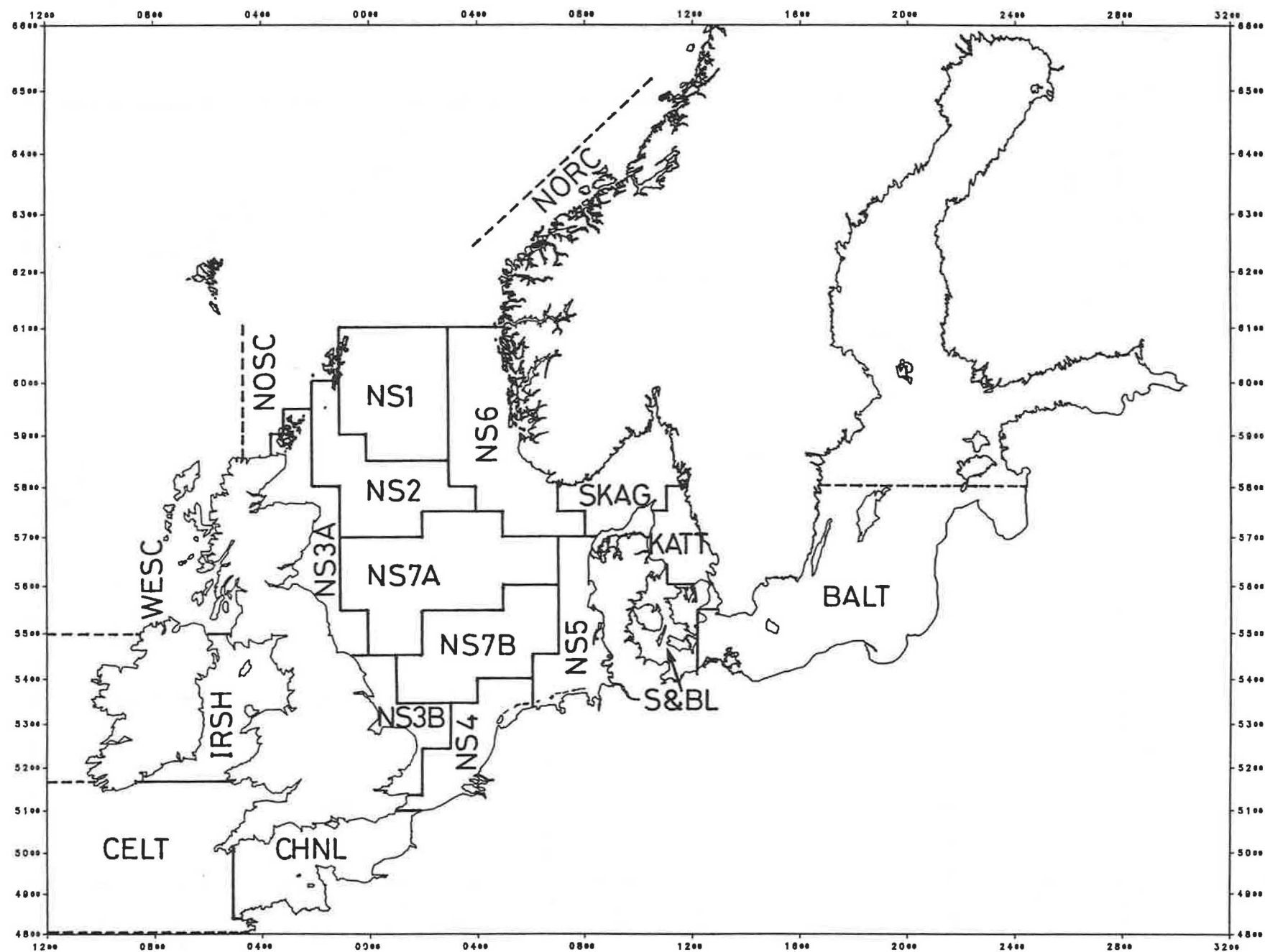


Figure 7.2 Designation of Areas used in Baseline Study of Trace Metals in Coastal and Shelf Sea waters (Southern European seas).

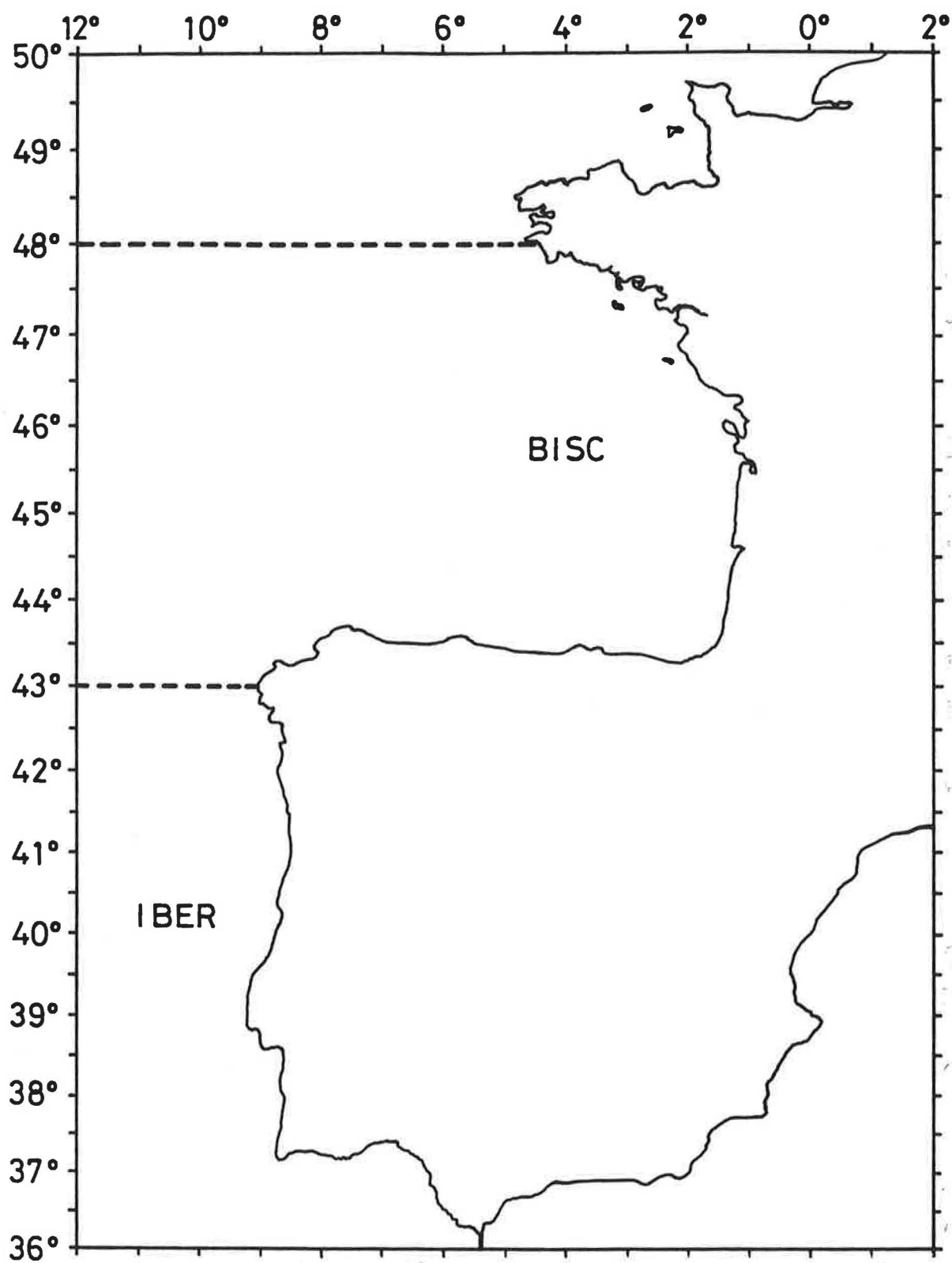
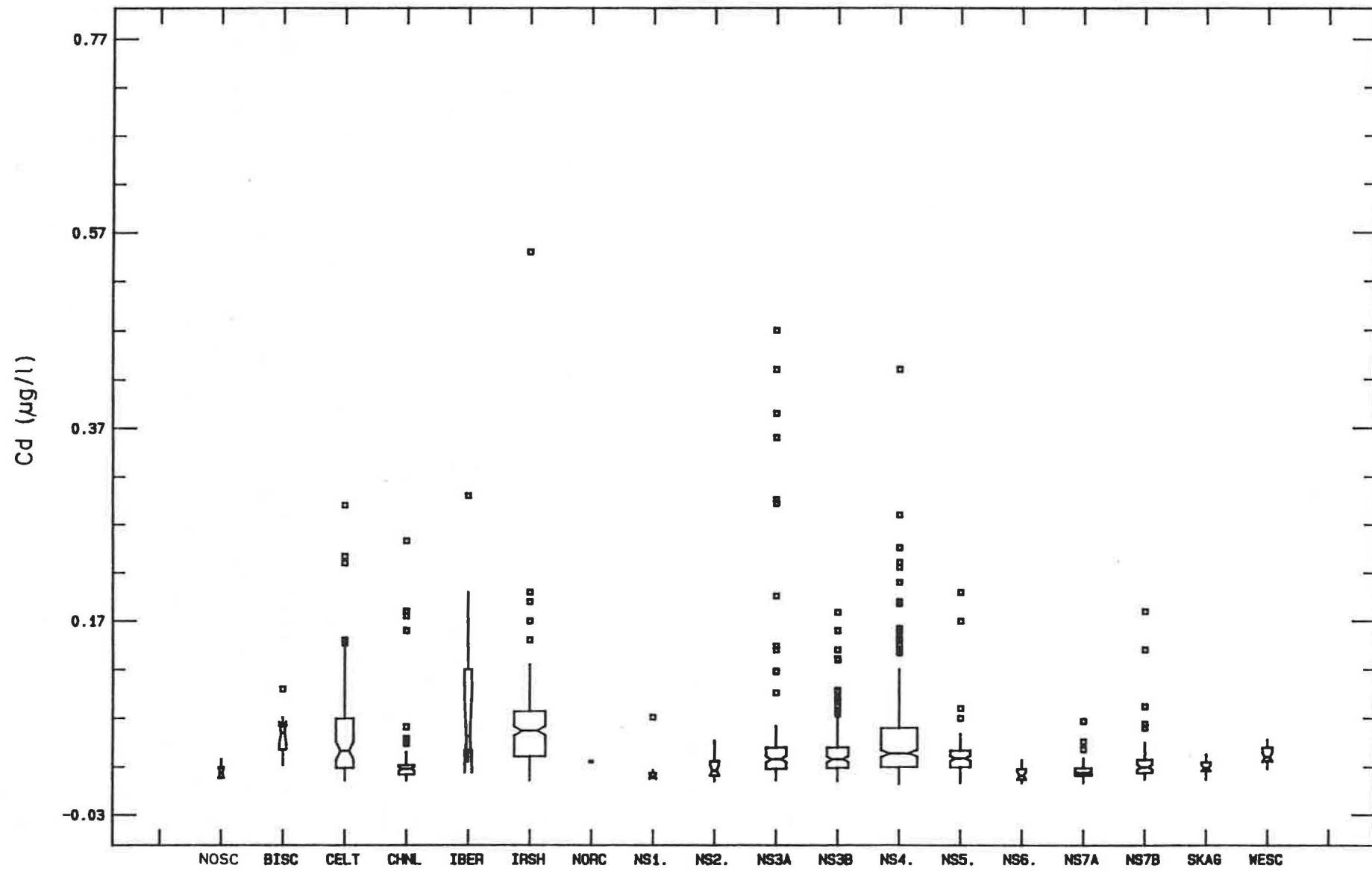


Figure 7.3 Notched Box-and-Whisker plots for Cadmium by Area for salinities >30.



8 BIOLOGICAL EFFECTS OF CONTAMINANTS

8.1 Bremerhaven Workshop

The ACMP noted that the ICES/IOC Workshop on the Biological Effects of Contaminants in the North Sea had been held from 12 to 30 March 1990 based at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Federal Republic of Germany. Eight vessels, six from Germany and two from the Netherlands, had taken part in the exercise, conducting investigations in the German Bight and off the Dutch coast to test techniques to monitor the biological effects of contaminants. The techniques tested covered physiological, biochemical, embryological, gross pathological, and cell pathological effects. Chemical analyses for a number of contaminants are being made on specimens of the types of organisms studied and the marine media, mainly sediments, from which they were taken.

The ACMP reviewed the preliminary draft report of the Bremerhaven Workshop prepared by the Working Group on Biological Effects of Contaminants. Although the final interpretation of the workshop results cannot be made until the chemical analyses and benthic community analyses are completed, the field component of the Bremerhaven Workshop should be considered a success for the following reasons:

1. 70 scientists from the ICES region were involved in a sea-going workshop;
2. biological effects measurements at different levels of biological hierarchy (biochemical, cellular, tissue levels) have been integrated along a nearshore-offshore transect;
3. bioassays have been deployed at sea; and
4. in spite of unpredictable weather during March in the North Sea, the primary workshop objectives were attained.

When all biological and chemical data have been compiled, the data will be subjected to statistical analysis before dissemination to all workshop participants; this will allow each workshop participant to interpret the results of individual tests within the context of all workshop results. The final evaluation of the results of the Bremerhaven Workshop will be possible only after the completion of all analyses, the compilation of the data, and the conduct of a detailed assessment of the results.

The ACMP recommends that, in the final analysis of the workshop results, the results of the Bremerhaven Workshop be compared with the results of earlier IOC workshops (i.e., Oslo, Bermuda) and guidance be provided on the appropriate use of specific biological effects measurements in monitoring programmes for the North Sea and other regions.

The ACMP supports the plans and recommendations of the Working Group on Biological Effects of Contaminants regarding the final stages of the Bremerhaven Workshop activities. These include pre-publication presentation of the outcome of the Workshop, publication of the Workshop's final results, and planning for the follow-up Symposium.

8.2 Leaflets on Biological Effects Techniques

Two leaflets providing detailed descriptions of methods, one on the oyster embryo bioassay and one on measurements of ethoxyresorufin-O-de-ethylase (EROD) activity in fish, have been reviewed and amended and are ready for publication in the Techniques in Marine Environmental Sciences series. A procedure to review future leaflets has been agreed by the Working Group on Biological Effects of Contaminants to facilitate this process, with the aim of accelerating the publication of further leaflets on biological effects techniques.

Participants in the ICES/IOC Workshop on Biological Effects Monitoring Techniques will be approached in order to obtain contributions relating to the techniques used on that occasion. The ACMP hopes that this will result in the publication of descriptions of several more proven techniques.

9 BENTHOS ISSUES

9.1 Results of the 1986 North Sea Benthos Survey

After some delay, the final report of the 1986 North Sea Benthos Survey is now approaching completion. Most of the practical problems arising from the integration of data from the different participants have been resolved following advice on analytical methods from a group of statisticians. The macrofauna data will be reported in a series of papers at the 1990 ICES Statutory Meeting (Mini-Symposium on Benthic Ecology of the North Sea). Parallel data on sediment particle size, heavy metals, pigments and protein will also be reported. The evaluation of the meiofauna data will be completed in 1991. The combined results will be published as a special issue of a journal or as a book.

9.2 Impacts on Benthos of Physical Disturbance of the Sea Bed

The ACMP has previously expressed a particular interest in the topic of anthropogenic disturbance of the sea bed, especially with regard to implications for the benthos and fisheries. In response to an inquiry from ACMP, the Benthos Ecology Working Group (BEWG) provided a short communication listing such disturbances. In addressing this question, the BEWG had taken account of the preliminary draft of a Cooperative Research Report being prepared by the ICES Working Group on the Effects of Extraction of Marine Sediments on Fisheries, and the report of the ICES Study Group on Effects of Bottom Trawling, which contain much relevant information.

Based on the advice of the BEWG, the ACMP considers that some of the major anthropogenic sources of disturbance of the sea bed are:

- a) Commercial fishing operations: e.g., bottom trawling including beam trawling, dredging for shellfish, potting, fixed gill and tangle nets.
- b) Industrial and navigational dredging: e.g., extraction of marine minerals and aggregates, and maintenance of unhindered passage for ships.
- c) Dumping from ships: e.g., deposition of dredged materials, mine tailings, sewage sludge.
- d) Discharge from pipelines: especially where there is a release of material with a significant particulate/solid content.
- e) Construction works: e.g., barrages, breakwaters, harbours, large pipelines.
- f) Shipping activities: e.g., ferry traffic in shallow coastal waters creating propeller-currents and waves.

The effects of disturbance of the sea bed can be categorized as:

- a) Physical (e.g., modifying bottom topography as a result of "ploughing" and "scooping" action by trawls and dredges; sediment compaction by towing/dragging of heavy gear, such as beam trawls; changes in siltation and resuspension patterns).

- b) Biogeochemical (e.g., alterations affecting water-sediment exchange processes, especially contaminant and nutrient fluxes, and those affecting biochemical reactions within microbial populations).
- c) Biological (e.g., changes or disappearance of infaunal species or species assemblages arising from severe disturbances: in disturbed environments, short-lived "opportunistic" species commonly flourish compared with long-lived species; diversity and species succession may be altered). These effects may have severe consequences on the type of biological production and the productivity of the sea bed, including its suitability for sustaining higher trophic levels, e.g., fish and birds.

The ACMP also considered the information from the BEWG on the methods for studying the effects of disturbance on benthos, and recognized the importance of being aware of the range of sampling methods that can be applied in obtaining biological data. Furthermore, the ACMP takes it for granted that sufficient emphasis is placed on quantifying the levels of accuracy and precision of these methods. However, the ACMP is most interested in obtaining a concise, but nevertheless informative, sketch outlining the conceptual and analytical framework for assessing environmental impacts on marine benthic communities.

This sketch should allude, inter alia, to the suitability or prospect of using key species, and their absolute and relative dominance, as indicators of habitat type for distinguishing anthropogenic from "natural" causes of change. In essence, this requires comparing variability within and between localities for both species assemblage as well as "abiotic" data (e.g., sediment type/quality, and hydrographic characteristics, such as temperature, oxygen content, current speed). As potentially large biotic and abiotic data sets are frequently involved in deciphering benthic assemblage/community trends, the ACMP has requested the BEWG to extend its summary of biological effects and methods by examining analytical "methods" applications (ranging from "log-normal" species abundance analysis to multivariate biostatistical techniques, e.g., cluster- and factor-analyses) that have successfully been applied in the field of benthic environmental impact assessment.

9.3 North Sea Task Force (NSTF) Monitoring Master Plan: Comments on Proposals for Benthos Studies

The ACMP endorses the comments of the BEWG regarding the NSTF's proposals for benthos studies within the framework of its Monitoring Master Plan. Accordingly, whilst the ACMP supports the general objectives of the Monitoring Master Plan, it wishes to draw particular attention to the following points in the context of the proposed studies on benthos:

Strategy:

1. The importance of flexibility should be stressed in the design and conduct of a programme for long-term monitoring, e.g., there may be a need to include new stations or to delete initially selected ones, as scientific knowledge accumulates.
2. The published results of the 1986 North Sea Benthos Survey will be available before 1993, when the next Quality Status

Report will be prepared. This should fulfill the requirement for an initial spatial assessment of quality, except for the English Channel, and near-coastal and estuarine localities. Thereafter, the results may aid in the selection or validation of stations for long-term monitoring. The BEWG is prepared, and should be asked, to advise on at least the final selections.

3. There is a preference among some sediment geochemists for seeking depositional areas in order to monitor trends in contaminants. This approach is broadly compatible with the needs of benthos studies, with the addendum that some dispersive areas of known or suspected high contaminant burden, e.g., the Dogger Bank, should also be sampled.
4. For benthos studies in particular, it has to be emphasized that there frequently are difficulties in interpreting spatial trends along transects running from inshore to offshore, since the effects of natural habitat variability may be so great as to mask any anthropogenic effects. Such considerations, however, are less important if representative stations are treated as individual entities for the purpose of monitoring temporal trends.
5. Whenever possible, representative stations should be chosen to correspond with pre-existing stations for which good historical data are available.
6. It was noted that the draft plan sets out the minimum requirements for cooperative study. In studies which are primarily macrobenthic, national efforts should be encouraged towards the investigation of other components of the seabed biota, e.g., the meiofauna and epifauna, both of which were included in the 1986 North Sea Benthos Study.
7. National coordinators responsible for NSTF survey implementation should be encouraged to establish and/or maintain contact with members of the BEWG in their respective countries for any necessary advice.

Methods

The ACMP deems that, whenever possible, the relevant benthos study guidelines already published (ICES, 1989a, 1989b) should be followed. In particular, the ACMP draws attention to the following:

1. Sediments should be sampled using 0.1 m^2 grabs and/or corers, and sieved to 1 mm for the macrofauna.
2. A minimum of five replicates should be taken at individual stations selected for the examination of temporal trends.
3. Coordination in survey timing is essential for any spatial comparisons. Sampling in the period February-May is greatly preferred since this will tend to limit "noise" arising from the transient presence of many newly recruited juveniles and related problems of taxonomic classification.

References

- ICES, 1989a. Report of the ICES Advisory Committee on Marine Pollution, 1989. ICES Coop. Res. Rep. No. 167, pp. 150-164.
- ICES, 1989b. Report of the ICES Advisory Committee on Marine Pollution, 1988. ICES Coop. Res. Rep. No. 160, pp. 28-45.

10 FISH DISEASE ISSUES

The ACMP noted that the report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) contains relevant information on those specific topics which ACMP had asked the Working Group to address. This information is summarized below.

a) Compilation and analysis of data on disease prevalence rates in marine fish stocks in the North Sea, Baltic Sea and Irish Sea

The Working Group reviewed the quantity and quality of data on prevalences of fish diseases in the North Sea, Baltic Sea, and Irish Sea, and noted that most data were for the North Sea. The statistical analysis for the interpretation of time-series trends in fish disease prevalence rates requires data for a minimum of five years for each station and for the area studied (e.g., North Sea) as a whole. These data must be collected according to the ICES standard fish disease survey methodology (in Coop. Res. Rep. No. 166) and reported in a standard format. In this connection, the ACMP stresses again the need to use the revised ICES standard reporting form for this purpose. Supplementary biotic and abiotic data, collected independently by other ICES working groups, will be used as a background for the evaluation of fish disease prevalence data. The Working Group proposes to undertake the first evaluation of trends in disease prevalences in 1992.

In view of the serious lack of data on fish disease prevalences in the Baltic Sea, it is proposed that problems with missing information about disease prevalences in Baltic fish stocks should be resolved by direct contact between the WGPDMO and the Working Group on the Baltic Marine Environment.

b) Proposed training guide for marine fish disease surveys

A Training Guide for marine fish disease identification has been prepared as a complement to ICES Cooperative Research Report No. 166, "Methodology of Fish Disease Surveys", and its rapid publication is recommended. It is noted that the diagnostic leaflets for fish diseases have not been in great demand, possibly due to a lack of publicity as to their availability. Leaflets No. 41-50 are currently being edited.

c) Immunocompetence as an indicator of pollution

The ACMP notes the advice provided by the WGPDMO to the effect that further research is needed to increase the understanding of mechanisms underlying increased immunocompetence in marine fish, before immunocompetence can be used as a reliable indicator of environmental pollution. The ACMP encourages such research, believing that measurements of immunocompetence hold promise as a useful indicator in pollution studies.

11 ENVIRONMENTAL IMPACTS OF MARICULTURE

The ACMP considered the report of the Working Group on Environmental Impacts of Mariculture (WGEIM). On the basis of national reports and material collated during the intersessional period, the Working Group had addressed a number of issues relevant to the management of mariculture and its environmental effects.

11.1 Production Trends

In several ICES member countries, finfish mariculture production has seen an even higher growth rate in 1989 than that reported in previous years. The trend in coastal fish farming continues towards larger units coupled with more stringent site selection criteria for new farm licences and stricter control over the use of chemicals. Figures on present mariculture finfish production trends are presented in Table 11.1. Shellfish production is relatively stable in most of the major producing countries.

Table 11.1 Production trends (metric tonnes) in finfish mariculture in selected ICES member countries.

Year	Country							
	Canada	Denmark	Ireland	Finland	France	German Dem. Rep.	Norway	Scotland
1988	12,300	5,500	5,200	~10,000	-	550	~ 89,700	18,660
1989	~18,000	6,690	6,400	1,000	1,100	840	~118,800	29,035

11.2 Chemical Usage in Mariculture

At the present time, quantitative data on chemical usage in ICES member countries are extremely sparse and of variable quality. Absolute amounts of chemicals can only be given for a few countries and occasionally these can be broken into amounts per tonne of fish produced. The number of chemicals used in large quantities is very limited (probably fewer than twenty chemicals are used in amounts greater than one tonne per country).

As regards the compilation of quantitative data on chemical usage, the ACMP notes that in many countries there is no statutory requirement to maintain records of chemical (including therapeutant) usage, and estimates of present usage are subject to considerable uncertainty. The amount of any particular drug used varies greatly from year to year, depending upon the amount of fish produced, the incidence of disease, and the particular drug selected to treat any particular disease.

The ACMP notes the increasing efforts on behalf of major producing countries to reduce the extensive use of chemicals by improving husbandry strategies and tightening regulations on chemical usage. Nonetheless, the ACMP strongly recommends the systematic collection of data on chemical usage. In this context, the ACMP draws attention to the system of reporting the use of veterinary drugs in fish farming in Norway, as outlined in Annex 6. Whilst in many countries new legislation might be necessary to achieve

such accuracy in recording veterinary drug use, ICES member countries are urged to examine the Norwegian system and consider how they might collect similar records.

The ACMP also recognizes that, despite the remarkable increase in finfish production in Norway, the use of chemicals per unit weight of fish produced has declined to such an extent that the overall amount of chemicals employed in fish farming has been almost halved since 1987 (see Figure 11.1).

ANTIBACTERIAL DRUGS 1980-1989

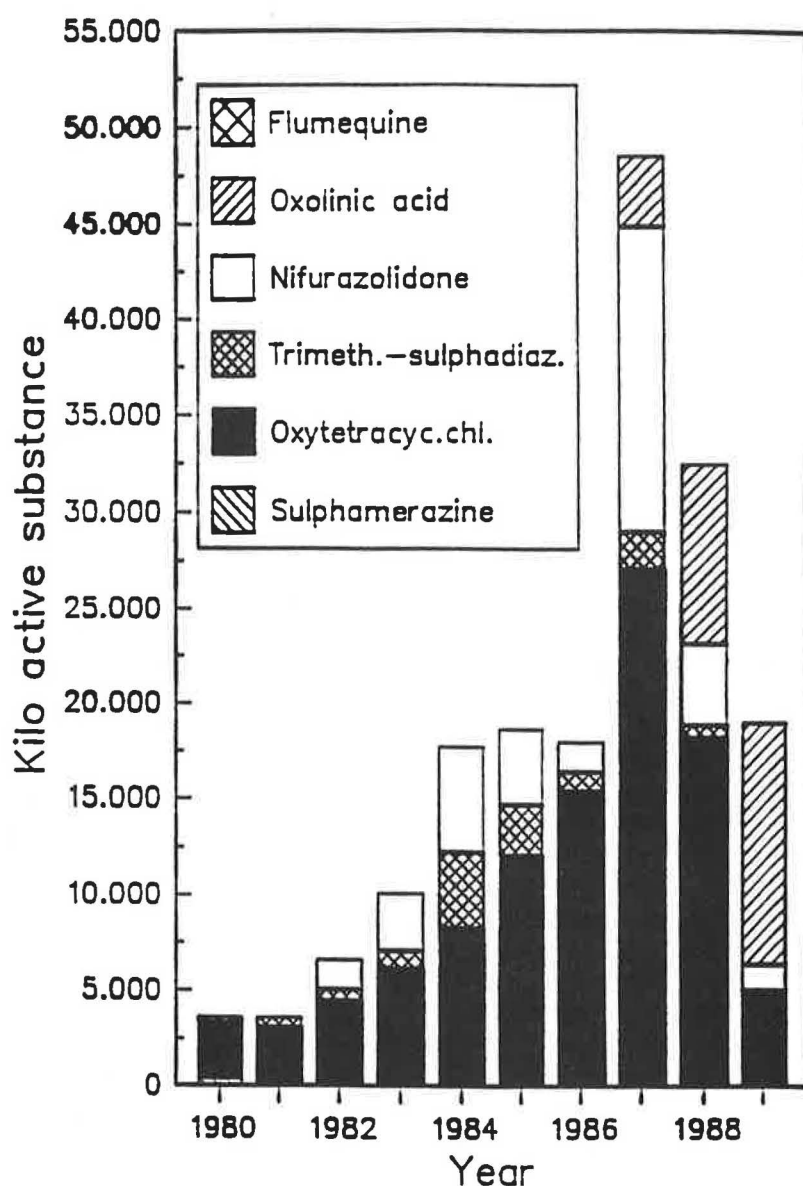


Figure 11.1 Amounts of chemicals used in fish farming in Norway.

11.3 Nutrient Inputs from Baltic Fish Farms

A preliminary response was made in the 1989 Report of ACMP (ICES, 1989) to the request from the Helsinki Commission for advice on issues related to nutrient inputs from fish farms in the Baltic Sea and this model could be used to estimate total inputs. However, it is the intention of ACMP that an updated and expanded version of the information provided in the 1989 ACMP report will be included in its report for 1992. By this date, it is expected that the WGEIM will have completed its task of compiling a report on chemicals used in mariculture and a report on the environmental impacts of mariculture.

Reference

ICES, 1989. Report of the ICES Advisory Committee on Marine Pollution, 1989. ICES Coop. Res. Rep. No. 167, pp. 51-56.

12 ALGAL BLOOMS AND RELATED ISSUES

12.1 Standard Method for the Measurement of Primary Production

Based on the recently published report on the results of the ICES ^{14}C Primary Production Intercomparison Exercise (Cooperative Research Report No. 170), the ACMP discussed both the need for and the feasibility of the development of a standard ^{14}C primary productivity method. The ACMP emphasizes that no definition of the uses to which an eventual standard method would be put has been made, either within or outside the ICES community. Conflicts in sampling strategy in studies aimed at collecting data on phytoplankton physiology/ecology, as opposed to studies designed to identify trends in primary production related to nutrients, make it necessary to clearly define for what purpose a standard method is being developed.

The ACMP recognizes that more work is needed, but acknowledges the start that the Working Group on Phytoplankton and the Management of their Effects has made on developing an incubator that could serve as a basis for a standard method. In addition, the ACMP recommends that the Working Group be charged with the task of developing a standard method for the ^{14}C determination of phytoplankton production for use in routine monitoring studies. The data collected from such studies should be suitable for use in, for example, trend analyses where changes in phytoplankton activity are related to changes in nutrient concentrations. Thus, the emphasis should be on producing data that can be compared between ships, stations, days and seasons. The ACMP also emphasizes the importance of being kept up to date on new developments in attempts to use remote sensing to estimate primary production. In this context, attention is drawn to the planned 1992 ICES Symposium on new methods/developments for primary production determination.

Noting that interest has been expressed in the possible establishment of an ICES data base on primary production, the ACMP briefly discussed this topic. In view of the variability associated with primary production measurements made by different laboratories, as demonstrated in the report on the results of the ICES ^{14}C Primary Production Intercomparison Exercise, the ACMP does not feel that an ICES data base on primary production should be established at the present time.

12.2 Factors Responsible for the Initiation of Exceptional Algal Blooms

The Helsinki Commission has asked ICES to provide information, on as quantitative a basis as possible, on conditions (physical, chemical and biological) relevant to the potential development of unusual algal blooms in the Baltic Sea area. Recognizing that the ICES Working Group on Phytoplankton and the Management of their Effects had been given this term of reference for their 1990 meeting, the ACMP discussion on this issue took as its starting point the report of this Working Group.

A major problem in addressing this type of request is defining "unusual" or "exceptional" algal blooms. In the purely scientific sense, a "bloom" consists of rapid growth resulting in a high biomass of a particular algal species. Often, however, the "blooms" that attract public attention (through toxicity, foam production, etc.) are not blooms at all in the true scientific sense, but merely the presence of a "harmful" algal species within the phytoplankton community. An example is the widely publicized occurrence of Chrysochromulina polylepis in the Kattegat/Skagerrak in spring 1988. Although this species dominated the phytoplankton community at the time, the distribution of algal biomass was quite typical for this area and time of year. Thus, the only "exceptional" aspect to this "bloom" was the presence of a toxic species.

It is, however, well known that some toxic/noxious species exist (and have always existed) within the phytoplankton community as a whole. For what is now the Baltic Sea area, it can be noted that there is fossil evidence of mass mortalities of mussels occurring in connection with dinoflagellate blooms about 140 million years ago (Surlyk and Noe-Nygaard, 1988). Many historical examples of the presence of toxic phytoplankton exist that cannot be related in any way to eutrophication or pollution. Thus, there is no evidence that the existence of toxic algal species, in itself, can be directly related to eutrophication or pollution. Indeed, there is an analogous occurrence of toxic plants in the terrestrial flora (poisonous mushrooms, berries, leaves, etc.).

Nevertheless, it seems clear that, in some areas, there is an increase in the frequency of occurrence of toxic/noxious algal blooms. In some cases, this increase may partly be "apparent" in the sense that there is more awareness and monitoring (due to aquaculture, etc.) directed towards phytoplankton "blooms". However, in other cases, the increases seem likely to be real (or a combination of real and apparent).

The most likely cause of this increase is nutrient enrichment. Just as adding nutrients to a field stimulates the growth of the plants in the field, an increase in available nutrients in the sea stimulates the growth of the plants (usually phytoplankton) in the sea. Acknowledging the presence of toxic/noxious species within the total phytoplankton community, it must be assumed that the growth of both toxic/noxious species and non-toxic species will be stimulated by eutrophication and the occurrence of "unusual blooms" will thus increase.

With respect to the factors which lead to the occurrence of a particular algal species at a specific time and place, the list is long and almost certainly incomplete at the present time. A list of these factors includes salinity, temperature, current speed and direction, light regime, turbulence regime, nutrient (including trace metals and micro-nutrients) availability, the ratio between the concentrations of different nutrients, the presence or absence of specific grazers, etc. Here, it may be useful to draw on a terrestrial analogy in order to appreciate the difficulties in predicting where and when toxic algal species will occur.

On any ploughed field, at a given latitude and longitude, there are a number of different plant species which can be expected to have the potential to grow. Exactly which species actually colonize this field, however, will depend upon the seeds that are transported to the field (via wind, animal movements, etc.) or are lying dormant on the field, the nutrients present in the field (and the relative concentrations of these nutrients), rainfall in or near the period following the arrival of new seed, the presence/absence of potential grazers (i.e., birds) on the seed and so on. Obviously, the composition of the flora which ultimately dominates this field will be the result of a series of complex ecological interactions.

Likewise, the composition of the algal flora (and the probability of the occurrence of toxic species) in the sea at any given time and place will be a function of complex ecological interactions. In fact, the situation in the sea can be considered to be even more complicated than that in the ploughed field owing to the relatively short generation times of phytoplankton as opposed to most terrestrial plants and the fact that phytoplankton do not remain at a fixed geographical position but are, by definition, moved about by water movements. Thus, at the present time, it is not possible, as a rule, to identify the overriding factors determining the presence or absence of toxic/non-toxic algal species at any given time/place in the Baltic Sea or any other sea area.

Nevertheless, the ACMP emphasizes that there is great progress being made through research at the present time. The fact that the toxicity of individual species may change as a function of environmental conditions (i.e., the relative concentrations of nutrients) has been appreciated and must be further investigated. The taxonomy of potentially toxic species is being critically examined to define the actual distribution of toxic species. Biological oceanographic interactions for specific regions and conditions are being described and other relevant investigations are being conducted. Provided that adequate research funding is made available, the ACMP is optimistic that it may ultimately be possible to identify areas at high risk with respect to the occurrence of toxic/noxious algal blooms and even, for some areas, to predict their occurrence.

Owing to the growing interest in this topic, the ACMP discussed the possible need for establishing a new ICES data base on the occurrence of algal blooms in the ICES area and was made aware, through the report of the Working Group on Phytoplankton and the Management of their Effects, of considerations on the establishment of a bloom data base within the Intergovernmental Oceanographic Commission (IOC). It is proposed that contact should be made, via the Biological Oceanography Committee, with the IOC group of experts on algal blooms to determine the status of the IOC considerations and to discuss possible collaboration on this issue.

Reference

Surlyk, F. and Noe-Nygaard, N. 1988. Alger og massedød for 140 millioner år siden. [Algae and mass deaths 140 million years ago]. *Naturens Verden* 1988:338-349.

12.3 Algal Toxins and Methods for their Determination

A review of the existing methods for the detection and quantification of algal toxins with direct human health impacts is included in the report "Management of the Effects of Harmful Algae on Mariculture and Marine Fisheries", prepared by the Working Group on Harmful Effects of Algal Blooms on Mariculture and Marine Fisheries for publication in the Cooperative Research Report series. Additional comments on algal toxin detection can be found in the 1990 report of the new Working Group on Phytoplankton and the Management of their Effects.

In agreement with the main conclusions of the above-mentioned reports, the ACMP notes that at present there are chemical methods, mainly based on high pressure liquid chromatography (HPLC), which allow the detection and quantification of Amnesic Shellfish Poison (domoic acid) and commonly occurring toxin components causing Paralytic Shellfish Poisoning (PSP), Diarrhoetic Shellfish Poisoning (DSP) and Neurotoxic Shellfish Poisoning (NSP). However, the implementation of chemical methods is hindered by the limited availability of reference standards. In addition, the necessary equipment is expensive and requires specially trained personnel.

Due to the above-mentioned problems, it is likely that bioassays, especially those based on the use of mice as experimental animals, will continue to be the most accepted reference methods for monitoring and regulation in the near future. However, many countries are introducing legislation to reduce the use of animals (especially mammals) in routine bioassays. There is, therefore, a need to:

- a) Develop additional methods and improve quality assurance procedures;
- b) Search for solutions to the shortage of reference standards; and
- c) Carry out the necessary testing to intercalibrate bioassays with alternative chemical methods.

New perspectives for the detection and quantification of algal toxins are offered by the development of immunological methods and the use of cell cultures. However, detailed evaluation and intercalibration of these techniques must be performed before they can be used in regulatory programmes.

An important point to be addressed is that chemical and immunological methods, even when fully developed, are directed towards the detection and quantification of known toxins and are unlikely to detect the appearance of new toxins.

The development of efficient methods for algal toxin determination is also of major importance for ecophysiological studies of toxin production.

13 NUTRIENT TRENDS IN THE NORTH ATLANTIC

The ACMP considered a report on nutrient distributions and trends in the ICES area, prepared by the Shelf Seas Oceanography Working Group. The compilation of this information on nutrient trends for the total ICES area was limited by the lack of participation of Working Group members with relevant background knowledge from some parts of the ICES area and by the lack of data. As a consequence, the report was focussed on Norwegian waters, the North Sea and the Baltic Sea. Statements by the Hydrography Committee (ICES, 1990) and advice from the Marine Chemistry Working Group on trend monitoring of nutrients were also considered.

Based on this information, the ACMP concludes that:

- There has been an increase in the anthropogenic supply of nutrients (nitrogen and phosphorus) to the Baltic Sea and the North Sea from the land and the air.
- There are portions of the coastal North Sea as well as the whole Baltic Sea where the effects of the anthropogenic nutrient supply can be clearly identified as increased nutrient levels in the water column, primarily in winter.
- The available data allow identification of changes over time in the nutrient levels in the Dutch estuaries, the German Bight, the Kattegat, and especially the Baltic Sea.
- For the Baltic Sea, the longer flushing time, the greater stratification, the greater nutrient supply (per unit volume), and the better international data set make the nutrient trends in the water column more apparent.
- For the North Sea as a whole, the quality of the available historical nutrient data does not permit a statistically sound statement to be made concerning a general trend. The results of local or regional studies may be affected by the same problem. They may not be representative for the whole of the North Sea. Hence, the answer to questions regarding possible general nutrient increases cannot be given solely upon the basis of a statistical analysis of existing data sets. The further examination of the existing historical data sets will not yield additional information.

It, therefore, seems clear that both previous and contemporary nutrient data are unsuited to the identification of trends because the data are too sparse, temporally and spatially. Equally, it is clear that nutrient introductions to the North Sea from anthropogenic sources have increased and that this has led to increased nutrient levels and biological production in some areas. Effort now needs to be applied to determining the best method of monitoring future nutrient changes in the area.

In the context of the development of nutrient studies, the ACMP suggests that primary attention should be devoted to experiments and observations that have the objective of delineating the important processes of the system in order to permit modelling to test scientific understanding and to enable prediction. Monitoring programmes should be designed using knowledge of these important basic processes in order to provide adequate sampling. In this respect, the North Sea Task Force Monitoring Master Plan (NSTF-MMP) appears to be inadequate. The temporal and spatial variability in the North Sea would confuse the interpretation of NSTF-MMP nutrient data to such an extent that any change in the nutrient levels would not be demonstrated unequivocally. Measurements every day, or every second day, at carefully chosen representative stations, combined with synoptic measurements once or twice per year on a very dense network of stations over the entire area, would constitute a better approach.

Reference

ICES, 1990. Procès-Verbal de la Réunion, 1989. pp. 75-76.

14 INTERCOMPARISON EXERCISES AND QUALITY ASSURANCE ACTIVITIES

14.1 Intercomparison Exercise on the Analysis of Nutrients in Sea Water

The ACMP reviewed the report of the Fourth ICES Intercomparison Exercise on the Analysis of Nutrients in Sea Water. Laboratories from all ICES member countries participated in the exercise, with 68 laboratories (out of a total of 85 receiving samples) returning results. The results show the degree of comparability of nitrate + nitrite, phosphate, and silicate analyses of a number of natural seawater samples containing different levels of the determinands. The ACMP noted that the experiment dealt only with analytical aspects of nutrient determinations in sea water. The results confirm the need for additional quality assurance procedures to be implemented in several laboratories to improve the comparability of their data; however, a substantial majority of the participants produced results with relatively good agreement (within about $\pm 5\%$ for nitrate + nitrite and about $\pm 10\%$ for phosphate). The exercise also provided a test of the stability of natural, unpreserved (i.e., devoid of chemical preservatives and not requiring special storage procedures) seawater samples for standardization purposes and, in large part, confirmed that such samples can be incorporated into quality assurance procedures as reference materials. The results also show that earlier concerns about the influence of high silicate concentrations on phosphate determinations appear to be unwarranted.

Statistical analyses of the results of the intercomparison exercise show that systematic errors are the primary cause of relatively poor laboratory performance. It was noted that the group of laboratories that reached consensus on nitrate + nitrite concentrations was not identical with the group agreeing closely on phosphate concentrations. Nevertheless, the coordinator of the exercise has provided, and continues to provide, assistance to the participants in identifying and correcting deficiencies in their analytical procedures. The ACMP was disappointed to note that about 10% of the participants had a limited appreciation of the precision and sensitivity of methods for nutrient determination, as reflected by their reports of zero concentrations and unrealistic numbers of significant figures.

It should be noted that the sample matrices and nutrient concentrations dealt with in this intercomparison exercise are representative of the real marine environment, adding weight to the credibility of both the exercise and its results. Clearly, there exists room for improvement in the comparability of the results of nutrient determinations among laboratories and, accordingly, there will be a need to repeat an intercomparison exercise of this kind, probably in about 2 years' time.

Attention now needs to be focussed on assessing the influence of sampling and sample storage procedures on the results of nutrient determinations.

14.2 Intercomparison Programme on Analyses of Polycyclic Aromatic Hydrocarbons

The ACMP reviewed the preliminary report of the first stage of the Intercomparison Programme on Analyses of Polycyclic Aromatic Hydrocarbons (PAHs), which had involved the distribution and

analysis of standard solutions of 10 selected PAHs in either acetonitrile or hexane. Seventeen laboratories had participated, using either high pressure liquid chromatography (HPLC) or gas chromatography (GC) procedures or, in a few cases, both procedures. The results from some laboratories displayed a high variability and indicated the need for some of them to optimize their instrumentation before undertaking the second stage of this exercise. The coordinator of the exercise has discussed these problems with the relevant laboratories, in accordance with the aims of this step-by-step exercise. A full report on the results of the first stage of this exercise will be available in February 1991 for review by the Marine Chemistry Working Group (MCWG) and ACMP. In addition to a detailed evaluation of the results in relation to the procedures used by each laboratory, the coordinator will include advice on optimization procedures for all future participants in this exercise.

The second stage of this exercise is designed to assess the ability of the participants both to prepare their own standards and to analyze the individual PAH compounds in a cleaned-up sediment extract. Stages 3 and 4 of this exercise will deal, respectively, with an assessment of extraction and clean-up procedures and the ability to quantify PAHs in a natural sediment.

The ACMP considers that it is appropriate to stress that the aim of this exercise, and the intercomparison exercise on CBs, is to improve the participants' ability to analyze these compounds so that, at the end of the exercise, all participants should be capable of providing comparable data for samples collected in coordinated monitoring programmes. Laboratories who experience difficulties during the individual stages of the exercise will be provided with guidance on how to overcome these problems before they participate in the next stage. It follows, therefore, that the Commissions or other organizations should be cautious in drawing conclusions about the long-term capabilities of participating laboratories on the basis of their performance in individual stages of the exercise.

14.3 ICES/IOC/OSPARCOM Intercomparison Programme on Analyses of Chlorobiphenyls

The ACMP reviewed the final report on the results of the first stage of the ICES/IOC/OSPARCOM Intercomparison Programme on Analyses of Chlorobiphenyls (CBs), which had involved the distribution and analysis of standard solutions of 10 CBs (IUPAC Nos. 28, 31, 52, 101, 105, 118, 138, 153, 180 and 189), an internal standard, and a blank solution. It noted that 58 out of 90 participants had returned results to the coordinators of this exercise. Despite the fact that the coordinators had provided extensive advice on optimization procedures and calibration procedures before the commencement of the exercise, the results from some laboratories revealed that they had experienced difficulties, in calibration (i.e., identifying the linear range of the electron capture detector), in separating some of the individual congeners, in identifying the four unknown CBs (IUPAC Nos. 49, 77, 110, 149) added to the standard solution, and in optimizing GC procedures. Positive identification of CBs in the blank solution by many participants revealed that they had background contamination present in their laboratories.

The coordinators of this exercise have provided feedback to the participants on these problems and suggestions as to how they might overcome them before they begin stage 2 of the exercise. The second stage of the exercise will assess the ability of the laboratories to prepare their own standard solutions and to identify and quantify the CBs in two cleaned-up extracts: a sediment sample and a seal blubber sample. Laboratories identified as having problems in the first stage will be given an extra set of standard solutions during the second stage to allow them to demonstrate that they have made the necessary improvements to their analytical procedures.

Laboratories which did not return results for the first stage will not be invited to participate in remaining stages of this exercise. The third stage of this exercise will check the ability of the participants to deal with the clean-up and extraction stages of the analysis, and the fourth stage will deal with the analysis of natural sediment and seal blubber samples.

In the light of recent findings on the effects of certain CB congeners (those with 0 and 1 ortho chlorine) on the reproduction of mink (see Section 18 of this report), the ACMP feels that the coordinators should, if practical, give serious consideration to including some of these CB congeners in this step-by-step learning exercise. Appropriate measures to this effect have subsequently been taken.

The report on the first stage of this exercise is expected to be published in the ICES Cooperative Research Report series in early 1991.

14.4 Intercomparison Exercise on the Determination of Trace Metals in Suspended Particulate Matter

The ACMP noted that the first phase of the Intercomparison Exercise on the Determination of Trace Metals in Suspended Particulate Matter (SPM) had tested the participants' ability to analyze trace metals in small amounts (1, 3 and 5 mg) of three samples of certified reference sediments. A preliminary report on the results, from 19 participants, had shown that the accuracy of the results had increased with increasing weight of the sample. A full report on this first stage will be prepared for review by ACMP in 1991.

Three alternative proposals have been submitted for the second stage of the exercise. The first proposal involves a sample of sea water to which a known amount of suspended sediment has been added. The second proposal involves a sample of sea water containing natural suspended particulate matter. The third proposal involves filters through which sea water containing natural suspended particulate matter has been filtered to provide <1 mg SPM/filter. Subsequent stages of this exercise would examine the collection and filtration steps of the procedure for the quantitative measurement of SPM in sea water.

Before embarking on the design of the second stage, the ACMP would be interested to learn from the Commissions which of these alternative procedures would best serve their requirements.

14.5 Plans for the Intercomparison of Dissolved Oxygen Measurements in Baltic Sea Water

The Helsinki Commission (HELCOM) had previously requested ICES to provide advice on the design and conduct of an intercomparison exercise for measurements of dissolved oxygen in Baltic Sea water. Following advice provided by ACMP and MCWG, an intercomparison exercise containing these components has now been adopted for execution in conjunction with the Biological Intercalibration Workshop to be held in Visby, Sweden on 23-27 August 1990.

The design of this intercomparison exercise has been outlined by the coordinator as follows:

"DETERMINATION OF DISSOLVED OXYGEN

The entire work will be carried out on one ship (R/V Argos) in order to minimize the influence of patchiness. The exercise will include two water masses with different oxygen saturations. The design of the sampling procedure implies that repeated sampling can be done from a homogeneous water body.

All analysts are supposed to use the same stock iodate and stock thiosulphate (and the same conditions for the preparation of working thiosulphate solutions) and to compare them against their own preparations of these reagents, under Test 3 (see below).

- 1) Test of the variability caused by sampling equipment: All different hydrocast bottles used by the participants are operated by one person taking three water samples from each sampler. When all samples are taken, the first sampler is used to obtain three more samples in order to study variability in the water body during the sampling period. One person has to withdraw samples from all the hydrocast bottles and perform all subsequent steps of fixation, titration, etc. Only mixed layer water is sampled for this exercise.
- 2) Test of the variability caused by sampling staff: All steps according to Test 1, with the exception that every participant operates his/her own hydrocast bottle to obtain the samples from the mixed layer water. From the water mass with lower concentrations of oxygen, all the samples are taken simultaneously using the rosette sampler to eliminate the effects of the oxygen gradient.
- 3) Test of the variability caused during the analysis: Two bulk samples of water with different concentrations of dissolved oxygen are used. From each bulk sample, every participant withdraws six subsamples which he/she subsequently takes through the entire procedure of fixation, titration, etc. Three of these samples are analyzed using the participants' own reagents. For the remaining three samples, the reagents used will be provided by the conveners."

The ACMP recognizes that this sequence of tests corresponds to each of the intercomparison components identified by MCWG. These are:

1. Test of the variability associated with the use of different sampling equipment.
2. Test of the variability associated with the sampling by individual laboratories/participants.
3. Test of the variability associated with the use of different analytical procedures.

The ACMP realizes that for Test 1 to be carried out effectively there is a need to minimize inhomogeneity among the replicate samples recovered for oxygen sampling and analysis. To this end, the selection of the sampling station should be based on a prior evaluation of water mass structure in the survey area. The structure of the water column should be assessed prior to the collection of the intercomparison samples. This pre-survey could usefully include a dissolved oxygen profile using a single sampling device and analyst. These measures should improve the selection of a sampling depth for Test 1 at which reasonable homogeneity can be assured.

The ACMP recognizes that there is an alternative procedure for Test 1. If all the samplers can be accommodated on a rosette, it would be logical to use a rosette for deploying all the sampling devices in Test 1 in order to minimize inhomogeneity, just as the use of this procedure is implied for the collection of low oxygen samples in Test 2. It is appreciated that this may be impractical because of the extended time required for the analyst to draw the replicate samples.

It should be made clear that in Test 2, all samples drawn by each participant are to be analyzed by a single analyst using a consistent procedure.

All other aspects of the proposed oxygen intercomparison exercise seem valid and include appropriate degrees of replication to ensure adequate evaluation of variance components associated with different sampling devices, sample processing and analytical procedures.

14.6 Quality Assurance Aspects for the Sampling of Sea Water

The ACMP noted that the MCWG had prepared a document based on a proposal from the Netherlands for quality assurance procedures for the sampling of sea water prior to analysis for trace metals. A final version of this paper will be reviewed by ACMP prior to its submission to the Oslo and Paris Commissions, and in time for any amendments to be incorporated for use in the 1992 JMG baseline study of trace metals in sea water.

14.7 Other Quality Assurance Activities

The ACMP noted that, on the basis of a request made by representatives of the Commission of the European Communities (CEC) on the North Sea Task Force, the Community Bureau of Reference (BCR) had convened a meeting in December 1989 to discuss the possibility of BCR funding for a three-year pilot programme on quality assurance (QA) for laboratories involved in the Joint Monitoring Programme (JMP) and NSTF monitoring activities. In addition to representatives from various offices in the CEC, the meeting was

attended by the Chairman and two other members of the Marine Chemistry Working Group and the ICES Environment Officer. The outcome of this meeting was BCR's agreement to fund a workshop on quality assurance for a representative number of participants from monitoring laboratories and the preparation of a detailed pilot programme proposal by the Chairman of MCWG for BCR's consideration. The workshop was subsequently held for three days in May 1990 in the Netherlands and a large number of representatives of JMG and NSTF laboratories and several representatives of Mediterranean (MEDPOL) laboratories attended. The ACMP noted that several members of ICES Working Groups (MCWG and WGBME) had participated as lecturers either in the plenary sessions or in the sub-sessions dealing with the sampling and analysis of nutrients in sea water, and metals and organochlorine compounds in water, sediment and biota. In terms of the proposal for the three-year pilot programme, the ACMP noted that this was currently under preparation and that BCR expected to review this proposal before the end of 1990. The ACMP discussed the extent to which future QA needs of the ICES, JMG and NSTF laboratories would be met by this programme. Participants in the programme can, in theory, only be from European Community countries, which would preclude some of the ICES member states (e.g., some Baltic countries). In relation to on-going ICES-sponsored intercomparison exercises (e.g., on CBs and PAHs), and whether they might be incorporated into this pilot programme, the ACMP considered that these exercises should remain within ICES since finances for their completion were assured.

On a related matter, the ACMP noted that a joint NSTF/JMG workshop, held in October 1989, had suggested the establishment of a Quality Assurance Group (QAG) to meet the needs of the future monitoring requirements, with appropriate terms of reference (see Report of the Fifteenth Meeting of JMG, Annex 7). It was envisaged that the QAG would report to the NSTF and the JMG. Although TWG and SACSA had endorsed the JMG's recommendation for the establishment of the QAG, they considered that it would be desirable for ICES to prepare a short overview on the QA project proposals by BCR for the information of the Commissions. The ACMP's initial impression is that, if the BCR initiative proceeds as proposed, the establishment of the QAG would not be required, although some group to review the results of quality assurance would be required.

The ACMP considers that the BCR proposal is very welcome. If it becomes a firm commitment, it will provide the type of comprehensive QA programme necessary for laboratories concerned with monitoring. This, in turn, will enable ICES, the JMG and NSTF to assess the quality of chemical monitoring data throughout the period of monitoring, instead of the present practice of occasional interlaboratory checks of laboratory performance. Accordingly, every effort should be made by all interested parties (BCR, ICES, OSPARCOM) to ensure the success of this project for improving and maintaining data quality.

The ACMP noted however that, according to the likely timetable of the BCR pilot programme, the QA results may not be available in time for the assessment of monitoring data collected during the 1990-1991 period under the auspices of the JMG and the NSTF. This had been one of the intentions behind the approach to BCR following the completion of the NSTF/JMG workshop in October 1989.

15 STUDIES OF CONTAMINANTS IN SEDIMENTS

15.1 Critical Review of Contaminants in Baltic Sediments

The ACMP was informed about the progress in sediment studies in the Baltic Sea and examined the contents of the first draft of the report on contaminants and geochemical data for Baltic Sea sediments. The report, entitled "Critical Review of Contaminants in Baltic Sediments", was compiled by M. Perttilä in cooperation with L. Brüggmann.

The report consists of several chapters, each dealing with particular aspects of the sediments of the Baltic Sea. With the exception of the first chapter, which gives the main conclusions and is based on the information contained in the rest of the report, each subject chapter contains sections of text and data contributed by individual scientists from the countries around the Baltic Sea.

The general characteristics of the Baltic Sea sedimentation areas are described in the first subject area chapter. The geological structure of each area is explained, followed by a description of the sediment types and an evaluation of the sedimentation rates in areas where relevant data were available. This information covers the Gulf of Bothnia, the Gulf of Finland, the Baltic Proper, the Gulf of Riga, and the southwestern Baltic Sea. A great deal of the data and texts on the Gulf of Riga are original and were specifically tabulated for this Review; for the other areas, mainly existing literature has been used.

In the Bothnian Bay, only weak sedimentation conditions seem to prevail, due to effective mixing and prevailing current patterns, leading to mainly eroded bottoms and a slow net sedimentation rate. One sedimentation station, however, has been used primarily by Finnish and German Democratic Republic experts to obtain contaminant data. In the Bothnian Sea, the main current from the Åland Sea turns to the east, and then runs northward along the Finnish coast. This current results in relatively quiescent conditions, permitting sedimentation in the southeastern part of the Bothnian Sea; this area has been extensively studied by Finnish scientists.

There are few data for the Gulf of Finland. Only one station, close to the Finnish coast, is regularly visited by Finnish scientists. This station shows the highest sedimentation rate found in the Baltic Sea, and is thought to mirror the contamination load of one of the major Finnish rivers flowing into the Gulf of Finland. The effects of the contamination load arising from the city of Leningrad and the largest river running into the Baltic Sea, the Neva river, are largely unknown.

Very few previous data have been published in the open literature for the Gulf of Riga. Therefore, the publication of the present Review seems to be timely in view of providing original data for this important Baltic Sea sub-area. High net sedimentation rates (1.5 - 2 mm/yr) have been found in two areas: one close to the outlet of the Daugava River, and another, more suitable for sea area monitoring, in the central basin.

The two most common types of sediments in the Baltic Proper are sand and clay mud. The central area of the Baltic Proper is well below the halocline, offering a relatively quiescent environment for sedimentation. The Gotland Deep is probably one of the best studied hydrographic and sediment stations in the world. However, the use of the Gotland Deep as a reference station for contaminant studies is possibly hampered by the quasi-permanent reducing conditions, which may affect the composition of contaminants in the sediments.

In the southwestern Baltic Sea, the Belt Sea, and the Kattegat, there are several deposition areas of muddy sediments. However, these areas may not be useful for monitoring, owing to the anthropogenic disturbance evident in the sediment surface because of the extensive trawling.

An evaluation of the sensitivity of the sediment response to changes in contaminant load is presented in the next chapter. This is also an original text. In the opinion of ACMP, this topic is very important and is often neglected in considering sediment studies in relation to pollution. The authors have taken into account the effects of the net sedimentation rate, the thickness of the mixing zone in the sediment surface, and the analytical uncertainties, in order to evaluate the time needed for a certain change in contaminant load to be detected in the chemical analysis of a sediment sample. One of the major aspects in the recommendations based on this report, namely, the selection of the temporal frequency of sediment monitoring, is based on the considerations presented in this chapter.

The most extensive chapter in the Review gives an account of the results of trace element studies, and conclusions concerning the overall distribution of elements in the Baltic Sea sediments. As the outcome of the ICES Baltic Sediment Intercomparison Exercise (1987) showed, most of the trace element data available on Baltic Sea sediments are not comparable. Consequently, most of the papers had to be reviewed separately.

A further chapter deals with the data available on organic contaminants, which are even more fragmentary than data on metals. In addition, most of the papers available failed to provide an adequate description of the sediment samples. The results are only of limited value for comparative studies. Therefore, it is not possible to assess the degree of organic contamination of the Baltic sediments. However, there is ample evidence to show that the Baltic sediments are contaminated by a number of anthropogenic organic substances. Distinct vertical gradients of DDT and PCB concentrations in sediments in anoxic basins are also reported.

A chapter is also devoted to phosphorus accumulation in the sediments of the Baltic Sea. The accumulation rate and exchange of phosphorus between bottom waters and sediments is discussed.

The ACMP considered that there is still more work to be done to improve the presentation and quality of this report. Accordingly, the ACMP has encouraged the editor to arrange for other specialists, e.g., marine sedimentologists, to review the document. The ACMP noted that the document will be ready for the 1990 Statutory Meeting. The ACMP was of the opinion that, after final editorial corrections, the document should be published in the Cooperative Research Report series.

On the basis of the conclusions of the report as presented, the ACMP recommended that the first Baseline Study on Contaminants in Baltic Sediments be conducted in 1993. Subsequent studies should be carried out at five-year intervals or longer. Finland has offered the use of R/V Aranda for the first exercise in 1993, which will include scientists from a number of the Baltic Sea countries. The proposed baseline study will cover all sedimentation areas identified in the review, and will be performed using identical sampling, storage and analytical methods for all aspects of the study. All countries bordering the Baltic Sea are invited to participate in the 1993 sediment baseline study. The details of the proposed study will be elaborated by a Steering Group to be established to coordinate this work, and the results of the 1993 exercise should be available in 1995 for the preparation of the Third Periodic Assessment of the State of the Baltic Sea.

15.2 Development of Sediment Quality Criteria

The ACMP has noted the considerable interest within the Oslo and Paris Commissions and national regulatory agencies in the development of criteria to evaluate the environmental significance of contaminants in marine sediments. Such criteria are required to assist in the interpretation of data from sediment monitoring programmes and for the assessment of dredged material intended for disposal at sea.

As described in previous ACMP reports, the comparison and interpretation of data on contaminants in sediments is complicated by the wide variation in sediment geochemistry, as well as the differing environmental conditions at the sea bottom. For similar reasons, there are inherent difficulties in developing sediment quality criteria that would be universally applicable on a regional basis. Nevertheless, the ACMP acknowledges that criteria for use at the regional or sub-regional level are a prerequisite for the development of standards or "limit values" that may be needed for regulatory purposes at the national or local level.

To address these issues, the ACMP has recommended the establishment of a special study group within ICES that will investigate and report on the scientific basis for the assessment of hazards associated with the presence of organic and inorganic contaminants in sediments. The study group will also examine methodologies and test procedures that may be used to evaluate the bio-availability of contaminants and which might afford a basis for sediment quality criteria. A progress report on these activities will be presented in the 1991 ACMP report.

16 EFFECTS OF EXTRACTION OF MARINE SEDIMENTS

The ACMP reviewed the draft Cooperative Research Report prepared by the Working Group on the Effects of Extraction of Marine Sediments on Fisheries and agreed that it is a useful background document for the formulation of basic guidelines for marine prospecting and mining, and also for fisheries consultations in connection with marine sand and gravel extraction. This report describes marine aggregate dredging, coastal engineering, and related activities in the coastal and shelf environments of ICES member countries. It then describes the effects of extraction activities on living resources and fisheries, including (1) the nature of physical impacts on the sea bed and water column, (2) the nature of chemical impacts on the sea bed and water column, and (3) the nature of biological impacts, including impacts on particularly sensitive species and communities. Finally, the report describes relevant management practices for aggregate extraction, including the development of laws and regulations, resource use planning activities, and monitoring activities. The ACMP noted that work on this report will continue intersessionally; the final report is expected to be completed in 1991 and should provide a useful review of current extraction activities and their effects.

The ACMP then reviewed the proposed "Code of Practice for the Commercial Extraction of Marine Minerals", which is also due to be finished in 1991. The ACMP agreed that there is a clear need for such a document. It considers that the aim of the Code of Practice is to provide a set of "rules" ensuring the balanced and effective protection of the marine environment such that commercially utilized fish, shellfish, and cephalopod stocks are not adversely affected. The ACMP asserts that the rationale for the Code of Practice is maintenance of the balance in favour of marine biota, and fisheries in particular, when other possibly conflicting and adverse activities are being planned or engaged upon. Fish and shellfish stocks, given a beneficial environment, are renewable resources with possibilities for long-term utilization, whereas the extraction of marine sediments/minerals is comparatively short-lived.

When completed, the ACMP expects this document to be of such a value and calibre that it will form the basic guidelines for how riparian states will manage and regulate the various steps in the extraction of marine sediments/minerals.

17 STUDIES IN THE BALTIC SEA AREA

17.1 Working Group on the Baltic Marine Environment

As far as studies in the Baltic Sea area are concerned, the ACMP is aware that the political changes occurring in some Baltic regions, with associated economic reorientation, will influence the future scientific studies in the Baltic Sea.

The ACMP is further aware that activities under the Helsinki Commission cover many important tasks and that the Helsinki Commission undertakes regular assessments of the environmental quality status of the Baltic Sea. The ACMP is anxious to ensure that some of the fundamental factors influencing the present environmental status of the Baltic Sea area are addressed and properly researched. To that end, the ACMP has asked the Working Group on the Baltic Marine Environment (WGBME) to identify important gaps in the knowledge of the Baltic Sea to supplement the Helsinki Commission's marine environmental protection programme. An example of success in identifying research gaps is given in the 1990 report of the WGBME, which identifies the need for more measurements on the production of bacteria, phytoplankton, mesozooplankton, zoobenthos and fish, as well as total biological community responses, biological oxygen demand, and particulate flux. The ACMP has asked that these research requirements be considered at the next meeting of the WGBME.

The ACMP took note of discussions within the WGBME to include in the present research programmes more quantitative investigations on biological production at different trophic levels, because there is a serious lack of rate measurements (which are now methodologically possible) for the ecosystem of the Baltic Sea. The ACMP also took note of discussions within the WGBME on net inputs of contaminants into the Baltic Sea, with the goal of proposing future joint investigations relevant to this topic. Such a project could compile realistic budgets and mass balances for contaminants in the Baltic Sea and will help in the understanding of the general problems of interaction and transport of substances between the coastal zone and the open sea. Further joint exercises should be supported by small-scale investigations on a national level. A description of the scientific objectives of these programmes should be carefully prepared within the WGBME, along with clear plans for how the objectives will be met.

17.2 Baltic Fish Chapter of the Second Periodic Assessment of the Baltic Marine Environment

The ACMP considered the information in the Baltic Fish Chapter that had been prepared under ICES as a contribution to the Second Periodic Assessment of the Baltic Marine Environment, conducted by the Helsinki Commission. This chapter had been reviewed by the Working Group on the Baltic Marine Environment (WGBME), which had commented on its coverage.

The chapter restricts itself to a detailed assessment of commercial fish stocks in the various regions of the Baltic Sea and possible environmental influences on them. It concludes that, while there are clear indications that changes in environmental conditions, such as the increasing occurrence of periods of hypoxia, notably in the Arkona Basin, Belt Sea, and southern

Kattegat, are affecting demersal fish and shellfish stocks, information is lacking on the influence of environmental conditions on pelagic stocks.

Having reviewed this chapter, the WGBME advocated that more ecologically oriented studies are needed. These should also take into consideration non-commercial organisms in an ecosystem approach using biological production rate measurements at different trophic levels. This would permit an assessment of the effects of changing environmental conditions on Baltic fish and shellfish.

The ACMP endorses this view. It considers that the detailed information about variations of commercial fish stocks and their recruitment in the various regions of the Baltic Sea, if supplemented by more ecologically oriented investigations, including non-commercial populations and better information on disease prevalences of commercial and non-commercial stocks, would significantly increase our understanding of how environmental changes are affecting the ecology of the Baltic Sea.

The ACMP considers that close cooperation between fisheries and environmental scientists will greatly increase the usefulness of such regional environmental assessments.

17.3 Joint International Investigation of the Skagerrak (SKAGEX)

The ACMP took note of a complete description of the plans for the joint international investigations in the Skagerrak area (SKAGEX), to be carried out between 14 May and 20 June 1990. The objectives of this programme are:

- a) to identify and quantify the various water masses entering and leaving the Skagerrak area, and their variations over time;
- b) to investigate the mechanisms that drive the circulation in the area, and its links with biological processes; and
- c) to investigate the pathways of contaminants through the Skagerrak.

The programme is designed to result in a substantial increase in understanding of the role of this transition area between the North Sea and the Baltic Sea, with its complicated circulation system. In particular, the ACMP expressed the hope that the project will result in an improved understanding of nutrient fluxes to and from the Skagerrak.

Based on experiences from earlier joint investigations (e.g., PEX), the ACMP emphasized that, when the results are integrated, particular attention should be directed towards the necessary quality assurance for all types of physical, chemical, and biological measurements within SKAGEX.

18 SEAL ISSUES

Previous advice on the seal disease epidemic of 1988 and its impact on seal populations around northern Europe was given in the 1989 ACMP report. Further findings on this epidemic and the potential role of environmental contaminants in its severity were discussed at a joint meeting of the Working Group on Baltic Seals and the Study Group on the Effects of Contaminants on Marine Mammals held in Stockholm on 14-17 May 1990. The ACMP examined the report of that meeting, and the following sections are largely drawn from it.

18.1 Final Report on the 1988 Seal Epidemic and its Impact on Seal Stocks

18.1.1 History of the Epidemic

The Study Group had agreed that the history and course of the epidemic in 1988 are precisely described in Dietz et al. (1989), from which the following description is drawn.

In April 1988 increasing numbers of aborted harbour seal (Phoca vitulina) pups were noted on the island of Anholt in the central Kattegat (see Figure 18.1 and Table 18.1 for the location of sites); this was soon followed by reports of dead seals older than one year. Aborted pups and older seals were found on the less accessible island of Hesselø (site 2, Figure 18.1) from late April onwards. However, a comparison of the time when 50% of the dead seals had been found for the two islands indicates that the epidemic probably originated on Anholt.

The disease spread rapidly to all other seal localities in the western Kattegat. Dead seals were observed at Læsø on 11 May, and ten days later in the eastern Kattegat and the Danish and Dutch Wadden Seas. The Skagerrak herds were not affected until June, when the disease was also identified in the German Wadden Sea and Limfjorden.

In early July, the seal herds in the Oslo Fjord area were hit, and by mid-July the small herd in the southwestern Baltic Sea was also affected. The first reports of infected seals in the British Isles were received at the end of July; during August and September the disease spread to all Scottish waters and the Irish Sea.

By the end of 1988 more than 18,000 dead seals had been reported. The majority of these were harbour seals, although some dead grey seals (Halichoerus grypus) were also found, particularly in the British Isles. By the end of 1988 only the scattered population of 2,500 harbour seals in northern Norway, the Icelandic population of 30,000 and a small group of around 100 seals in the Baltic Sea had escaped the disease. The distribution of deaths is summarized in Table 18.2.

Table 18.1 Timing of the seal epidemic in different European seal herds. Numbers of localities refer to the sites identified in Figure 18.1.

Area	Date in 1988 when 50% of dead seals were found
<u>Kattegat</u>	
1. Anholt	25 May
2. Hesselø	12 June
3. Læsø	28 June
4. Samsø	7 July
5. Southern Halland	25 June
6. Mid-Halland	27 June
7. Onsla-Öckerö	8 July
<u>Wadden Sea</u>	
8. Danish Wadden Sea	13 August
9. Schleswig-Holstein	17 August
10. Niedersachsen	4 September
11. Dutch Wadden Sea	4 September
<u>Skagerrak</u>	
12. Lysekil	19 July
13. Väderöarna	24 July
14. Koster	2 August
<u>Limfjorden</u>	
15. Limfjorden	3 August
<u>Western Baltic</u>	
16. Öresund	25 July
17. Southwestern Baltic	11 August
<u>Norway</u>	
18. Oslo Fjord	August
19. Southwestern Norway	August
<u>British Isles</u>	
20. East Anglia	September
21. The Irish Sea	September
22. Orkney Islands	September
23. West Scotland	October
24. Shetland Islands	October
25. East Scotland	September

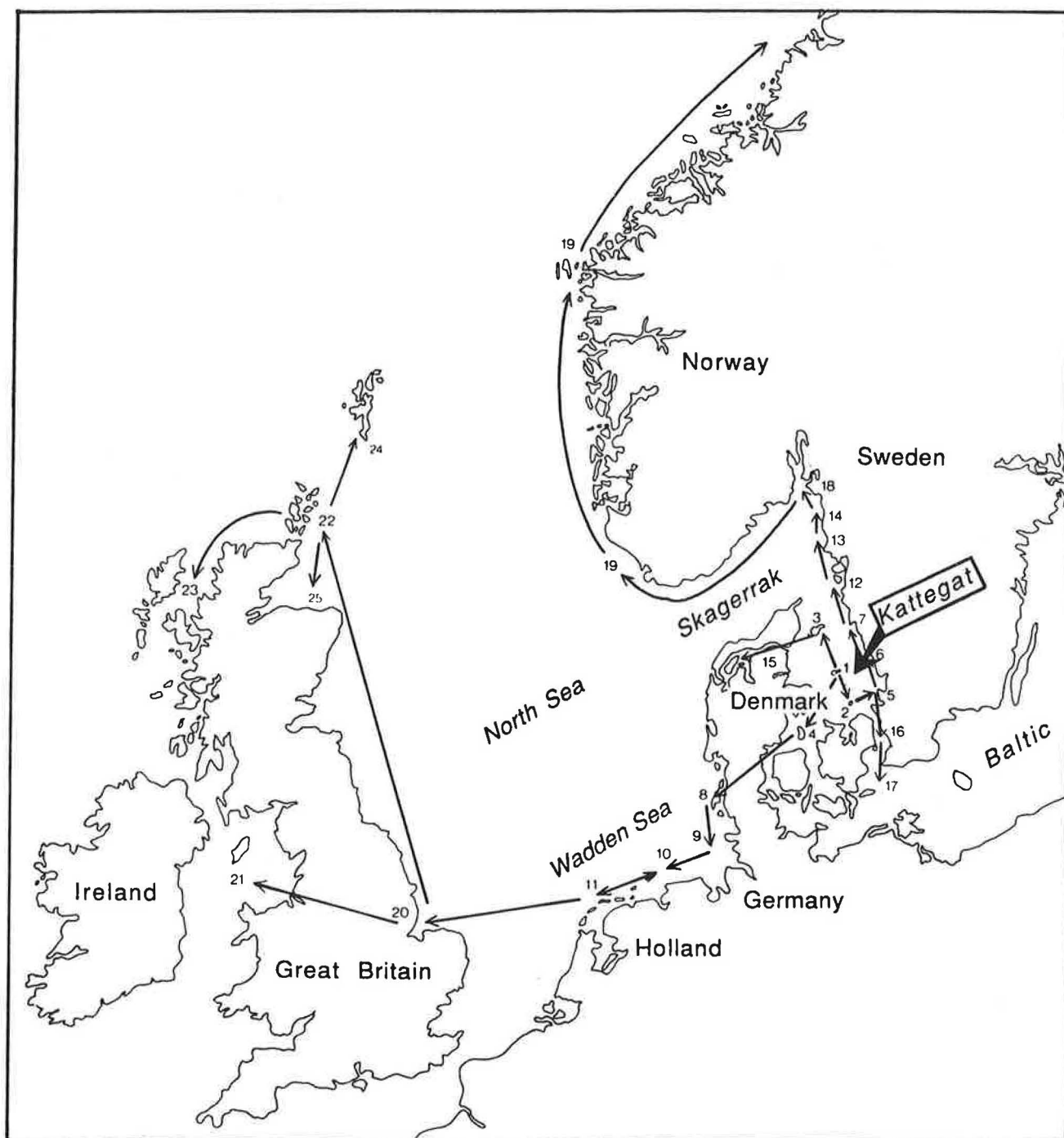


Figure 18.1 Map of Northern Europe showing route of dispersal of the seal disease (Numbers correspond to areas listed in Table 18.1). (From Dietz *et al.*, 1989, *Ambio* 18:258-264.)

Table 18.2 Number of dead harbour seals, grey seals and unidentified (unID) seals reported to national authorities in 1988 and 1989 using the areas defined in Table 18.1.

	1988	1989
<u>Western Baltic</u>	143 + 3 grey	4+3 grey
German Democratic Republic	9 + 2 grey	
<u>Kattegat</u>	3909 + 3 grey	<20
<u>Wadden Sea</u>		
Denmark	1238	22
Schleswig-Holstein	5808 + 2 grey	91
Niedersachsen	1100 + 4 grey	64
Netherlands	417	38+2 grey
<u>Skagerrak</u>	1469	18+1 grey
<u>Limfjorden</u>	391	1
<u>Norway</u>		
Oslofjord	467	-
Southwest	443	-
North	-	<50
<u>British Isles</u>		
East Anglia and NE England	316+57 grey+1115 unID	13+3 grey+27 unID
Irish Sea	71+28 grey+ 284 unID	0+1 grey+ 4 unID
Orkney Islands	159+ 4 grey+ 369 unID	66 + 3 unID
W & N Scotland	185+40 grey+ 349 unID	14+5 grey+ 5 unID
Shetland Islands	34+ 8 grey+ 17 unID	2 unID
East Scotland	59+23 grey+ 52 unID	4+7 grey+ 4 unID

In all areas apart from the north and west coasts of Norway and the British Isles, it was believed that at least 95% of all animals dying in 1988 had been recorded. This was because the deaths had occurred in relatively closed bodies of water and the carcasses had tended to float because of the effect of pneumonia. However, in the British Isles this phenomenon had probably resulted in a substantial proportion of carcasses being carried away from the coast and therefore not recorded. An approximate estimate of the level of under-reporting could be made if it was assumed that the proportion of seals hauling out on the east coast of England in August was the same as that estimated by Härkönen and Heide-Jørgensen (in press) for seals in the Kattegat/Skagerrak. In this case, it was estimated that 2,700 harbour seals had died in East Anglia in 1988, but only 1,400 (approximately 50%) had been found. Some of these missing carcasses may have washed ashore in the northern part of the Wadden Sea.

In the Kattegat/Skagerrak, western Baltic Sea and Wadden Sea, almost all of the dead animals which were examined in 1988 showed evidence of severe pneumonia, indicating that they had probably died as a result of phocine distemper virus (PDV) infection, or had been abandoned or born prematurely as a result of this infection. However, in the British Isles only about 50% of the small number of carcasses examined in detail had shown these symptoms.

Less than 500 dead seals were found in 1989. However, in the Wadden Sea, the number of dead seals reported in 1989 was substantially higher than in the years before 1988. In the Kattegat/Skagerrak, the number of dead seals found in 1989 was not different from the numbers found in the years before 1988, but this may have been because fewer pups than expected had been born in 1989, although the numbers at Anholt and Koster had been close to the expected level. This reduction was most noticeable at sites in the south. Almost all of the animals found dead in normal years were pups.

Seals showing symptoms of infection with the phocine distemper virus were recorded in Norway, Scotland and the Wadden Sea in 1989. Pneumonia was recorded for the first time in Baltic seals in 1988. However, many of the seals found dead in 1989 did not show symptoms of the disease.

18.1.2 Source of the disease

As reported in the 1989 ACMP Report, it is now generally accepted that the primary cause of the 1988 mass mortality was infection with a previously undescribed virus, now known as phocine distemper virus (PDV).

The origin of the virus is still unclear and may never be completely resolved. However, research is underway in laboratories in the UK, Netherlands, Denmark, Sweden, and the Federal Republic of Germany on the structure of the virus and its relationship to other morbilliviruses (such as canine distemper virus - CDV), and on the prevalence of these viruses in seal populations in the North Atlantic. Preliminary work (Dietz *et al.*, 1989b) has already indicated that ringed and harp seals around Greenland, and harbour seals in Canada (ICES, 1989) have been exposed to morbilliviruses. The viruses known to occur in Antarctic and Baikal seals appear to be more closely related to CDV than to PDV (Bengtson *et al.*, in press; Osterhaus *et al.*, 1989).

Analysis of the historical literature from the British Isles has indicated that mass mortalities have occurred there at least five times over the last 200 years (Harwood and Hall, in press). In many cases, the reported symptoms shown by the affected seals were similar to those observed in 1988.

18.1.3 Impact of the disease on seal populations

The most reliable way to estimate the mortality caused by the epidemic is to compare the results of surveys conducted before and after the epidemic, provided they have used the same techniques. The comparison should take account of expected population trends.

In the Kattegat/Skagerrak, aerial surveys were conducted in August 1988 after mortality due to the epidemic had ceased. Until 1988 the population had been increasing by 11% per annum and it was possible to calculate the expected population in August 1988 (see Härkönen and Heide-Jørgensen, in press). Results of land-based pup surveys carried out in the Kattegat/Skagerrak throughout June, July and August 1989 showed that pup production was lower than expected in the seal groups where the disease had its highest intensity from the end of June to the end of July.

In the Wadden Sea and the British Isles, the equivalent surveys were conducted in July and August 1989. The harbour seal population in the German Wadden Sea had been increasing up to 1988 and an expected population size in 1989 was calculated on this basis. There was no precise information on rates of change for harbour seal stocks in the British Isles and it has been assumed that these were stationary.

Table 18.3 Results of seal surveys in 1988 and 1989 and estimates of mortality due to the 1988 virus epidemic. Survival was calculated as: (result of the 1989 survey [or 1988 survey if this was conducted after deaths from the epidemic had ceased])/(number of animals expected if there had been no unusual deaths in 1988)

<u>Kattegat</u>	expected 1988: 1666 mortality: 56%	observed 1988: 732
<u>Skagerrak</u>	expected 1988: 5287 mortality: 60%	observed 1988: 2239
<u>Wadden Sea</u>	expected 1989: 12000 mortality: 60%	observed 1989: 4500
<u>British Isles</u>		
East Anglia	expected 1989: 3900 mortality: 48%	observed 1989: 2013
Irish Sea	expected 1989: 750 mortality: 40%	observed 1989: 449
Orkney	expected 1989: 6616 mortality: 0%	observed 1989: 7070
West Scotland	expected 1989: 3498 mortality: 0%	observed 1989: 3605
East Scotland	expected 1989: 1180 mortality: 15%	observed 1989: 1004

It was impossible to calculate mortality for the western population of Baltic harbour seals because there were no estimates of the size of the portion of the population in Danish waters. Similar problems existed for the calculation of mortality in Limfjorden. However, in both areas mortality was believed to be of a similar order to that estimated for the Kattegat/Skagerrak and Wadden Sea.

18.1.4 Status of other North Sea and Baltic seal stocks

Although grey seals appeared to have been less affected by the epidemic than harbour seals, the number of pups born at UK colonies was about 15% less than expected. It is not known whether this was related to virus infection, but over 98% of all breeding grey seals tested in 1988 had significant levels of antibodies to PDV. There was no evidence of PDV in grey seals before this date.

Recent data from Soviet scientists have made it possible to revise estimates for the size of the Baltic grey seal population from 2,000 (ICES, 1989) to 2,500 - 3,000 animals.

18.1.5 Vulnerable populations and causes for concern

The joint meeting of the Working Group on Baltic Seals and the Study Group on the Effects of Contaminants on Marine Mammals had concluded that, although a number of harbour seal populations around the North Sea had suffered a substantial mortality as a result of the seal epidemic, only the population in the Baltic Sea could be described as vulnerable. Overall, the only seal populations in Northwestern Europe which are potentially vulnerable are those in the Baltic Sea. However, some groups of seals - such as those in the Dutch Wadden Sea - which are part of a larger non-vulnerable population, might be considered vulnerable within particular national boundaries.

18.2 Relationship between Contaminant Burden and the Health of Seal Stocks

None of the information on contaminant levels in seals found dead during the epidemic, nor in seals which had been exposed to PDV but which had survived, provided any evidence of a direct link between environmental contamination and the extent and severity of the 1988 seal epidemic. However, the general feeling of the experts directly involved was that evidence is accumulating, from other mammal species, concerning the potentially detrimental effect of organohalogen compounds on resistance to disease and reproduction.

Unpublished work in Sweden on mink (Mustella vison) has indicated that the 0 and 1 ortho chlorine fractions of chlorobiphenyls were the most biologically active fractions in suppressing reproduction. Only one of the standard PCB congeners used in ICES analyses is of this type. The joint meeting recommended that additional 0 and 1 ortho chlorine congeners, as well as some coplanar ones, should be added to the list of compounds being considered by the Marine Chemistry Working Group for intercomparison exercises. This suggestion has been taken up and acted upon by the ACMP (see Section 14.3).

Results of experiments with mice (Jönsson et al., in press) have indicated that the methylsulphonyl metabolites of DDE could have a substantial effect on adrenal gland activity. The primary cause of the disease complex (including skin and claw lesions, regional chronic intestinal ulcers, arteriosclerosis, renal glomerulopathy, and uterine lesions) that has been observed in Baltic seals is pathological changes in the adrenals (adrenocortical hyperplasia) (Bergman and Olsson, 1986). Methylsulphonated metabolites of DDE and PCB have been found in Baltic seals (Jansson et al., 1975).

These findings imply that measurements of the concentrations of total PCBs and DDT in seal tissues, particularly blubber, might not provide a reliable indication of the biological effects of these compounds.

Although marine mammal tissues often contain relatively high concentrations of contaminants, particularly those which are fat soluble, they are not suitable animals for the quantitative monitoring of environmental contamination. This is because the body burden will have been accumulated over the animal's life time, during which time it may have fed over a wide area. Changes in the structure of the marine food web as a result of man's activities may well affect the way contaminants are transmitted up the food chain. This makes the interpretation of changes in contaminant levels in top predators difficult. However, marine mammals are useful qualitative indicator species in three senses:

1. They provide an integrated view of contaminant levels over wide geographical areas.
2. The first measurable levels of novel organic contaminants are likely to be found in their tissues.
3. The wide range of contaminant burdens found in marine mammals of the same age and sex may be a consequence of different feeding strategies. If this is so, it may be possible to identify local contamination "hot spots" by tracking the movements of individuals with particularly high body burdens.

In a number of sea areas, the decline in organochlorine contaminant levels in marine mammals observed in the late 1970s and early 1980s has not continued. This implies that there is some continuing input of these compounds into the marine environment. Further research on the source and nature of these inputs is therefore required.

In view of the evidence of continuing sources and inputs of PCBs and the accumulating evidence that PCBs may be adversely affecting seals in some parts of the ICES area, the ACMP recommends the continued development and use of safe disposal and/or destruction methods for PCBs.

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19 CLASSIFICATION OF SUBSTANCES IN THE CONTEXT OF THEIR HAZARDS

The ACMP is aware that the Helsinki Commission has requested advice on schemes for the identification of chemical substances that might be of concern to the marine environment based on toxicity and other properties of these substances. The ACMP has, in its statement of management principles for environmental protection contained in the 1989 ACMP Report, outlined some of the considerations relevant to schemes that attempt to classify and assign priority to substances.

In the statement of management principles, the ACMP stressed the difference between: (1) substances that have toxicological effects that are related to exposures above some threshold; and (2) substances that have purely probabilistic (stochastic) effects. In the first case, substances having deterministic (non-stochastic) effects include elements and compounds that are essential to biological systems, but may become toxic at high levels of exposure. In the second case, substances having stochastic effects are those for which the risk of adverse effect is proportional to exposure. Thus, assessments of the potentially adverse effects of these substances have to be made on the basis of risks and their acceptability.

It is currently more difficult to deal with the potential for impacts on marine organisms than the potential for impacts on human health. This is because our understanding of dose-response and dose-effect relationships is better for humans than for marine biota. Both national and international guidelines exist regarding the limits of exposure to members of the public, for example through seafood consumption, to a variety of substances, many of which are environmental contaminants. These guidelines are usually based on evaluations of exposures through a range of contributing exposure pathways. Partitioning of total exposures among different sources may also be a component of guideline and standards formulation. Some authorities also specify limits of exposure in the context of advisory statements concerning human activities that involve exposure to particular substances. For example, standards for mercury in seafood have occasionally been accompanied by a recommendation to limit the frequency of consumption of certain types of seafood.

In the case of human exposures to substances suspected of having stochastic effects (e.g., assumed cancer-causing agents), some agencies have taken a relatively cautious or conservative approach for public policy purposes in assessing the likely risks to human health. Such approaches often adopt an assumption of a linear relationship between exposure and the risk of adverse effects extending to zero exposure (i.e., no threshold for effect is assumed). An example of this is the current U.S. Environmental Protection Agency procedure for assessing the risks of cancer induction in humans caused by exposure to assumed carcinogens. The risks to human health associated with the consumption of seafood containing a range of organic compounds, suspected of being cancer-causing agents, have been evaluated. This procedure allows the relative magnitudes of risk associated with such exposures to

be evaluated. These are then used for assigning priorities to the acquisition of further data on the incidence of these substances in food or the imposition of remedial measures to reduce risks to human health. This procedure thus provides a basis for the classification of hazards associated with contaminants in the marine environment, but only from human health protection perspectives.

Finally, in the context of this discussion, the ACMP wishes to draw attention to the statement prepared by GESAMP (Annex 7), particularly Section 3.4, which provides some additional perspectives on the manner in which persistence, toxicity, and bio-availability need to be considered in classification schemes.

20 OVERVIEWS OF CONTAMINANTS IN THE MARINE ENVIRONMENT

20.1 Overview on Hexachlorobenzene and Lindane in the Marine Environment

An updated overview on hexachlorobenzene (HCB) and Lindane (γ -hexachlorocyclohexane (γ -HCH)) is provided in this section.

20.1.1 Introduction

This paper gives an update on previous overviews (Portmann, 1986; ICES, 1987) on the occurrence, distribution and fate of hexachlorobenzene (HCB) and lindane (γ -HCH) in the aquatic environment. Both materials are still used extensively, for different applications, in different environments, and both enter the marine environment in trace concentrations through riverine inputs, atmospheric deposition or by direct disposal of wastes at sea. Clearly, it may be possible to restrict the inputs to the sea by discharge or dumping, but this is less so for inputs via runoff to the rivers or from atmospheric deposition. Both compounds are usually determined as part of a scheme for the measurement of "organochlorine residues" in which DDT and its metabolites and polychlorinated biphenyls (PCBs) tend to be the predominant determinands and are present at significantly greater concentrations unless the sample is contaminated locally by γ -HCH or HCB. The inclusion of HCHs and chlorobenzenes in these master analytical schemes can lead, misguidedly, to their being regarded as chemically similar simply because they are amenable to a common method of detection.

The physiochemical and biological properties of these compounds are significantly different from each other and from many of the other, more routinely determined, organochlorine residues. There is a large body of information which has been compiled in a number of reference texts (Verschuieren, 1983; Sax, 1985; Mayer and Ellersieck, 1986). Data compiled on both compounds by Verschuieren (1983) show that there can be a wide range of values for a number of properties. For example, literature values for the water solubility of lindane (γ -HCH) range from 2 to 17 mg/l (Table 20.1), which may reflect the observations in recent studies (Smith *et al.*, 1988) that other factors, e.g., the dissolved humic fraction, can significantly influence properties such as solubility (Chiou *et al.*, 1986) and bioavailability (Ekelund *et al.*, 1987).

There are some serious nomenclature anomalies in the literature, particularly in reviews and data compilations, for hexachlorocyclohexane (HCH) and hexachlorobenzene (HCB). The often used, but incorrect, name for HCH has been "Benzene Hexachloride" (BHC). In some instances, this has even been misinterpreted as equivalent to HCB.

As an example from an otherwise authoritative compilation of environmental data (Verschuieren, 1983), bioconcentration factor data for γ -HCH have clearly been entered under hexachlorobenzene.

Even environmental chemists who are aware of this problem need to remain vigilant.

20.1.2 Hexachlorobenzene (HCB)

Hexachlorobenzene (perchlorobenzene) is used in the manufacture of other materials, e.g., in pesticide production, as a fluxing agent in aluminium smelting; it is a bi-product in the synthesis of other organic compounds, e.g., pentachlorophenol production, vinyl chloride monomer production. It is also used in formulation products as a seed dressing and as a wood preservative. The potential origins of HCB waste are numerous and may come from industry, not only during HCB production, but from its use in urban industry, in semi-rural (timber treatment) and rural (seed dressing) settings, although most recent estimates (Portmann, 1979b) would suggest that it has been largely replaced as a fumigant. These activities contribute to the presence of HCB in rivers and streams.

HCB has a reasonably high volatility (1.089×10^{-5} mmHg) and will also enter the atmosphere from the surface water film and from soils. However, it is only sparingly soluble in water (1-10 µg/l) and, like most other similar lipophilic materials, it partitions readily into the surface water organic film, onto suspended solids and sediments, and is absorbed by biota, having a bioconcentration factor of (log BCF) 5.23-6.2 (Portmann, 1986; Veith *et al.*, 1979). The ratio of the distribution in each of the three compartments is governed by the type of water body. Smith *et al.* (1988), in their review on partitioning of non-ionic organic compounds in aqueous systems, showed that dissolved organic material (DOM) (1-100 mg/l) could significantly increase the effective solubility of materials like HCB ($\times 2-10$), whereas more soluble materials, such as γ -HCH, with a solubility three orders of magnitude higher, were not affected in the same way.

Although HCB has been monitored as an environmental contaminant for a number of years, there is relatively little consistent information on the trophic transfer in aquatic ecosystems (Biddinger and Gloss, 1984). The relative importance of the route of uptake, observed by different researchers, is often a reflection of the conditions of the experiment and the species studied, e.g., bioconcentration factors (i.e., water to tissue ratios) for catfish (*Ictalurus punctatus*) were measured in close proximity to HCB-rich sediment, which may have compromised the real "water to tissue" transfer by absorption of HCB-rich particulates rather than adsorption through the aqueous phase (Isensee, 1978). Some data (Metcalf *et al.*, 1973) suggest that a major transfer route is via the food chain. Most workers conclude that HCB is highly persistent and is not easily degraded, the main route of metabolism being hydroxylation to pentachlorophenol with excretion in urine as the glucoronide or the sulphate.

The LC_{50} values for HCB range from 0.5-100 mg/l (96 hr) in a static system and exceed 1.0 mg/l (96 hr) in a flow-through system for a range of freshwater species using both wettable powder and technical formulation exposures (Mayer and Ellersieck, 1986).

No major environmental incidents involving the spillage (discharge of acutely toxic levels) of HCB have been reported recently. Most concentrations of HCB in water are of the order of at least 10^3 , and often 10^5 , less than the most sensitive LC_{50} levels. In normal, uncontaminated waters, the concentrations of

HCB would be <1 ng/l (Table 20.2). Concentrations above this level would indicate a local source of HCB, but even in such circumstances the concentration is likely to remain some 10^3 below acutely toxic levels.

Most of the HCB in the water column remains attached to particulate material and this is fully supported by data from the Ebre Delta, Western Mediterranean (Grimalt *et al.*, 1988) (Table 20.2).

Higher levels of HCB are found in sediments (0.1-10 $\mu\text{g/kg}$; Portmann, 1986) and particularly in southern North Sea sediments (3-100 $\mu\text{g/kg}$; Boon *et al.*, 1985) where the organic content absorbs the HCB and acts as a sink, as it does for other non-polar aromatic lipophilic trace organics. HCB is slowly degraded in sediments, probably by microbial dechlorination; but in most places, remote from point sources, the concentrations are likely to be kept relatively constant at this low, background level with the input from terrestrial and atmospheric sources (Table 20.3).

The concentrations of HCB in biota from a wide range of sources reflect both the location relative to local HCB inputs and the food chain (Tables 20.4-20.6). Most samples contain concentrations of <100 $\mu\text{g/kg}$ and, in most cases, considerably less. Biota obtained from areas where there is a local source of HCB have elevated concentrations, viz., flounder from the Baltic Sea south of Copenhagen contained 233 $\mu\text{g/kg}$ HCB; similarly, mussels from the Firth of Forth, Scotland contained 231 $\mu\text{g/kg}$ HCB.

De Boer (1989) has reported a decline in HCB levels in cod liver in the southern North Sea from 470 $\mu\text{g/kg}$ in 1977 to around 50 $\mu\text{g/kg}$ in 1987. However, there was no such similar trend in the northern North Sea, where the concentrations remained between 40-80 $\mu\text{g/kg}$ during the decade 1977-1987. Although there are known sources of HCB which enter the northern North Sea (DAFS, 1978), it is clear that the major inputs are from the rivers which discharge into the southern North Sea.

Knickmeyer and Steinhart (1989) found an average HCB concentration of 21.4 ± 24.1 $\mu\text{g/kg}$ in dab liver (*Limanda limanda*) taken from 28 stations in the southern North Sea in 1987. The level of HCB in the ovaries was 84.5 ± 66 $\mu\text{g/kg}$. These data, along with data on individual chlorobiphenyl analysis, have been used to suggest that there is a preferential transfer of hexachlorinated aromatic chemicals from female liver to ovaries.

Marine mammals from the northern hemisphere generally have higher concentrations of organochlorine residues than most lower trophic levels and this is evident for HCB (Tables 20.4-20.6) (Muir *et al.*, 1988). Most of the intake of organic contaminants for the top predator group is via the food chain and, since these materials concentrate to a high degree in the blubber and are only metabolised slowly, there is an increase in concentration with age (Phillips, 1980). However, the presence of these compounds in marine mammals is very dependent on latitude (Tanabe, 1988) and this is reflected in the very low values for HCB in fur seals caught in southern Australia (Smillie and Waid, 1987). This trend may be related to variations in the proportion of fat in mammalian tissues.

20.1.3 Lindane (γ -HCH)

Gamma-hexachlorocyclohexane (lindane) is one of a series of HCH isomers, but is the most widely used. Technical formulations comprising mixtures of the isomers have been used in the past, but most HCH is now marketed as the single γ isomer: lindane. It has a wide variety of uses in agriculture as a seed dressing (in common with HCB) and as an insecticide. It is used in veterinary products, horticultural and domestic applications, as well as for preventative and remedial timber treatment, often in conjunction with pentachlorophenol. It remains one of the few organochlorine formulations which is still in widespread use, with less limiting restrictions in most countries.

Although this widespread use has led to significant quantities of HCH being released into the fresh water and eventually the marine environment, the concentrations in biota are relatively small. This is due to the high vapour pressure (0.031 mm Hg @ 20°C) and relatively high solubility (2-12 mg/l) (Portmann, 1986; OECD, 1981; Sax, 1985). Both are significantly greater than those properties for hexachlorobenzene. This higher solubility, some 10^3 greater than for many other organochlorine pesticide residues, accounts for the tolerance of the aquatic biosphere to such a powerful, toxic insecticide.

The higher water solubility of HCH also decreases the proportion of the aquatic load which is associated with particulate material. Oliver and Niimi (1988) confirmed this relationship during the compartmental studies on Lake Ontario. Similarly, less HCH is associated with the sediment (Tables 20.2 and 20.3).

The bioconcentration factor (BCF) ranges between 10^2 and 10^3 and this is reflected in the relatively low residue levels in most samples of biota from sites relatively remote from specific inputs of HCH (Tables 20.3-20.6).

The concentration of HCH in most biota remote from local sources is normally <10 $\mu\text{g/kg}$, but may reach several 100s $\mu\text{g/kg}$ in contaminated areas. Reviews of the toxicity of HCH to marine life (Portmann, 1979) suggest that water concentrations below 10 ng/l are unlikely to be a threat to most species of marine life. However, in this context, it should be noted that concentrations of the order of a few ng/l have been reported in the North Sea, especially in the German Bight (Gaul, In prep.).

De Boer (1989) has reported a clear temporal trend for γ -HCH in cod livers in the North Sea; from 300 $\mu\text{g/kg}$ in 1977 to around 50 $\mu\text{g/kg}$ in 1987 in the southern North Sea, and from 150 $\mu\text{g/kg}$ in 1977 to about 50 $\mu\text{g/kg}$ in 1987 in the northern North Sea. The mean γ/α ratio declines from 1.1 in the south to 0.26 in the north. Since γ -HCH can be converted into α -HCH in the aquatic environment (Benezet and Matsumara, 1973), these differences in γ/α ratios would suggest that there is a continuing source of lindane input into the southern North Sea.

A northern/southern hemisphere distribution pattern for HCH concentrations occurs in marine mammals, reflecting the difference in global use and distribution (Smillie and Waid, 1987; Muir *et al.*, 1988; Tanabe, 1988).

20.1.4 The Value of Detailed Analysis of HCB and γ -HCH

Information on the concentrations of both HCB and γ -HCH generally becomes available as part of the analytical schemes for the determination of more abundant organochlorine residues, such as chlorobiphenyls and DDT. With their present usage and distribution, neither compound appears (on the basis of present knowledge) to be a direct threat to aquatic wildlife. However, both compounds are relatively easy to determine as they do not appear to suffer from the same gas chromatography analytical interference problems associated with chlorobiphenyl (CB) determinations and are not complicated by a high degree of metabolism (as for, e.g., DDT). Their physiochemical parameters are significantly different and their behaviour in each of the three main aquatic compartments is one of contrast.

These factors, coupled with the existing knowledge of the compounds, should make them suitable, if not ideal, model compounds to study the transport of trace organic components in fresh water and the gross and net fluxes to the open sea (Halfon, 1986; Chan *et al.*, 1986). The value of such an approach is clearly dependent on the background concentrations and fluxes in any riverine system, but the determination of these compounds can give valuable additional information in the study of the processes involved in the transport of trace organics to the marine environment.

20.1.5 References and Bibliography

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Table 20.1 Physiochemical and biological properties of γ -hexachlorocyclohexane (γ -HCH) and hexachlorobenzene (HCB).

	γ -HCH	HCB	Reference
Solubility in water	2-12 mg L ⁻¹	1-5 μ g L ⁻¹	Portmann (1986)
	9.12 mg L ⁻¹	9.77 μ g L ⁻¹	OECD (1981b)
Density	1.87 gm L ⁻¹	2.05 gm L ⁻¹	Portmann (1986)
Vapour pressure (mmHg)	1.5×10^{-5} @ 25 ⁰ C	1.09 @ 20 ⁰ C	Portmann (1986)
Log P (octanol:water)	3.72	6.2	Portmann (1986)
	3.89 ^a	5.23 ^b	a) Bruggeman <i>et al.</i> (1982) b) Veith <i>et al.</i> (1979)
	3.66 ^a	5.56 ^b	a) Kanazawa (1981) b) OECD (1981)
Log BCF	2-3	4-5.2	Portmann (1986)
<u>Asellus aquaticus</u>	1.7		Thybaud and le Bras (1988)
Guppies		5.46	Könemann & van Leeuwen (1980)
Rainbow trout		5.16-5.37	Oliver & Niimi (1983)
Catfish		5.9	Pereira <i>et al.</i> (1988)
Fathead minnow (<u>Pimephales</u> <u>prometas</u>)	2.26	4.27	Veith <i>et al.</i> (1979)

Table 20.2 Concentrations of γ -HCH and HCB in water and suspended particulate matter.

Water solution

Location of the samples	Date	Sample type	Mean HCH pg/l	Range - HCH pg/l	Mean HCB pg/l	Range - HCB pg/l	Reference
Northern North Pacific	1980-82	solution		610 - 680			Kawano <i>et al.</i> , 1988
Port Said (Med)	1983	solution	775	100 - 7600	2100	100 - 12600	el-Dib and Badawy, 1985
Lake Ontario	1984	solution	300	180 - 420	150	100 - 200	Oliver and Niimi, 1988
Ebre Delta (west Med)	1985-86	solution			4.0	1.0- 21	Grimalt <i>et al.</i> , 1988
Ebre Delta (west Med)	1985-86	solution			2.0	0.8- 4.0	"
Ebre Delta (west Med)	1985-86	solution			1.0	0.6- 2.0	"
Ebre Delta (west Med)	1985-86	solution			2.2	0.6- 9.0	"
Ebre Delta (west Med)	1985-86	solution			55	2.4- 200	"
Ebre Delta (west Med)	1985-86	solution			200	4.0- 1000	"
Ebre Delta (west Med)	1985-86	solution			20	2.4- 53	"

Water suspension

Location of the samples	Date	Sample type	Mean HCH pg/l	Range - HCH pg/l	Mean HCB pg/l	Range - HCB pg/l	Reference
Lake Ontario	1984	particulates	0.9	0.2-1.6	36	26 - 46	Oliver and Niimi, 1988
Ebre Delta (west Med)	1985-86	particulates			14	5.0- 53	Grimalt <i>et al.</i> , 1988
Ebre Delta (west Med)	1985-86	particulates			19	5.0- 81	"
Ebre Delta (west Med)	1985-86	particulates			31	16 - 150	"
Ebre Delta (west Med)	1985-86	particulates			12	0.0- 35	"
Ebre Delta (west Med)	1985-86	particulates			600	30 - 1500	"
Ebre Delta (west Med)	1985-86	particulates			780	38 - 2200	"
Ebre Delta (west Med)	1985-86	particulates			51	16 - 120	"

Table 20.3 Concentrations of γ -HCH and HCB in sediment.

Sediment

Location of the samples	Date	Sample type	Mean HCH $\mu\text{g/kg}$	Range - HCH $\mu\text{g/kg}$	Mean HCB $\mu\text{g/kg}$	Range - HCB $\mu\text{g/kg}$	Reference
Southern North Sea	1982	Sediment	6.0		2.0		Boon <i>et al.</i> , 1985
"	1982	Sediment	0.0		3.0		"
"	1982	Sediment	2.0		5.0		"
"	1982	Sediment	10		50		"
"	1982	Sediment	8.0		6.0		"
"	1982	Sediment	40		100		"
"	1982	Sediment	20		90		"
Port Said (Med)	1983	Sediment	27	5.0 - 126	4.1	0.1 - 12	el-Dib and Badawy, 1985
Lake Ontario	1984	Sediment	1.0	0.4 - 1.6	100	41 - 159	Oliver and Niimi, 1988
Bay of Bengal	1984	Sediment		10 - 210			Sarka and Sen Gupta, 1988

Table 20.4 Concentrations of γ -HCH and HCB in biota.

Location of the samples	Date	Sample type	Species	Tissue	Mean HCH $\mu\text{g/kg}$	Range - HCH $\mu\text{g/kg}$	Mean HCB $\mu\text{g/kg}$	Range - HCB $\mu\text{g/kg}$	Reference
Wadden Sea	1970-73	Herring		Muscle	3.3				
English catches	1974	Many species		Muscle		1.0- 66			Portmann <u>et al.</u> , 1979b
Dutch coast, North Sea	1974	Mussel	<u>Mytilus edulis</u>		3.2				Ten Berg & Hillebrand, 1974
Wadden Sea	1975	Plaice		Muscle	11.3				"
Lake Superior	1975	Lake trout		Muscle	100		80		Swackhammer & Hites, 1988
Siskiwit Lake	1975	Lake trout		Muscle	300		100		"
Lake Superior	1975	Whitefish		Muscle	100		60		"
Siskiwit Lake	1977	Whitefish		Muscle	200		0		"
Solway, Scotland	1977	Mussel	<u>Mytilus edulis</u>		7.0	6.0-12	6	6 - 6	Cowan, 1981
Clyde, Scotland	1977	Mussel	<u>Mytilus edulis</u>		11	6.0-53	6	6 - 12	"
West coast, Scotland	1977	Mussel	<u>Mytilus edulis</u>		6.0	6.0-12	6	6 - 6	"
North coast, Scotland	1977	Mussel	<u>Mytilus edulis</u>		6.0	6.0-12	6	6 - 6	"
Moray Firth, Scotland	1977	Mussel	<u>Mytilus edulis</u>		8.0	6.0-12	6	6 - 12	"
East coast, Scotland	1977	Mussel	<u>Mytilus edulis</u>		8.0	6.0-12	6	6 - 12	"
Tay, Scotland	1977	Mussel	<u>Mytilus edulis</u>		8.0	6.0-12	6	6 - 6	"
Forth, Scotland	1977	Mussel	<u>Mytilus edulis</u>		9.0	6.0-23	19	6 - 53	"
Orkney, Scotland	1977	Mussel	<u>Mytilus edulis</u>		6.0	6.0- 6.0	7	6 - 12	"
Shetland, Scotland	1977	Mussel	<u>Mytilus edulis</u>		6.0	6.0- 6.0	8	6 - 12	"
Lake Superior	1977-79	Lake trout		Muscle	100		50		Swackhammer & Hites, 1988
Lake Superior	1977-79	Whitefish		Muscle	200		100		"
English catches	1977-84	Many species		Muscle		1.0-75		1 - 98	Franklin, 1987
River Tweed, Scotland	1979	Trout	<u>Salmo trutta</u>	Liver		1.0-19			Wells (DAFS Un- pub. data)
" " "	1979	Trout	<u>Salmo trutta</u>	Muscle		1.0- 5.0			"
Firth of Clyde, Scotland	1980	Herring	<u>Clupea harengus</u>	Liver		4.0-31			"
Firth of Clyde, Scotland	1980	Herring	<u>Clupea harengus</u>	Muscle		4.0-11			"
Northern North Pacific	1980-82	Zooplankton			17	12.0-21			Kawano <u>et al.</u> , 1988
Northern North Pacific	1980-82	8-armed squid		Muscle	9.0	8.0-10			"

(cont'd)

Table 20.4 (cont'd)

Location of the samples	Date	Sample type	Species	Tissue	Mean HCH µg/kg	Range - HCH µg/kg	Mean HCB µg/kg	Range - HCB µg/kg	Reference
Northern North Pacific	1980-82	Walleye pollock		Muscle	14	13 - 14			Kawano <u>et al.</u> , 1988
Northern North Pacific	1980-82	Chum salmon		Muscle	11	9.5- 12			"
Northern North Pacific	1980-82	Dalls porpoise		Muscle	73	35 - 100			"
Northern North Pacific	1980-82	Thick billed murre		Muscle	9.0	4.0- 15			"
Baltic, South Copenhagen	1981	Flounder		Ovaries		0.4- 5.6		0.1 - 2	Westernhagen <u>et al.</u> , 1981
Baltic, South Copenhagen	1981	Flounder		Liver		4.0- 13			"
Signdals Fjord, Dalsfjord	1982	Cod		Liver	10	6.0- 16			Skane <u>et al.</u> , 1985
Signdals Fjord, Dalsfjord	1982	Haddock		Liver	9.0	4.0- 15			"
Signdals Fjord, Dalsfjord	1982	Lemon sole		Liver	1.0	1.0- 3.0			"
Signdals Fjord, Dalsfjord	1982	Flounder		Liver	1.0	0.0- 2.0			"
Orkney Islands, Scotland	1982-86	Otters		Liver	580	0.0-2440			Mason & Reynolds, 1988

Table 20.5 Concentrations of γ -HCH and HCB in biota.

Biota

Location of the samples	Date	Sample type	Species	Tissue	Mean HCH $\mu\text{g/kg}$	Range - HCH $\mu\text{g/kg}$	Mean HCB $\mu\text{g/kg}$	Range - HCB $\mu\text{g/kg}$	Reference
Siskiwit Lake	1983	Lake trout		Muscle	100		60		Swackhammer & Hites, 1988
Siskiwit Lake	1983	Whitefish		Muscle	200		90		"
Port Said (Med)	1983	Sole	<u>Solea vulgaris</u>	Muscle	20.4		0.1		el-Dib & Badawy, 1985
Port Said (Med)	1983		<u>Spartus auratus</u>	Muscle	0.1		12.3		"
Port Said (Med)	1983		<u>Argyrops spinifer</u>	Muscle	1.5		3.9		"
Port Said (Med)	1983		<u>Saurida</u> sp.	Muscle	0.1		2.5		"
Port Said (Med)	1983		<u>Trichurus</u> sp.	Muscle	0.1		0.1		"
Port Said (Med)	1983	Sardine	<u>Sardinella aurita</u>	Muscle	0.1		0.1		"
Port Said (Med)	1983	Sole	<u>Solea vulgaris</u>	Muscle	14.7		63.5		"
Port Said (Med)	1983		<u>Spartus auratus</u>	Muscle	45.3		78.3		"
Port Said (Med)	1983		<u>Argyrops spinifer</u>	Muscle	40.4		96.2		"
Port Said (Med)	1983		<u>Saurida</u> sp.	Muscle	41.1		74.3		"
Port Said (Med)	1983		<u>Trichurus</u> sp.	Muscle	40.4		23.9		"
Port Said (Med)	1983	Sardine	<u>Sardinella aurita</u>	Muscle	1.2		0.1		"
Lake Ontario	1984	Plankton			0.2		1.6		Oliver & Niimi, 1988
Lake Ontario	1984	Trout		Muscle	2.8	1.0 - 4.6	5.0	2.0- 8.0	"
Quebec-Labrador Lakes	1984	Trout		Muscle	1.0	0.0 - 1.0			Lockerbie & Clair, 1988
Quebec-Labrador Lakes	1984	Trout		Liver	2.0	1.0 - 3.0			"
Quebec-Labrador Lakes	1984	Trout		Gonads	1.0	0.0 - 2.0			"
Lawn River, FRG	1984	Roach		Muscle	1.0	0.0 - 2.0	1.0	0.0-233	Schüler <i>et al.</i> , 1985
Shatt al-Arab River, Iraq	1984	Indian shad	<u>Tenvalosa ilisha</u>	Muscle	9.0	3.0 -15			Douabel <i>et al.</i> , 1987
Shatt al-Arab River, Iraq	1984	Indian shad	<u>Tenvalosa ilisha</u>	Muscle	4.0	2.0 - 7.0			"
Shatt al-Arab River, Iraq	1984	Indian shad	<u>Tenvalosa ilisha</u>	Muscle	3.0	0.0 - 3.0			"

(cont'd)

Table 20.5 (cont'd)

Location of the samples	Date	Sample type	Species	Tissue	Mean HCH µg/kg	Range - HCH µg/kg	Mean HCB µg/kg	Range - HCB µg/kg	Reference
Canadian Arctic	1984	Arctic cod		Muscle	18		3.0		Muir <i>et al.</i> , 1988
Canadian Arctic	1984	Ringed seal		Blubber	227	186 - 386	32	23 - 41	"
Canadian Arctic	1984	Ringed seal		Blubber	204	119 - 289	24	18 - 20	"
Canadian Arctic	1984	Ringed seal		Liver	2.0	1.0- 3.0	1.0	0.0- 1.0	"
Canadian Arctic	1984	Ringed seal		Liver	1.0	0.0- 1.0	1.0	0.0- 1.0	"
Valencia coast, Spain	1985	Mussel	<u>Mytilus galloprovincia</u>			0.4- 1.5		0.0- 2.8	Pastor <i>et al.</i> , 1988
Valencia coast, Spain	1985		<u>Venus gallina</u>	Muscle		0.3- 0.8		0.3- 0.7	"
Valencia coast, Spain	1985	Pilchards	<u>Sardina pilchardus</u>	Muscle		0.0- 6.4		1.5-13	"
Valencia coast, Spain	1985		<u>Mullus barbatus</u>	Muscle		0.0- 16		0.7-11	"
Valencia coast, Spain	1985		<u>Mullus surmulentus</u>	Muscle		0.1- 0.1		0.1- 4.1	"
Rivers, Leon Spain, Med	1985	Trout	<u>Salmo trutta fario</u> L.	Muscle	8.0	4.0- 17			Teran & Sierra, 1987
Rivers, Leon Spain, Med	1985	Trout	<u>Salmo trutta fario</u> L.	Liver	13	2.0- 34			"
Rivers, Leon Spain, Med	1985	Trout	<u>Salmo trutta fario</u> L.	Brain	105	32 - 180			"
Rivers, Leon Spain, Med	1985	Trout	<u>Salmo trutta fario</u> L.	Kidney	54	4.0-814			"

Table 20.6 Concentrations of γ -HCH and HCB in biota.

Location of the samples	Date	Sample type	Species	Tissue	Mean HCH $\mu\text{g/kg}$	Range - HCH $\mu\text{g/kg}$	Mean HCB $\mu\text{g/kg}$	Range - HCB $\mu\text{g/kg}$	Reference
Westerport Bay, S Australia	1985	Fur seal	<u>Actocephalus pusillus</u>	Muscle	0.6	0 - 0.6	0.1	0.1- 0.1	Kawano <i>et al.</i> , 1988
Westerport Bay, S Australia	1985	Fur seal	<u>Actocephalus pusillus</u>	Liver	0.6	0 - 0.8	0.2	0.1- 0.2	Smillie & Waid, 1987
Westerport Bay, S Australia	1985	Fur seal	<u>Actocephalus pusillus</u>	Blubber	3.0	0 - 4.9	0.5	0.3- 0.8	"
Westerport Bay, S Australia	1985	Fur seal	<u>Actocephalus pusillus</u>	Testes	0.0	0 - 0.0	0.2	0.0- 0.4	"
Clyde, Scotland	1985	Mussel	<u>Mytilus edulis</u>		12	6 - 20	7.0	1.0- 26	Wells (DAFS Unpub. data
West coast, Scotland	1985	Mussel	<u>Mytilus edulis</u>		12	1 - 35	4.0	1.0- 24	"
North coast, Scotland	1985	Mussel	<u>Mytilus edulis</u>		4.0	2 - 11	25	1.0- 42	"
Moray Firth, Scotland	1985	Mussel	<u>Mytilus edulis</u>		2.0	1 - 2	12	1.0- 23	"
East coast, Scotland	1985	Mussel	<u>Mytilus edulis</u>		2.0	1 - 3	17	5.0- 29	"
Tay, Scotland	1985	Mussel	<u>Mytilus edulis</u>		1.0	1 - 1	1.0	9.0- 12	"
Firth, Scotland	1985	Mussel	<u>Mytilus edulis</u>		71	2 - 273	90	1.0-231	"
Chilean coast, Pacific	1986	Horse mackerel	<u>Trachurus murphi</u>	Muscle	9.0		43		Ober <i>et al.</i> , 1987
Chilean coast, Pacific	1986	Hake	<u>Merluccius gayi gayi</u>	Muscle	0.0		0.0		"
Chilean coast, Pacific	1986	Black cusk eel	<u>Genypterus maculatus</u>	Muscle	8.0		0.0		"
Chilean coast, Pacific	1986	Plaice	<u>Paralichthys microps</u>	Muscle	0.0		0.0		"
Chilean coast, Pacific	1986	Jack	<u>Seriotelella violecea</u>	Muscle	7.0		0.0		"
Chilean coast, Pacific	1986	Croaker	<u>Cilus montti</u>	Muscle	740		0.0		"
Chilean coast, Pacific	1986	Red cusk eel	<u>Genyterus chilensis</u>	Muscle	0.0		0.0		"
Chilean coast, Pacific	1986	Mussel	<u>Mytilus edulis</u> <u>chilensis</u>	Muscle	3.0		0.0		"
Chilean coast, Pacific	1986	Ribbed mussel	<u>Aulacomya ater</u>	Muscle	43		0.0		"
Chilean coast, Pacific	1986	Clam	<u>Ameghinomya antiqua</u>	Muscle	113		0.0		"
Chilean coast, Pacific	1986		<u>Mesodesma donacium</u>	Muscle	11		0.0		"

(cont'd)

Table 20.6 (cont'd)

Location of the samples	Date	Sample type	Species	Tissue	Mean HCH µg/kg	Range - HCH µg/kg	Mean HCB µg/kg	Range - HCB µg/kg	Reference
S Italian rivers, Garigiano	1986	Black bluehead	<u>Ictalurus melus</u>	Muscle	5.0				Amodio- Cocchieni, 1988
"	1986	Bleak	<u>Alburnus alburnus</u>	Muscle	5.0				"
"	1986	Chub	<u>Leuciscus cephalus</u>	Muscle	5.0				"
"	1986	Common carp	<u>Cyprinus carpio</u>	Muscle	0.0				"
"	1986	Eel	<u>Anquilla anquilla</u>	Muscle	7.0				"
"	1986	Tench	<u>Tinca tinca</u>	Muscle	7.0				"
S Italian rivers, Volturno	1986	Black bluehead	<u>Ictalurus melus</u>	Muscle	5.0				"
S Italian rivers, Volturno	1986	Bleak	<u>Alburnus alburnus</u>	Muscle	5.0				"
S Italian rivers, Volturno	1986	Chub	<u>Leuciscus cephalus</u>	Muscle	7.0				"
S Italian rivers, Volturno	1986	Common carp	<u>Cyprinus carpio</u>	Muscle	5.0				"
S Italian rivers, Volturno	1986	Eel	<u>Anquilla anquilla</u>	Muscle	16				"
S Italian rivers, Volturno	1986	Tench	<u>Tinca tinca</u>	Muscle	0.0				"
S Italian rivers, Calore	1986	Black bluehead	<u>Ictalurus melus</u>	Muscle	13				"
S Italian rivers, Calore	1986	Bleak	<u>Alburnus alburnus</u>	Muscle	5.0				"
S Italian rivers, Calore	1986	Chub	<u>Leuciscus cephalus</u>	Muscle	5.0				"
S Italian rivers, Calore	1986	Common carp	<u>Cyprinus carpio</u>	Muscle	6.0				"
S Italian rivers, Calore	1986	Eel	<u>Anquilla anquilla</u>	Muscle	5.0				"

20.2 Progress on other Overviews

The ACMP noted that the Marine Chemistry Working Group (MCWG) had prepared a first draft of an overview on chromium in the marine environment and that, following amendment during the intersessional period, a final draft will be available for review by ACMP in 1991.

The ACMP also noted that MCWG is considering the preparation of overviews on the following: octochlorostyrene, brominated fire retardants, surface active agents, compounds arising from the chlorination of domestic waste, simazine and atrazine.

21 GESAMP STATEMENT ON PRINCIPLES FOR THE PROTECTION AND
MANAGEMENT OF THE MARINE ENVIRONMENT

The ACMP discussed a statement, entitled "Underlying Principles and Elements for the Protection and Management of Marine and Coastal Environments", that had been prepared by GESAMP (the IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution) at its Twentieth Session in May 1990. This statement had been prepared at the request of the Agencies, particularly UNEP, for use in the context of regional seas and global pollution control protocols. The ACMP considered it significant that another international marine environmental advisory body, with a largely different composition of scientists, had adopted such a statement of principles and noted that it incorporates similar scientific perspectives to those embodied in the ACMP statement on management principles contained in the 1989 ACMP Report. For these reasons, whilst ACMP does not intend to imply that it endorses all aspects of the GESAMP statement, it decided to attach the statement to its report as Annex 7. Specifically, while the ACMP agrees with the scientific principles and elements of the GESAMP statement, it considers that the policy aspects of the GESAMP statement that were developed from a global perspective (e.g., Section 4 of Annex 7) are not wholly relevant to the regional focus of ACMP's activities. The ACMP holds the view that the GESAMP statement highlights a number of considerations that are essential to a proper integration of scientific advice into marine environmental management.

22 AUTOMATIC DATA PROCESSING ISSUES

The ACMP discussed the status of ICES automatic data processing (ADP) activities in relation to data on contaminants in marine media and the handling of the data from the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions.

In relation to the JMP data handling, some improvement in the submission of data in advance of the deadline was noted; in particular, data for 1988 on contaminants in fish and shellfish for the determination of temporal trends had all been submitted by the deadline. The Commissions had decided that if these data were not submitted on time, they would not qualify for inclusion in the assessment programme of the ad hoc Working Group on Monitoring for 1989.

On the matter of the workload placed on the ICES Secretariat by ADP activities, the ACMP noted that the data handling work for the Commissions, and that associated with the North Sea Task Force (NSTF) commitments, are placing increasing demands on the resources of the Secretariat. Whereas previously the majority of the workload associated with, for example, the handling of JMP data, occurred during the latter part of the year (August - December), the present demands for ADP are placing a much more continuous, year-round requirement on the Secretariat to provide data processing services. This is related to two main activities: (i) the handling of submissions of back-years of data, to extend time-series (trend monitoring) data sets and to accommodate the NSTF request to consolidate data sets back to 1985, and (ii) the increasingly heavy demands associated with data evaluation activities.

As both the volumes and the types of data suitable for inclusion in assessments grow, the data evaluation procedures which have been operated in the past by the assessment groups of both the Commissions and ICES are becoming less appropriate. In view of, e.g., the approaching NSTF data evaluation activities, the ACMP gave some consideration to procedures which might be adopted to ensure that future data assessment activities constitute an effective component of the monitoring programmes. In this connection, reference was made to Section 23 of the 1988 Report of ACMP and to a document prepared by the ICES Secretariat for consideration by the Oslo and Paris Commissions' Joint Monitoring Group at its January 1990 meeting. Both propose a division of responsibilities, with ICES concentrating on the development of procedures and the Commissions' working groups taking responsibility for the routine application of proven procedures to handle data sets.

In connection with the NSTF data handling requirements, it was noted that new types of data will need to be considered in the context of ADP systems (results from fish disease surveys, biological effects monitoring, etc.). They will also add to the ICES work-load. A further issue that will have to be addressed is the question as to whether any restrictions or moratoria should be applicable to some of the data held within the ICES data banks.

ANNEX 1

The following text has been reprinted from the 1989 Report of the ICES Advisory Committee on Marine Pollution (Coop. Res. Rep. No. 167), pp. 22-29. It should be read in conjunction with the matrix tables and text in Section 6.1 of the present report.

6 MONITORING ISSUES

6.1 Matrix Tables for Monitoring Purposes

The Oslo and Paris Commissions have requested that ICES provide advice by means of matrix tables on how most effectively to monitor each contaminant of interest for the Joint Monitoring Programme (JMP). Based on the report of the Working Group on Environmental Assessments and Monitoring Strategies (WGEAMS), the ACMP endorsed the matrix tables presented below with the caveat that such tables must not be considered out of context with the following text.

6.1.1 Introduction

The matrices are selected as those most appropriate for the provision of the greatest information in relation to each monitoring purpose. They have been selected on scientific grounds, and do not take any account of relative costs or the convenience of the alternative choices.

In some cases, no matrix has been recommended, either because the monitoring of a particular contaminant is not appropriate to the monitoring purpose, or because advice could not be given for technical reasons. More complete explanations of individual cases are given below.

In many cases, primary and secondary choices of matrix are given, and, in some cases, tertiary choices. These choices should be viewed as alternatives, or complementary choices, but if circumstances permit, a primary matrix should preferably be selected for analysis, as this would provide the greatest return for effort in terms of information relevant to the particular monitoring purpose. Suitable primary matrices may not be available in all monitoring locations and, in such cases, secondary or tertiary matrices should be considered. In some cases, particularly in relation to the assessment of the existing level of marine pollution, a more comprehensive expression might be obtained by the analysis of the contaminant in all matrices. However, the priority selections of matrices were made with the aim of providing the most useful scientific information for assessing distributions of contaminants, and focussing attention on those matrices that might enable the most consistent picture of distributions over wide areas to be obtained through the collective efforts of a number of laboratories and countries.

In some cases, matrices will be chosen on the basis of pre-existing local information and on-going monitoring programmes. The ACMP wishes to stress that the advice in the following sections should not be taken as opposing the continuation of existing monitoring programmes, designed in the context of local conditions, that are yielding useful information even if they do not wholly match the selections advocated here.

In all circumstances, the reliability of the information from a monitoring programme, and its consequent value, is dependent upon the attention paid to quality assurance at all stages of the measurement programme (sample collection, storage, preparation, pre-concentration, analysis, standardization and interpretation). Participating laboratories should be required to adopt appropriate procedures in this area.

6.1.2 The assessment of possible hazards to human health (JMP purpose (a) - Table 1)

In the general area covered by the JMP, none of the contaminants considered presents a widespread serious hazard to human health through the consumption of marine foodstuffs. Moreover, in some cases (e.g., copper, zinc, arsenic, chromium, and nickel), the contaminants are not normally of concern with respect to fisheries products. Equally, the monitoring of contaminants in sea water or sediment would not have any direct applicability to human health risk, and these considerations are reflected in the matrix Table 1. This table, therefore, provides advice on the contaminants and matrices that might be included in a regional or wider scale survey to assess the possible hazards to human health presented by the presence of selected contaminants in marine foodstuffs. In several cases, primary and secondary choices of matrix are given.

There may be areas where sources of contamination could give rise to localized increases in the concentration of one or more contaminants in marine foodstuffs. Such situations are unlikely to be detected or adequately described by large-scale surveys, and are better approached through specially designed and targeted monitoring exercises by national or local authorities. In such circumstances, the relevant authorities should assess the most important exposure pathway by which the contaminant may reach the public through marine foodstuffs. The monitoring programme should be directed at that pathway, and not be constrained by the advice given in Table 1 in relation to broader scale surveys. For example, in some areas there may be concern over the concentrations of CBs in the muscle of fatty fish species such as herring or mackerel, and in such circumstances it would be appropriate to analyse herring or mackerel muscle.

Matrix Table 1

In relation to the assessment of possible hazards to human health

[JMP Purpose (a)].

(This matrix table must not be considered independently of the preceding text)

Matrix	Contaminant									
	PCB/CBs	γ -HCH	Hg ⁵	Cd	Cu ³	Zn ³	As ⁴	Cr ³	Ni ³	Pb
Shellfish	P	P	P	P						P
Fish muscle			P							
Fish liver	S ²	S ²		S ¹						

P: primary matrix

S: secondary matrix

Notes and Qualifications:

1. If fish liver is not a consumed fisheries product, no analysis is needed.
2. If fish liver is not a consumed fisheries product and there remain human health concerns, transfer attention to fish muscle.
3. These contaminants are not normally of concern in respect to the consumption of fisheries products.
4. Arsenic is present in seafood in measurable concentrations, but its chemical form makes it of little concern with respect to human health.
5. Hg should be understood to include methylmercury compounds. In countries where public health regulations refer to methylmercury rather than total mercury, samples may be analysed for methylmercury.

CBs: Chlorobiphenyls on an individual basis, congener Nos. 28, 52, 101, 118, 153, 138, and 180.

6.1.3 The assessment of the existing level of marine pollution (JMP purpose (c) - Table 2)

Water

A distinction is to be made between nearshore and offshore waters. In the former, marked salinity gradients occur, and contaminant distribution is more likely to be influenced by riverine or land-based inputs. In the latter, which is more remote from the above-mentioned inputs of contaminants, gradients are normally substantially less marked.

The use of water analysis to reflect current levels of marine contamination is attractive in that it concerns the important aqueous phase, the environment in which both biota and sediment exist. However, considerable efforts are still required to improve the comparability of analytical performance among laboratories engaged in sea water analysis in member countries. The requirements for precision and accuracy of analysis at low concentrations limit the number of determinands that can be considered in offshore waters to mercury, cadmium, copper, zinc, lead, and lindane, all at secondary matrix level. Even in these cases it would be essential for each laboratory to establish in-house quality control procedures, and for rigorous attempts to be made to establish comparability between laboratories, with particular attention being paid to lead.

In nearshore waters subject to anthropogenic influences, concentrations may be somewhat more variable, and chromium and nickel analyses might also be added to the above list. The same quality assurance precautions would be needed. In nearshore waters it is necessary to take account of any correlation between contaminant concentrations and salinity, and of the influence of the concentration and composition of suspended matter on the dissolved contaminants.

Sea water is not a matrix of choice for CBs, as the octanol:water partition coefficients indicate that the compounds would be predominantly associated with sediment or biota.

The concentrations of arsenic naturally present in sea water make the discrimination of anthropogenic influences from natural processes difficult and, therefore, sea water is not indicated as an appropriate matrix.

There are some sheltered bays or lagoons in which the inputs of contaminants are sufficiently large to cause marked elevations of contaminant concentrations in sea water, or in which changes in concentrations can be expected. As agreed by the Commissions, in such areas it might be appropriate for national authorities to give more prominence to water analysis in monitoring programmes, but this should not be regarded as a general recommendation.

Matrix Table 2

In relation to the assessment of the existing level of marine pollution
(i.e., contamination) [JMP Purpose (c)]

(This matrix table must not be considered independently of the preceding text)

Matrix	Contaminant										
	PCB/CBs	γ-HCH	Hg	Cd	Cu	Zn	As	Cr	Ni	Pb	TBT
Nearshore water		P	P ¹	P ¹	P ¹	P ¹		P ¹	P ¹	P ¹	S ¹
Offshore water		S	S ¹	S ¹	S ¹	S ¹				S ¹	
Surficial sediments ²	P		P	P	P	P	P ⁵	P	P	P	P
Shellfish	S ³	S ³	S ¹	S ¹		S ¹				S ¹	P
Fish muscle			T ^{1,4}				S ^{1,4}				
Fish liver	S ⁴		T ^{1,4}							T ^{1,4}	

P: primary matrix

S: secondary matrix

T: tertiary matrix

Notes and Qualifications:

1. Potential addition/alternative to sediment measurements in areas where sediment conditions are not wholly favourable.
2. Should be accompanied by organic carbon measurements and appropriate normalization procedures, following the most recent ICES guidelines for monitoring contaminants in sediments.
3. Could be carried out on an opportunistic basis, as may provide additional information on distribution.
4. Sedentary species only (e.g., flatfish).
5. The signal-to-noise ratio for discriminating between anthropogenic and natural influences is extremely low.

CBs: Chlorobiphenyls on an individual basis, congener Nos. 28, 52, 101, 118, 153, 138, and 180.

Sediments

There is very considerable emphasis laid on the use of surficial sediments as a primary matrix for most of the contaminants. Participating laboratories should take full account of the most recent advice on the selection of sampling locations and methods (see, e.g., Section 15, 1986 ACMP Report (Coop.Res.Rep. No. 142); Annex 2, 1983 ACMP Report (Coop.Res.Rep. No. 124); Annex 2, 1984 ACMP Report (Coop.Res.Rep. No. 132)). Areas of high sedimentation and low bioturbation rates are particularly favourable. It is also necessary to subject the samples or data to appropriate normalization procedures to compensate for the natural distribution of contaminants in relation to the texture, provenance and grainsize of the sediment (see Section 14.1 of the 1989 ACMP Report (Coop. Res. Rep. No. 167)).

Biota

Both sediment and shellfish are indicated as primary monitoring matrices for tributyl-tin (TBT). Whilst the main area of concern over TBT is its effects on shellfish, particularly molluscs, for example oyster and dogwhelk, these organisms are by nature of limited geographical distribution. TBT, and its derivatives DBT (dibutyl-tin) and MBT (monobutyl-tin), can be found in sediments, especially near shipyards and busy shipping lanes, in harbours and marinas and, at least until recently, in the vicinity of some mariculture operations. The monitoring of sediment for these compounds would allow the use of a single matrix in a wider range of environments (e.g., into low salinity areas of estuaries) than would be possible using a single molluscan species.

6.1.4 Assessment of the effectiveness of measures taken for the reduction of marine pollution within the framework of the Conventions (JMP purpose (d) - Table 3)

Measures taken within the framework of the Conventions to reduce the level of marine pollution are primarily directed at the control and reduction of inputs of contaminants. The main inputs are from riverine sources, land-based discharges, the atmosphere, and direct dumping. The most efficient way to assess the effectiveness of the measures taken to reduce inputs is, therefore, to monitor the inputs. The Joint Monitoring Group (JMG) may wish to take note of the comments in the 1988 ACMP report on the estimation of gross and net riverine inputs, and on atmospheric inputs. The monitoring of inputs can give detailed information on the effects of control measures on individual or localised groups of contaminant sources, and can, therefore, be particularly useful in regulatory procedures.

It is also necessary to assess the effectiveness of the control measures in improving the quality of the marine environment. It is this aspect of trend monitoring that is covered by Table 3. The table represents a statement of the current "state of the art" and, as the subject is developed, additional combinations may become appropriate. Thus, most of the recommendations are indicated as primary matrices, to reflect that they are very much alternatives.

Matrix Table 3

In relation to the assessment of the effectiveness of measures taken for the reduction of marine pollution (i.e., contamination) in the framework of the Conventions [JMP Purpose (d)].

(This matrix table must not be considered independently of the preceding text)

Matrix	Contaminant										
	PCB/CBs	γ -HCH	Hg	Cd	Cu	Zn	As ⁵	Cr ⁵	Ni	Pb	TBT
Water		P ²									
Sediment profiles ⁴	P		P	P	P	P			P	P	P
Shellfish			P	P	P	P				P	P
Fish muscle			P ^{1,3}								
Fish liver	S ^{1,3}										

P: primary matrix

S: secondary matrix

Notes and Qualifications:

1. Considerable care has to be taken with species selection and availability, sampling protocol, and statistical aspects of data analysis.
2. Considerably greater effort is required, in respect to sampling and analytical frequency, if measurements are made in water, but the potential signal-to-noise ratio for trends is greater than that in sediments.
3. Sedentary species should be selected.
4. Care should be taken in selecting favourable areas of high sedimentation rate and limited bioturbation, following the most recent ICES guidelines for monitoring contaminants in sediments, including organic carbon measurements and appropriate normalization procedures.
5. No recommendation can yet be made, except that the sediment does not seem to be appropriate for purpose (d).

CBs: Chlorobiphenyls on an individual basis, congener Nos. 28, 52, 101, 118, 153, 138 and 180.

When considering monitoring for temporal trends, it is necessary to consider the likely length of time that may elapse before any change in input may be reflected in the monitoring matrix. This length of time will be a complex function of environmental factors and processes, the magnitude and rate of changes in inputs, analytical factors, and data analysis procedures, with particular emphasis on the variance of each of the contributory media and processes. This may have particular importance in relation to the frequency with which the JMG may wish to assess the effectiveness of measures taken by the Commissions, or the frequency of regional assessment exercises (e.g., in the North Sea area).

Biota

Given the situation described above, it is important to note that it is difficult to interpret biota trend monitoring data in relation to changes in environmental levels in response to "measures taken to reduce marine pollution" in areas other than those where marked changes were involved (e.g., near strong point sources). In other words, the levels of change referred to are levels of change within the organisms, which cannot necessarily be assumed to reflect levels of environmental change.

Sediment

Table 3 particularly emphasises the potential of down-core analysis of sediments in temporal trend monitoring for a wide range of contaminants. As noted with respect to Purpose (c), and in footnote 4 to Table 3, it is particularly important to pay attention to the site selection and data normalization procedures discussed in other ICES documents, including Section 14.1 of the 1989 ACMP Report. Arsenic and chromium analyses are not recommended as it is as yet unclear how the distribution of these elements may be affected by variations in redox potential in coastal sediments.

The JMG should take note of comments in the 1988 ACMP report (Annex 2) on the influence of sedimentation rate and bioturbation intensity on the ability of sediment core samples to reflect changes in input to the sediment. It is also likely that sediment core analyses will reflect general basin conditions, rather than changes resulting from discharges from single sources or particular types of input.

Water

Water analysis is not recommended for trend monitoring (except for lindane). However, in circumstances of marked contamination and where changes are expected, contaminant monitoring in sea water may be appropriate, provided that statistical considerations indicate that such analyses could reliably reflect the effects of control measures.

It should be noted that the CBs referred to on the matrix tables are the chlorobiphenyls that ICES has recommended for determination in general monitoring situations, namely, primarily, IUPAC Nos. 28, 52, 101, 118, 153, 138, and 180, and, secondarily, IUPAC Nos. 18, 31, 44, 66/95, 110, 149, 187, and 170.

ANNEX 2

AN EXAMPLE OF THE CONSEQUENCES OF APPLYING THE GUIDELINES FOR THE THREE PURPOSES OF MONITORING AT DIFFERENT SAMPLING LOCATIONS

An example of the consequences of applying the present guidelines for the sampling and analysis of fish for the three purposes of monitoring (temporal trend, geographical distribution, and human health) at two different sampling locations is given below.

NOTE: This example is very simplistic and is designed to highlight some particular points and difficulties; it should not be considered as a statistical demonstration, nor should the numbers be considered to be applicable outside the particular data set assumed for this example.

Assume the frequency distributions of fish length shown in Figure 1 to be true for sampling locations A and B, respectively:

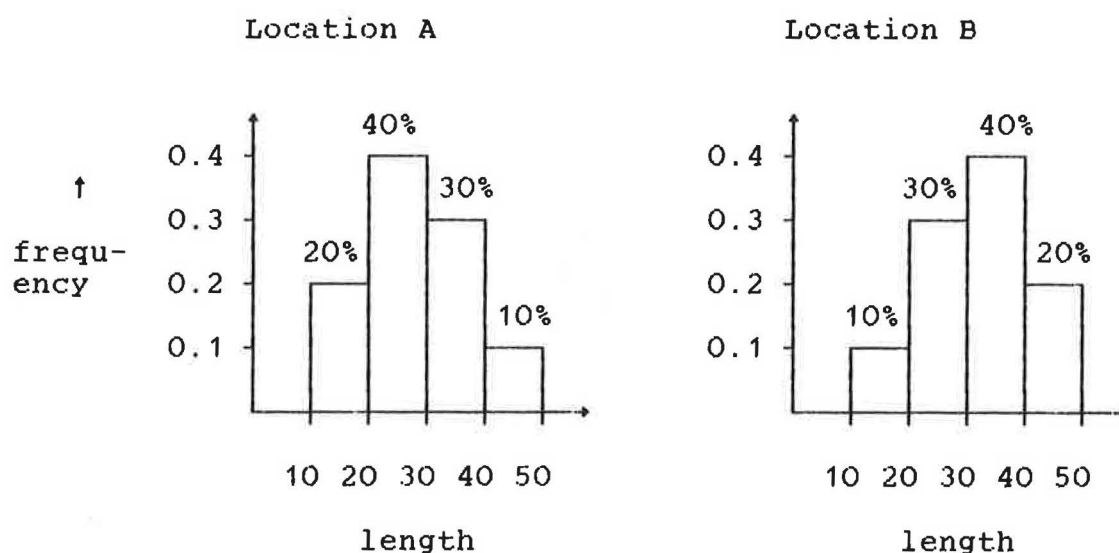


Figure 1: Frequency distributions of fish length at two different locations, A and B.

Subsequently, assume the relationships shown in Figure 2 for the concentration of a contaminant, y , with fish length at the two sites:

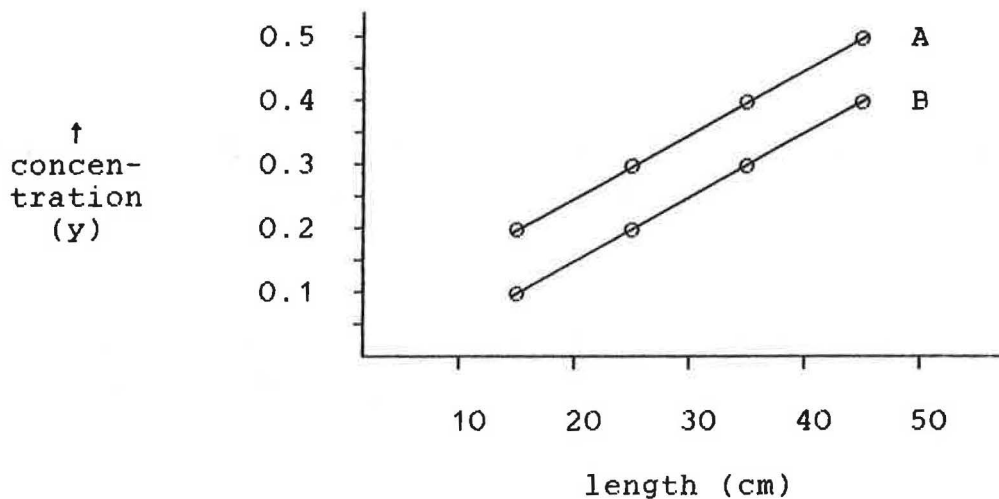


Figure 2: Relationships for the concentration of a contaminant with fish length at two locations, A and B.

- i) Application of the sampling guidelines for temporal trend monitoring will reveal the relationships shown in Figure 2.

Concentration estimates are derived for the overall average length, which equals 30 cm in the example. This corresponds to a contaminant concentration estimate of 0.35 for site A and 0.25 for site B.

- ii) Application of the sampling guidelines for geographical distribution monitoring

Unfortunately, these guidelines are somewhat ambiguous as to which size class should be sampled: "Fish should be selected so as to be representative of the area in question,.... Each sample should consist of the same or similar sized fish." Consequently, it is unlikely that the lengths of the fish in samples taken at different sites will be equal.

Let us first assume that the sample is random (if possible). This will result in estimates of contaminant concentration (y) for sites A and B, respectively, of

$$A: E(y) = 0.2 \cdot 0.2 + 0.4 \cdot 0.3 + 0.3 \cdot 0.4 + 0.1 \cdot 0.5 = 0.33$$

$$B: E(y) = 0.1 \cdot 0.1 + 0.3 \cdot 0.2 + 0.4 \cdot 0.3 + 0.2 \cdot 0.4 = 0.27$$

If, however, the modal class is sampled, this gives a concentration of 0.3 for both sites A and B!

iii) Application of the sampling guidelines for human health risk monitoring

Sampling for the human health risk assessment objective is only concerned with that part of the population which is used as a foodstuff. If we assume that this corresponds to all fish larger than 30 cm, this will result in the following estimates of concentration:

$$A: E(y) = 0.75 \cdot 0.4 + 0.25 \cdot 0.5 = 0.425$$

$$B: E(y) = 0.67 \cdot 0.3 + 0.33 \cdot 0.4 = 0.333$$

Thus, from this example and a comparison of the concentration estimates derived in (i) - (iii) above, we can see that results can differ considerably depending on the guidelines applied; from no difference between sites (both equal, $y=0.3$), to differences between sites ranging from 0.06 up to 0.092 and 0.1. Nevertheless, from the information given in Figures 1 and 2, all other statistics can be derived.

Where it is intended to use temporal trend monitoring data for geographical distribution studies, the length class sampled for the geographical distribution monitoring should ideally coincide with a length class covered in the temporal trend monitoring study. It may then be possible simply to treat this particular length group from the temporal trend monitoring sample as the entire sample for the geographical distribution study. If this is not the case, it will be necessary to use the contaminant concentration-length relationship from Figure 2 to obtain an estimated concentration, corresponding to a fish length appropriate to the geographical distribution sampling guidelines, including the standard error of the estimate.

However, the model shown in Figure 2 is too simple and the model which was used for temporal trend monitoring (cf. Annex 1 to the 1986 Report of the ICES Advisory Committee on Marine Pollution (Coop. Res. Rep. No. 142)) must be preferred. This assumes the log of the concentration to be linearly related to fish length and furthermore assumes a multiplicative log-normally distributed error. So:

$$\Lambda$$

$$z = \log_e y = \beta_0 + \beta_1 \cdot \text{length} + \epsilon \quad (1)$$

where the error ϵ is Normally distributed with mean 0 and constant variance σ^2 .

At sampling sites where only geographical distribution monitoring has to be carried out, all fish are bulked into a single pool before chemical analysis. Assuming equal weight for each fish, the resulting estimate of the contaminant concentration is equivalent to the arithmetic mean.

This means that we cannot simply use model (1) to give the estimated value

$$\hat{y}_i = \exp(\hat{z}_i).$$

Think of this value as equivalent to a geometric mean! An appropriate estimate of the arithmetic mean, given length i , equals:

$$\exp(\hat{z}_i + \sigma^2/2)$$

The fact that this estimate is somewhat biased is ignored.

To reiterate, samples taken under the current guidelines for geographical distribution monitoring cannot be used for temporal trend monitoring.

ANNEX 3

FISH/SHELLFISH MONITORING GUIDELINES INCORPORATING REVISED GUIDELINES FOR SAMPLING AND HANDLING OF MUSSELS FOR TEMPORAL TREND MONITORING PURPOSES*

GUIDELINES FOR THE CONDUCT OF MONITORING WITHIN THE CONTEXT OF THE ICES COOPERATIVE MONITORING STUDIES PROGRAMME (CMP)

ANNEX 1/BIO - Monitoring of Contaminants in Biota (Fish and Shellfish)

GUIDELINES TO BE FOLLOWED FOR SAMPLE COLLECTION, PREPARATION AND ANALYSIS OF FISH AND SHELLFISH IN THE CONDUCT OF THE COOPERATIVE ICES MONITORING STUDIES PROGRAMME (June 1990)

DETAILS TO BE FOLLOWED FOR SAMPLE COLLECTION, PREPARATION AND ANALYSIS IN THE CONDUCT OF COOPERATIVE MONITORING

Monitoring, using fish or shellfish as indicator species, may be conducted for one of the following three purposes:

- (1) The provision of a continuing assurance of the quality of marine foodstuffs with respect to human health.
- (2) The provision over a wide geographical area of an indication of the health of the marine environment in the entire ICES North Atlantic area.
- (3) The provision of an analysis of trends over time in pollutant concentrations in selected areas, especially in relation to the assessment of the efficacy of control measures.

SAMPLING

Samples to meet Objective 1 (Samples to be collected every second year starting in 1982)

- (a) A sample should consist of 25 fish or large crustaceans such as crabs or lobsters, 50 mussels or other molluscs, and 100 small crustaceans such as shrimps.
- (b) The sample should be selected in such a way as to reflect the size distribution of the commercially exploitable portion of the catch of that species within that particular geographical area. This distribution may be determined from previous data or on board the sampling vessel but, having been established, should only be amended if a significant change in the distribution can be demonstrated.
- (c) Sampling should be conducted prior to spawning of the species concerned.
- (d) Samples should be collected from at least the following areas: the estuaries of the Forth, Thames, Rhine, Scheldt and Clyde, the Skagerrak, Kattegat and Oslo Fjord, the Irish Sea, German Bight and Southern Bight of the North Sea, certain parts of the Gulf of St. Lawrence and the US middle Atlantic Bight, and the area off Portugal.

*Amendments are sidelined for ease of identification.

Samples to meet Objective 2 (Samples to be collected every 5 years starting in 1985)

- (a) A sample should consist of 25 fish or 50 mussels.
- (b) Fish should be selected so as to be representative of the area in question, i.e., should not be very recent immigrants to the area or on passage through it. Each sample should consist of the same or similar sized fish.
- (c) Mussels should be between 20 and 50 mm in size and preferably as close to the lower end of this range as possible.
- (d) Sampling should take place prior to spawning of the species concerned.
- (e) Samples should be collected from as many locations as practicable throughout the ICES area.

Samples to meet Objective 3 (Samples to be collected every year starting in 1982)

- (i) Fish and shellfish, other than mussels

- (a) A sample of fish should consist of at least 25 individuals, and preferably more individuals. The sample should be collected in a length-stratified manner, i.e., the sizes of the fish should span as wide a length range as possible and there should be an equal number of individuals in each length grouping.

The stratification should be based upon an equidistant logged length interval, i.e., the log (upper bound) minus log (lower bound) should be equal for each length interval. The length range of the entire sample should be selected so that the individuals in the lower bound yield sufficient tissue for the chemical analyses, while the upper bound should be selected such that at least 5 fish can readily be found in the sampled catch. The length range should be divided into 5 (or more) length intervals of equal size (after log transformation). (See notes on length stratification at end of Annex 1/B for an example.) Once the length stratification for a particular species and area has been agreed, this stratification should be strictly adhered to for a number of years. No length interval should be less than 2-3 cm. If the length range is smaller than 2-3 cm, the species is not ideally suited for the proposed analysis.

- b) Sampling should be conducted annually from the same areas and from the same stock and at the same time each year.
- c) Samples should be collected in such a way that at least the following areas are adequately covered: the estuaries of the Forth, Thames, Rhine, Scheldt and Clyde, the Skagerrak, Kattegat and Oslo Fjord, the Irish Sea, German Bight and Southern Bight of the North Sea, certain parts of the Gulf of St Lawrence and the US middle Atlantic Bight and the area off Portugal.
- d) The species of interest can only be selected in the light of information on fish stock composition and history and the known or perceived problems which define national priorities. It is preferable to use a fish species which continues to grow throughout its life. Species which are of particular interest in an ICES context are:

Cod (Gadus morhua) or Hake (Merluccius merluccius)
 Plaice (Pleuronectes platessa)
 Flounder (Platichthys flesus)
 Mackerel (Scomber scombrus)
 Shrimps (Crangon crangon)

but data relating to other species are also required.

(ii) Mussels

- a) From a site, collect a random sample of mussels with the number of individuals large enough to be divided into at least 3 equal pools, with each pool consisting of at least 20 animals and enough soft tissue for all analyses.
- b) The length range should be fixed and narrow (e.g., 5 mm). It should be chosen to yield young individuals (to reflect recent contaminant levels) but ensure an adequate number each sample year. One size interval is recommended because of the uncertainty of the effect of size on the uptake of contaminants.
- c) The age range of the individuals in the sample should be inferred from local knowledge and/or experimental studies. Information on the ages should be submitted as commentary.
- d) The sampling should be conducted during the late autumn/early winter when mussels are in a more stable physiological state. Gametogenesis and spawning generally occur in late spring to early summer, when individuals may lose up to 50% of their soft tissue weight.
- e) Samples should be collected sub-tidally. They should be collected as near to the same depth and exposure (in respect to sunlight and wave action) as possible in order to reduce variability in uptake of contaminants.
- f) Given these constraints in sampling procedure, the investigator should first define the target "population" of mussels to be sampled and sample appropriately (e.g., randomly) within the confines of that definition. These criteria must be clearly reported as commentary. For example, a population could be defined by 4-4.5 cm mussels at 0.5-1.5 m depth below the lowest low water level and only those individuals that are free of fouling and bored shells, within specified borders of a stretch of rocky shore.
- g) Sampling should be conducted annually and consistently in accordance with points (a)-(f), above.

STORAGE AND PRETREATMENT OF SAMPLES PRIOR TO ANALYSIS

General - i.e., for all three objectives:

- a) Fish samples should be collected ungutted and preserved (deep frozen) as soon as practicable after collection; length and weight should be determined before freezing.

- b) As a general rule, mussels should be depurated prior to preservation and analysis. There may, however, be instances where this is considered unnecessary or inappropriate (e.g., where mussels are used to monitor production water discharges from oil wells). The decision on whether to depurate or not should therefore be taken by the institute concerned according to local conditions and requirements. Depuration is to facilitate discharge of unassimilated particles in the mantle cavity or gut that might contaminate the sample. The suggested depuration method is to place the mussels on a polyethylene tray elevated above the bottom of a glass aquarium; fill the aquarium and submerge the mussels with unfiltered sub-surface sea water collected in close proximity to the sampling site; aerate the aquarium; and allow the mussels to remain there for 10-15 hours. Depuration is required for mussels collected in water with high turbidity or on silt/clay bottoms. Comments on whether or not the sample has been depurated should be submitted.
- c) Mussels shall be shucked live and opened with minimum tissue damage by detaching the abductor muscles from the interior of one valve. The mussels should be inverted and allowed to drain on a clean towel or funnel at least 5 minutes in order to minimize influence on dry weight determinations.
- d) The soft tissues are removed and deep frozen (-20°C) as soon as possible in containers appropriate to the intended end use analysis. When the analysis is eventually undertaken, all fluids that may initially separate on thawing should be included with the materials homogenized.
- e) Since a wide variety of factors can affect the total body burden of a pollutant in shrimps, the only useful objective in analysing shrimps is Objective 1. For this purpose, the shrimps should be boiled whole in sea water from the area of collection for 10 minutes. The tails should then be removed, peeled and thoroughly homogenized in preparation for storage or analysis.

To meet Objectives 1 or 2

- (a) In order to reduce the number of analyses which have to be performed, pooled samples may be used. These should be prepared as described below and analysed in duplicate.
- (b) An equivalent quantity of muscle tissue must be taken from each fish, e.g., a whole fillet of every fish. If the total quantity of tissue so yielded would be too large to be handled conveniently, the tissue may be subsampled, but a fixed proportion of each tissue must then be taken, e.g., 10% of each whole fillet or 10% of each whole liver, the sub-sample being taken after homogenisation of the whole fillet/liver or in the form of complete longitudinal sections.

To meet Objective 3

- (a) Each fish should be analysed individually and the following biological variables should always be recorded when sampling for time trend analysis purposes:

Age

Total weight

Total length

Liver weight - when contaminants in liver are determined. (If another fatty organ is used, the weight should be recorded.)

Sex (where applicable)

Degree of sexual maturation (where applicable)

(b) For each pool of mussels, the following information should be submitted:

Number of individuals in pool
 Mean, minimum and maximum length and standard deviation
 Mean dry shell weight
 Mean soft tissue weight
 Mean soft tissue dry weight (or %) and, if organic contaminants are analyzed, mean soft tissue lipid weight (or %)
 Method of determination of lipid content should be specified
 Method of determination of dry content should be described in comments if this is different from air-drying to a constant weight at 105⁰ C.

REPORTING OF RESULTS

For Objective 1

Results should be reported on a wet weight basis along with details of the size range of the sample and details of site, date and method of collection, preservation details (if appropriate) and brief details of the methods of analysis used; if PCBs were analysed for, these details should include the formulation or chlorobiphenyls and the method of quantitation used.

For Objective 2

- (a) Results should be reported as for Objective 1. In addition, results of analyses of mussels for metals should also be reported on a dry weight basis. All results of analyses for organochlorine compounds must be reported also on an extracted fat weight basis or as a minimum be accompanied by a fat weight determination result.
- (b) Dry weight determinations should be carried out in duplicate by air-drying to constant weight at 105⁰ C of sub-samples of the material analysed for the contaminants.
- (c) Fat weight should be determined on a sub-sample of the extract used for the organochlorine compound analyses. The results should be accompanied by a brief description of the method used for extraction.

For Objective 3

- (a) For fish, results should be reported as for Objective 2, but the individual analysis figures should be given together with full details of the size, age, weight, sex, etc., of the individual fish analysed.
- (b) For mussels, the contaminant concentration shall be submitted to ICES on an "as analyzed" basis (i.e., either on a dry weight basis or wet weight basis).
- (c) A commentary should be submitted as to the influence of local sources of contaminants. This is to help identify samples collected in "areas of concern".
- (d) In reporting these data to ICES, the ICES Reporting Format for Contaminants in Fish and Shellfish must be used for such data so as to allow machine handling and statistical analysis of the data.

General

Results should be submitted to the ICES Environment Officer not later than 30 June of the calendar year following collection of the sample. These results should be accompanied by the name of the contributing laboratory(s) and the name of an individual contact in the event of queries. The contributors should specify the most recent ICES intercalibration exercise in which they took part. A brief commentary on the data is also required, at least in relation to those supplied for the purposes of Objectives 1 and 3.

Notes on Length stratification

The main finding from the statistical analyses of data on contaminants in fish tissue is the gain in precision which can be obtained from stratification using biological variables. Although several biological parameters have been shown to be significant as stratification variables in different materials, length appears to be the only parameter which is simple to apply at sea and which shows up as being significant in most analyses.

Much discussion has been devoted to whether simple linear or log-linear (multiplicative) models give the better fit. General experience with other fish and other types of data indicate preference for the log-normal model at least for the present. As the length dependence of the contaminant level is not well understood, sampling should keep the length-contaminant relationship under constant surveillance, i.e., the entire length range should be covered evenly. The length range should be defined from practical considerations, the lower bound ensuring that enough tissue is available for chemical analysis and the upper bound such that at least 5 fish in the largest length interval can readily be found. The length stratification should be determined in such a way that it can be maintained over many years. The length interval should be at least 2-3 cm in size.

It is suggested that the length range be split into 5 length intervals which are of equal size after log transformation. For example, if the length range is 20-70 cm, then the interval boundaries could be (rounded to 0.5 cm) as follows:

cm	No. of fish	Log upper - Log lower
20 - 25.5	5	0.243
25.5 - 33.0	5	0.258
33.0 - 42.5	5	0.253
42.5 - 54.5	5	0.249
54.5 - 70.0	5	0.250
Total	25	
=====	==	

Care should be taken that samples are not unduly clustered within each stratum (length interval). More length intervals could be used and the test of the hypothesized contaminant-length relationship becomes stronger if the lengths are evenly distributed. But the item of major importance is to keep the length stratification identical from one year to the next.

ANNEX 4

BASIC GUIDANCE FOR THE SAMPLING AND ANALYSIS OF NUTRIENTS IN SEA WATER

Sampling Strategy

Measurements of nutrients in sea water are carried out for the following purposes:

- a) to measure the changes in nutrient concentrations in specific estuarine and coastal waters which are directly attributable to anthropogenic inputs, i.e., via rivers, pipeline discharges, sea dumping, and atmospheric inputs;
- b) to monitor the changes in the above concentrations with time in order to assess whether there is an increasing or decreasing trend as a result of changes in inputs;
- c) to study the relationship between nutrient concentrations and the production and species composition of phytoplankton;
- d) for the classification of water masses in oceanographic studies.

For the purposes of the Paris Commission's interests, these guidelines will be confined to purposes a) and b), above.

For purposes a) and b), sampling should be carried out during the winter period (November-January). This requirement is based on the fact that during spring and summer the surface waters (0-20 m) can become progressively depleted of inorganic nitrogen (NO_3^- , NO_2^- , NH_4^+) following removal by phytoplankton. As a consequence, it² is difficult to assess the impact of anthropogenic inputs on coastal and estuarine waters.

Station Positions

The selection of sampling points for purposes a) and b) must be based on knowledge of the hydrographic characteristics of the area and the location and magnitude of the various inputs containing nutrients. Since winter levels of inorganic nutrients in sea water can vary from year to year, it is important to ensure that a reference station is selected which is not directly affected by anthropogenic nutrient sources.

For those institutes with sufficient staff and laboratory resources, and access to larger vessels, the ideal sampling programme would involve monthly surveys during the October-February period. In practice, however, most laboratories may have to confine their survey work to one sampling session; this should be done during the January-February period.

On each sampling occasion, a sufficient number of water samples must be collected along the salinity gradient created by the mixing of river water with the offshore water, to allow the construction of a graph of salinity versus nutrient concentrations. A salinity probe may be deployed over the side of the ship to allow the investigator to identify this salinity gradient. In order to ensure that an appropriate number of samples are collected along this salinity gradient to characterize the relationship, it will be necessary to measure the salinity of the sea water samples either on board the ship or on return to the laboratory. On-board salinity measurements are preferable, as they will enable the investigator to check that sufficient numbers of samples have been collected to characterize the nutrient levels along the salinity gradient. In the absence of either a salinity probe or on-board measurements of salinity, it will be necessary to design a grid of stations to cover the area where the gradient is likely to be located.

Sampling Equipment

There is a variety of sampling bottles which can be used for the collection of nutrient samples; the most common are the reversing Nansen and Niskin types. A modification of the Niskin sampler is the GoFlo sampler. Hydrobios produces another sampler designed for water collection. All of these samplers are either deployed on a rosette or clamped to a hydrowire, lowered to the prescribed depth and then 'triggered' by means of a weight which slides on the hydrowire. Some investigators, working in estuaries and coastal areas, have collected sea water samples by pumping water through a flexible plastic hose which is deployed over the side of the ship. This system can be used from research boats which do not have winches for raising and lowering sampling bottles on hydrowires.

The sampling equipment, the ship and on-board activities can be a source of contamination during the collection of samples. Cooling water and wastewater from toilets are significant sources of organic nitrogen, ammonia and phosphate. Sampling should be done from a position forward of these discharges while the ship is head into the wind. When samplers are not in use, they should be kept closed, and when handling them one should avoid touching the inside of the sampler since contact with the hands may lead to contamination.

Filtration of samples

In coastal and estuarine samples, high concentrations of particulate material may be encountered. This material may interfere with the storage and analysis of the sample and, therefore, the sample should be filtered before it is analysed on board or stored in a sample bottle for analysis at a shore-based laboratory. No one type of filter is ideal for all nutrient determinations, but glass fibre filters probably represent the best compromise. A nominal pore size of $1.2\ \mu\text{m}$ (e.g., Whatman GF/C) is appropriate for estuarine samples.

Sub-sampling

Glass sample bottles should be used for the storage of sea water intended for analysis of salinity, nitrate and phosphate; plastic bottles should be used for silicate samples. If plastic bottles have to be used for the storage of all nutrient samples, then checks for adsorption of nutrients on the walls of the storage bottle should be done using sea water spiked with known amounts of nutrients.

Storage of samples

Because, in general, seawater samples remain biologically active after sampling, the subsequent analysis should preferably be carried out on board the research vessel. Modern automated methods allow the nutrient analysis to proceed on board even in relatively bad weather conditions, so that storage over periods of time longer than a few hours is seldom necessary. Nutrient samples can usually be relatively safely stored for up to two hours in a cool and dark place (i.e., refrigerator).

Although several institutes have established procedures under which they can preserve and store samples for selected nutrients for a limited time, there is at present no procedure which can be recommended for general use, i.e., for all nutrients in all sea areas at all times of the year. Therefore, analysis at sea is to be preferred and is strongly recommended for the nutrients. If this is not feasible for logistic reasons, each institute must verify storage procedures before they are used routinely.

Sub-samples for total nutrients (total phosphorus and total nitrogen) should be measured directly in autoclavable vials (glass or polyethylene). Since the whole vial undergoes the complete digestion procedure, no preservatives are needed. However, nitrogen compounds are easily contaminated by the atmosphere. Therefore, it is recommended that autoclaving (digestion) should take place immediately after sampling, as the stability of the samples is increased after the oxidation step.

Analysis

The methods currently used by most investigators for the analysis of nutrients in sea water are those documented in "Methods of Sea Water Analysis" (second and extended edition - K.R. Grasshoff, M. Ehrhardt and K. Kremling, Verlag-Chemie, Weinheim, New York, 1983; ISBN 3-527-25998-8). Other references to methods for the sampling, filtration, storage, and analysis of sea water in relation to nutrient and salinity measurements can be obtained from the following publications:

"Analysis of Seawater" by T.R. Crompton, Butterworths.

"Practical Estuarine Chemistry: a Handbook" edited by P.C. Head, Cambridge University Press, Cambridge, London, 1985.

In addition to the above, the analyst is referred to Annex 3 of the Report of the ICES Fourth Intercomparison Exercise for Nutrients in Sea Water, in which a review is given of the participants' methods for the determination of phosphate in sea water.

Guidelines for Good Laboratory Practice

1. Before employing any method for routine use, ensure that the method has been fully tested in the laboratory by the staff who are to be employed in this work, staff who have received training in analytical chemistry, to confirm that the required accuracy, precision, and limit of detection are achievable.
2. Once the analyst has an analytical procedure that meets the aims of the particular programme, a quality control procedure should be established to ensure that the required levels of accuracy and precision are maintained in routine measurements. In this respect, the following procedures should be adopted:
 - a) On each occasion when analyses of nutrients are made, a check on the accuracy of these measurements should be made using the appropriate Sagami standards (the European supplier of these standards is Wako Chemicals, Nissan Strasse 2, 4040 Neuss 1, Federal Republic of Germany, Fax No. 49-2101-39879). In the event that the results of the analysis of Sagami standards fall outside the acceptable values, the results of the particular batch of analyses of sea water samples should be rejected and routine analysis should not be conducted until the source of error has been identified and rectified.
 - b) The analysts should take every opportunity to participate in external intercomparison exercises. In the event that this cannot be done, he/she should arrange for samples to be exchanged with a recognized expert laboratory. Participation in such exchanges is the only independent check on the accuracy and precision of a laboratory's analytical results.
3. Other Quality Assurance Practices
 - a) Always run a blank with each batch of analyses to check on any contamination arising from the laboratory environment and the handling practices. Ideally, this blank should be a sample of sea water which contains undetectable levels of nutrients (this can be produced by allowing phytoplankton to grow in sea water under light conditions, separating the sea water by filtration and storing it in a suitable container in a cool and dark place).
 - b) Calibrations should be carried out on a daily basis using working standards which cover the range of concentrations of nutrients in the samples. If the calibration is not linear, then the number of standards over the curvilinear section of the calibration line should be increased to provide proper calibration.
 - c) Working standards should be made up daily and not used after 2 hours. Stock standards can be stored for much longer periods (i.e., 4-6 months), but when they are replaced by new ones, the accuracy of the latter should be checked against the older stock standards before they are used for routine work.

- d) In the absence of Sagami standards for calibration purposes, the analyst should calibrate the procedure using spiked samples of either a 'blank' sea water or a sea water containing low levels of nutrients.
- e) Smoking in the laboratory and the use of cleaning products with an ammonia base should not be allowed, since these can lead to contamination of samples.
- f) If an autosampler is used in conjunction with an auto-analyser for nutrient analysis, ensure that there is an air gap between the sample surface and the top of the sample cup to reduce atmospheric contamination; this precaution is particularly important for measurements of ammonia in sea water.
- g) Always check the salinity of samples if the analytical procedure is influenced by a salt effect.
- h) Measurements of salinity should always be done using a salinometer which is calibrated using standard sea water.

ANNEX 5

POOLING MAY ECONOMIZE A SAMPLING PROGRAMME

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Abstract

When estimating concentrations of contaminants in marine organisms, the confidence of these estimates can be improved considerably by the pooling of organisms before chemical analysis. An example shows that analyzing 4 pools, each containing 22-23 mussels (*Mytilus edulis*), yields estimates of the average metal concentrations with the smallest associated confidence intervals, compared with alternative pooling strategies involving the same costs (i.e., 2 pools of 105 mussels, 3 pools of 50 mussels, or 5 pools of 6 mussels). Without any pooling, the same confidence interval would be obtained at about 5 times the expense.

Introduction

In the 1989 report of the Working Group on the Statistical Aspects of Trend Monitoring (WGSATM), I described a simple method to determine the optimal number of pools and number of organisms within a pool when estimating contaminant concentrations in marine organisms (van der Meer, 1989). However, the WGSATM suggested that an example, including real data, with a clear, non-mathematical description of its use, would provide an important contribution for consideration of the approach by, e.g., WGEAMS and ACMP. Therefore, this paper will first try to explain the method, requiring of the reader only an elementary mathematical and statistical knowledge. Secondly, it gives an example using real data.

The method

When attempting to estimate the mean concentration of some contaminant in a population of animals, one has to deal with two sources of variability: biological variability and analytical variability. Nevertheless, whatever the magnitude of these variabilities, one can get a precise estimate of the mean simply by sampling enough animals and performing enough chemical analyses. However, what is enough?

Remembering that the variance of the average (or squared standard error) is equal to the variance of the observations (or squared standard deviation) divided by the number of observations, it follows that the variance of the average concentration equals the biological variance divided by the total number of animals sampled plus the analytical variance divided by the number of chemical analyses performed. If the number of analyses is then

taken to be equivalent to the number of pools, and the errors are independent,

$$\sigma^2 = \sigma_1^2 / (n \cdot m) + \sigma_2^2 / m \quad (1)$$

where

σ^2 = variance of the average concentration

n = number of animals in a pool

m = number of pools

σ_1^2 = biological variance

σ_2^2 = analytical variance.

However, it is well known that resources are not inexhaustible. The number of animals which can be sampled and the number of analyses which can be conducted are in some way restricted. Therefore, let us assume that the available resources, expressed in some monetary unit, e.g., Norwegian kroner, equals an amount c .

The objective of the sampling programme can be stated as: To minimize the variance of the average concentration, with respect to the number of animals in a pool (n) and the number of analyses performed (m), given the constraint:

$$n \cdot m \cdot c_1 + m \cdot c_2 < c \quad (2)$$

where

c = available amount of money

c_1 = costs of using an extra animal

c_2 = costs of conducting an extra chemical analysis.

Note that costs which are incurred anyway (overheads) are not considered. The solution to the minimization problem can be easily derived, analytically, and yields the optimal number of animals in a pool:

$$n^* = \sqrt{(\sigma_1^2 / \sigma_2^2) \cdot (c_2 / c_1)} \quad (3)$$

The optimal number of animals in a pool depends upon the ratio of the biological and the analytical variances, and upon the ratio of the costs of both parts of the work. The larger the biological variance, and the lower the costs of using an extra animal, the more animals a pool should contain. Note that it does not depend upon c itself. One needs only to know c_1 , c_2 , σ_1^2 and σ_2^2 .

However, usually σ_1^2 and σ_2^2 are unknown and, in practice, we use the estimate of the variance of the average concentration (s^2) to calculate a $1-\alpha$ % confidence interval for this average concentration:

$$y \pm t_{a, m-1} \cdot s \quad (4)$$

where

$t_{a, m-1}$ = Student's t -value, with $m-1$ degrees of freedom.

It seems, therefore, more appropriate to minimize the expected confidence interval, instead of minimizing the expected variance σ^2 . Note that the t-value can be regarded as a sort of penalty for badly estimating the variance. These t-values depend heavily on the number of the degrees of freedom, which is equal to the number of analyses minus one. A few t-values, for $\alpha = 0.05$, are given in Table I.

TABLE I

Critical values of Student's t-distribution, corresponding to $\alpha = 0.05$ and $m-1$ degrees of freedom.

Number of pools m	Student's t-value
2	12.706
3	4.303
4	3.182
5	2.776
10	2.262
25	2.064
∞	1.960

Analyzing only one pool is out of the question, since no variance and therefore no confidence interval can be estimated. Note that an increase from 2 to 3 pools decreases the t-value considerably, whereas an increase from 10 to 25 pools has only a minor influence on the t-value.

Minimizing

$$t_{a,m-1} \cdot \sqrt{(\sigma_1^2 / (n \cdot m) + \sigma_2^2 / m)} \quad (5)$$

with respect to constraint (2) cannot be done analytically, but must be done iteratively. The optimal solution not only depends on c_1 , c_2 , σ_1 and σ_2 , but also on c .

An example: Estimating the concentration of metals in mussels*

Swedish data contributed to the Cooperative ICES Monitoring Studies Programme (CMP) were used to estimate the sum of the biological and analytical variance. Each year 20-25 mussels were analyzed individually. The variances within each year are, therefore, estimates of:

$$\sigma_1^2 + \sigma_2^2$$

These estimates, after removal of a few outlying observations, are given in Table II. The much larger variance of the lead concentrations in 1983 for mussels from area 46G1 corresponds to a much higher average level (7.48), compared to other years (0.69-2.22).

*Figures provided in this example apply only to the data in question; different relative costs and advantages would apply in different situations.

TABLE II

Estimates of the sum of the biological and analytical variance for the concentrations of four metals in the mussel *Mytilus edulis*, derived from Swedish CMP data 1981-1988 for two sampling areas on the Swedish west coast, Fladen (43G1) and Väderöarna (46G1). Data from four animals from area 46G1 in 1983 were excluded as outliers. Stars indicate the number of other outlying values. Metal concentrations are expressed in mg/kg on a dry weight basis.

Year	Area	n	Cd	Cu	Zn	Pb
1981	43G1	20	0.14**	5.08	510	0.14
1981	46G1	20	0.22	1.31	1156	1.64
1982	43G1	20	0.29	6.51	5357	-
1982	46G1	13	0.49	5.22	3844	4.56
1983	43G1	25	0.12	2.15	871	1.20*
1983	46G1	21	0.83	1.15	3326	26.08*
1984	43G1	25	0.08	5.41	1778	0.72
1984	46G1	25	0.22	0.83	4545	1.04
1985	43G1	0	-	-	-	-
1985	46G1	25	0.52	1.76	-	1.98
1986	43G1	0	-	-	-	-
1986	46G1	25	0.05	1.57	541	0.21
1987	43G1	25	0.11	0.53	442	0.21
1987	46G1	25	0.04	1.71	836	0.27
1988	43G1	25	0.08	2.95	483	0.05
1988	46G1	25	0.23	2.11	7316	0.36
Weighted average			0.229	2.580	2312	2.562

The analytical variance was estimated separately, using data from an intercalibration exercise (Berman and Boyko, 1987). Six replicates from an homogenate were analyzed in the intercalibration. Since the exercise treated results for only two different homogenates, it yielded only two separate estimates of the analytical variance for the laboratory which conducted the CMP analyses. We have already seen in Table II that estimates of variances can vary considerably. Therefore, the intercalibration results for two other Swedish laboratories were also used. The results are given in Table III. The analytical variance is much smaller than the biological variance, and contributes about 2-6 percent of the total variance, if animals are analyzed individually.

TABLE III

Estimates of the analytical variance for the concentrations of four metals in the mussel *Mytilus edulis*. Intercalibration results from three Swedish laboratories and two different homogenates were used to calculate a weighted average. The estimated analytical variance is also expressed as a percentage of the biological plus the analytical variance, as shown in Table II. The optimal number of mussels in a pool n^* , as calculated in equation (3), is also given.

Lab	Homogenate	n	Cd	Cu	Zn	Pb
1	1	6	0.0577	0.0537	26.7	0.0907
1	2	6	0.0013	0.0411	25.5	0.0008
2	1	6	0.0006	0.0547	21.4	0.0347
2	2	6	0.0027	0.0467	80.0	0.0530
3	1	6	0.0147	0.0147	110.0	0.0627
Analytical variance s_2			0.015	0.042	52.7	0.048
Biological variance s_1			0.214	2.538	2259.1	2.514
$100 \cdot s_2 / (s_1 + s_2)$			6.5 %	1.6 %	2.3 %	1.9 %
n			29	60	51	56

The average metal concentrations in the CMP data set and the intercalibration data set were more or less comparable (Table IV).

TABLE IV

Average metal concentrations in the CMP data from two areas on the Swedish west coast, 1981-1988. Average concentrations in an intercalibration exercise data set from three Swedish laboratories and two different homogenates.

Metal	Data set	n	Average	Minimum	Maximum
Cd	CMP	14	1.23	0.73	1.83
Cd	Intercalibration	5	1.11	0.80	1.33
Cu	CMP	14	6.13	5.32	7.22
Cu	Intercalibration	5	7.08	6.67	8.00
Zn	CMP	13	106	54	164
Zn	Intercalibration	5	152	145	158
Pb	CMP	13	1.99	0.69	7.48
Pb	Intercalibration	5	2.25	1.93	2.72

Cost estimates used are based on a personal communication from N. Green, Norwegian Institute for Water Research, Oslo. The costs of handling one extra mussel (sampling, dissecting etc.) was estimated at 25 Norwegian kroner, which is approximately the costs of 3 minutes labour (10 kroner \approx 3 Guilder \approx 3 DMark \approx 1.5 US dollar \approx 1 Pound Sterling). One extra chemical analysis costs approximately 1500 kroner. The Norwegians usually take 50 mussels in each of three pools. Thus, their c equals $50 \cdot 3 \cdot 25 + 3 \cdot 1500 = 8,250$ kroner. The Swedes analyze 25 mussels individually, which

on the basis of these figures would cost them $1 \cdot 25 \cdot 25 + 25 \cdot 1500 = 38,125$ kroner.

Table V illustrates how the 8,250 kroner can be allocated between taking more mussels or conducting more analyses. The estimates of the biological and analytical variance for zinc and cadmium were used. The analytical variance for zinc is relatively low and for cadmium relatively high.

TABLE V

Estimated variance of the average zinc and cadmium concentrations for different allocations of 8,250 kroner between conducting analyses (m) or taking more mussels per pool (n).

m	n	$m \cdot c_2$	$n \cdot m \cdot c_1$	t	Zinc		Cadmium	
					Var.	Conf.int.	Var.	Conf.int.
2	105	3000	5250	12.71	37.1	77.4	0.00852	1.173
3	50	4500	3750	4.30	32.6	24.6	0.00643	0.345
4	22.5	6000	2250	3.18	38.3	19.7	0.00613	0.249
5	6	7500	750	2.78	85.8	25.7	0.01013	0.279

Equation (3) indicates an optimal number of animals in a pool of 51 using the zinc figures. Indeed, Table V shows the second possibility ($m=3$, $n=50$) to give the smallest variance. However, taking into account what has been said above about the Student's t-value, the third possibility ($m=4$, $n \approx 22$) must be preferred. This can also be seen in figures 1 to 3, which show, for different numbers of pools, the size of the confidence interval and the number of animals in a pool against the total costs, c. The figures clearly show the validity of the 'marginal value theorem'. Initially, increases in the effort result in a considerable decrease of the confidence interval. Further increases yield much less gain. In addition, the figures show that the optimal number of animals in a pool is much lower than the 51 from equation (3), especially at low costs.

The Swedish strategy of analyzing 25 mussels individually would have resulted in a confidence interval of 19.847 for zinc. This value is even higher than the optimal strategy shown in Table V, despite the considerable extra costs (38,125 kroner against 8,250 kroner).

References

- Berman, S.S. and Boyko, V.J. 1987. ICES Seventh Round Intercalibration for Trace Metals in Biological Tissue, Part 2. ICES MCWG 1987/7.1.
- Meer, van der, J. 1989. Pooling may economize a sampling program. In: Report of the Working Group on Statistical Aspects of Trend Monitoring. ICES, Doc. C.M.1989/E:13.

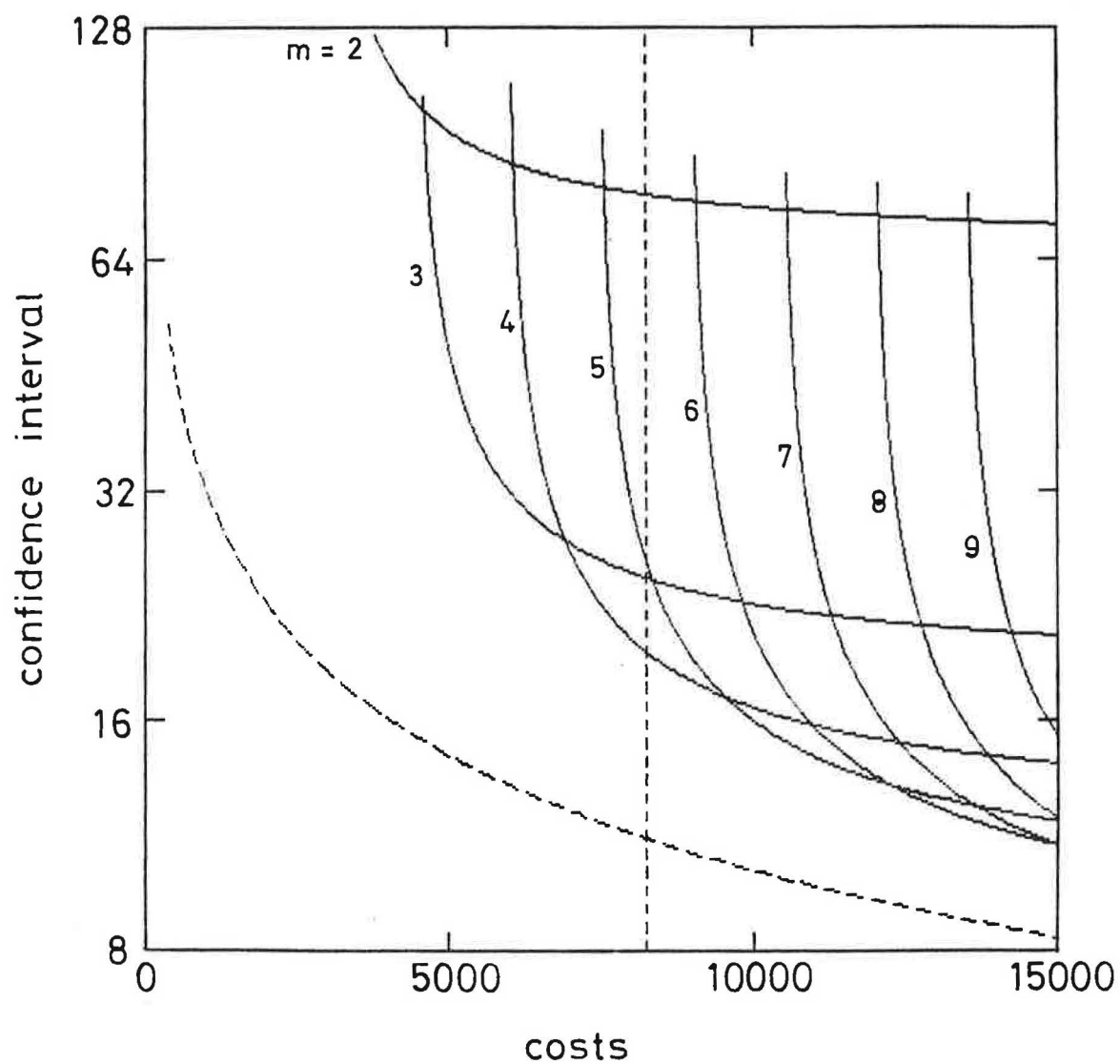


Figure 1 Confidence interval for the average zinc concentrations against costs, for different numbers of pools (m). The broken line shows $t_{(\alpha=0.05, df=\infty)} \cdot \sqrt{\text{variance}}$. The vertical broken line indicates costs = 8,250.

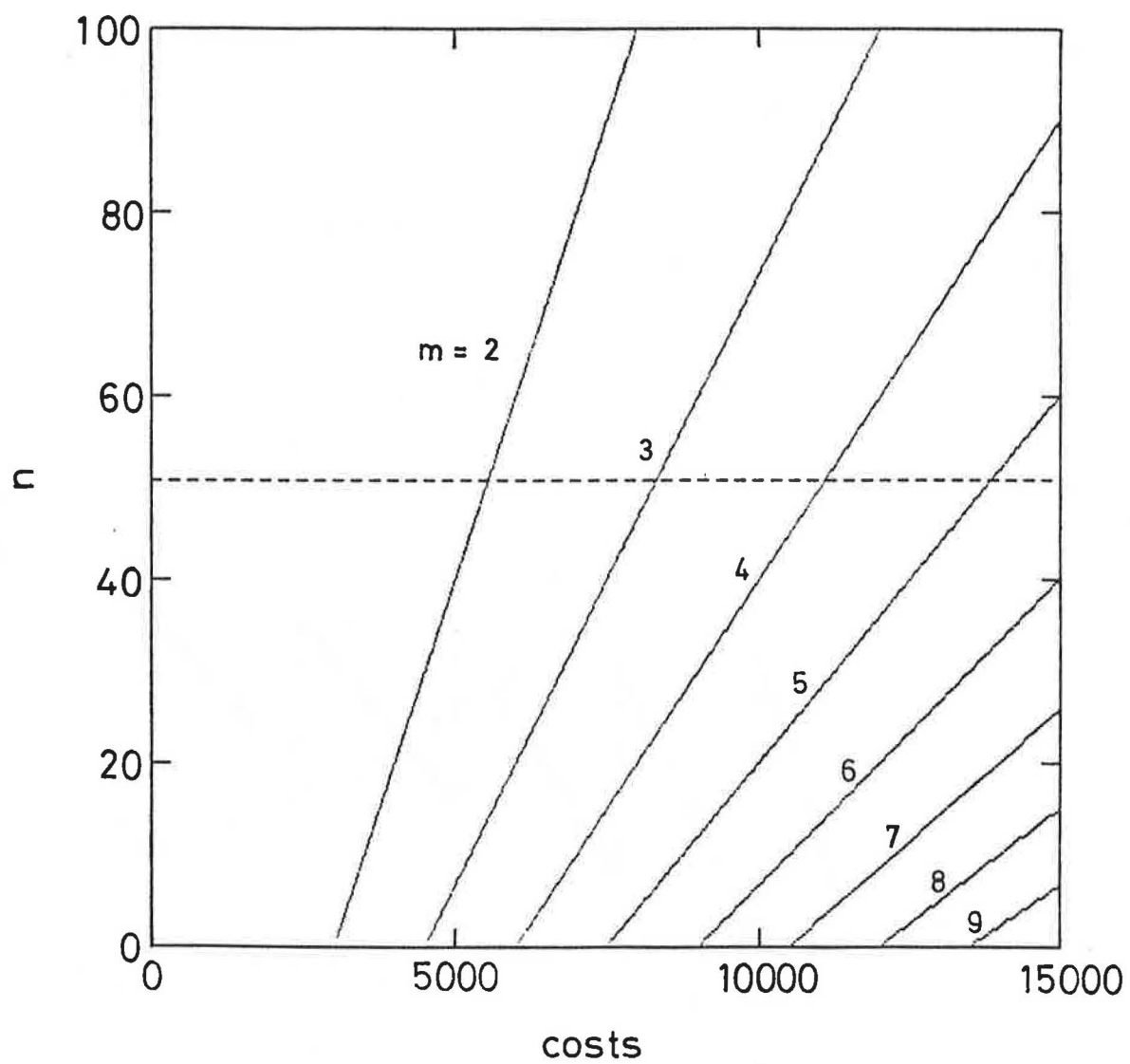


Figure 2 Number of mussels in a pool against costs, for different numbers of pools (m). The broken line shows $n^*(\text{zinc data})$.

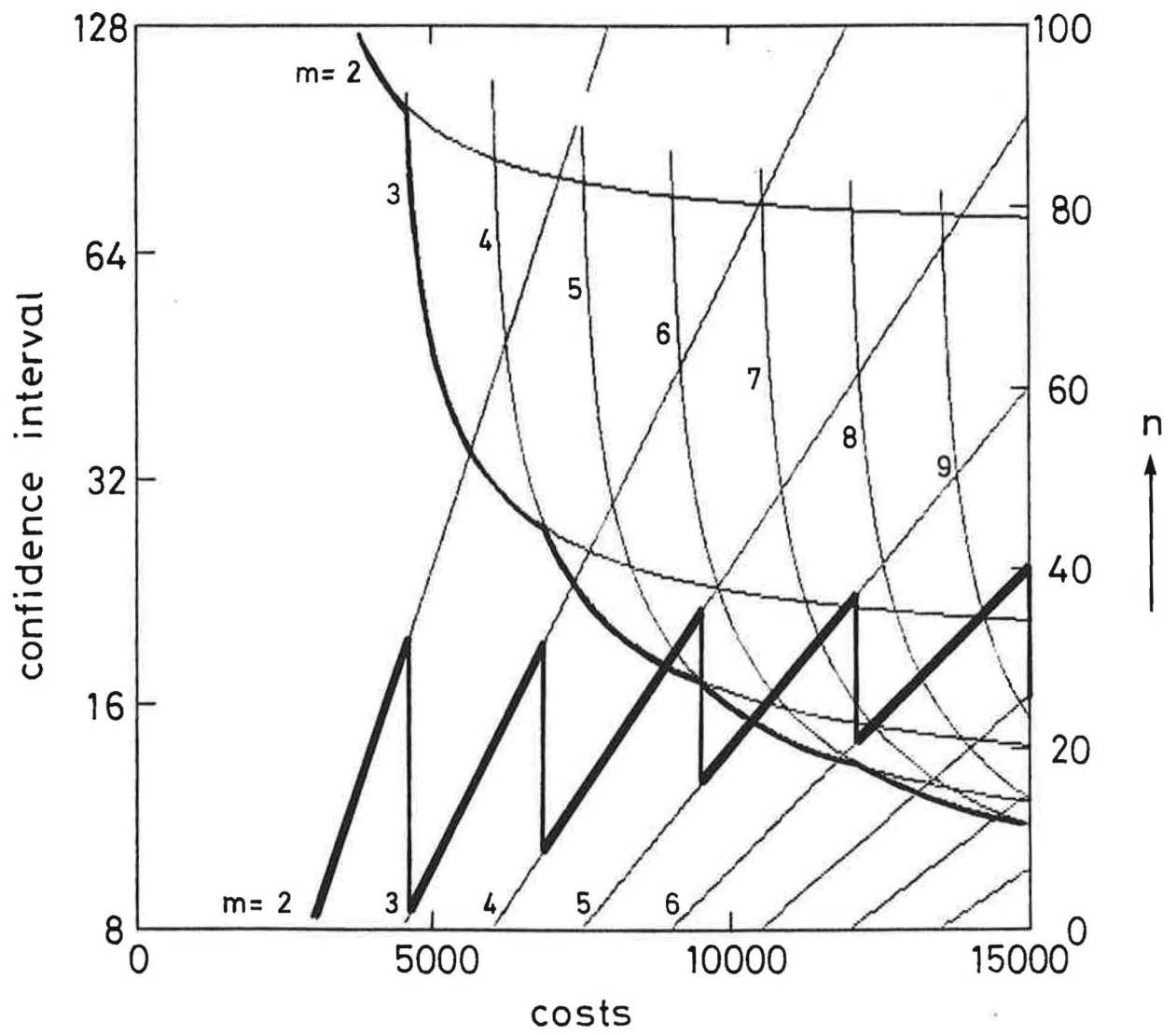


Figure 3 A combination of Figures 1 and 2. The thick line indicates the optimal solution.

ANNEX 6

NORWEGIAN CONTROL SYSTEM FOR DRUG USE IN FISH FARMS

Norway has established a centralized control system for drug use in fish farms. The Norwegian control system and the principles of handling drugs can be described as follows:

All medicated feed products and the formulated fish medicines are considered as pharmaceutical specialities and must have a marketing license issued by the Norwegian Medical Control Authority to permit prescription. Drugs are distributed by or under the supervision of one wholesaler: The Norwegian Medical Department, which has a monopoly on raw materials for feed mills and for formulated drugs. This centralized control system makes it easy to obtain total sales statistics in Norway.

The procedures require that all prescriptions are filled in, separately, by both the veterinarian and the pharmacy or feed mill. Each prescription form has to be provided in three copies: one goes to the farmer, one will be retained by the Department of Fisheries (Quality Control Laboratory), and one is for the veterinarian, feed mill or pharmacy. The scheme of reporting is outlined in Figure 1.

The prescriptions are standardized and contain the following information:

- Veterinarian, name and ID-number,
- fish farmer, name and license number,
- fish species and size,
- amount/number of fish treated,
- chemical used, strength and formulation,
- diagnosis (reason for application),
- dosage recommendation,
- treatment procedure (start and end),
- information on whether fish were vaccinated against the disease (yes/no),
- recommended withdrawal time (in days after the last day of treatment),
- pharmacy/feed mill (name and address).

All data contained in the prescriptions are immediately fed into a central computer system. The data are used for statistical and research purposes (epidemiological research, quality control and follow-up studies, and control measures on residues).

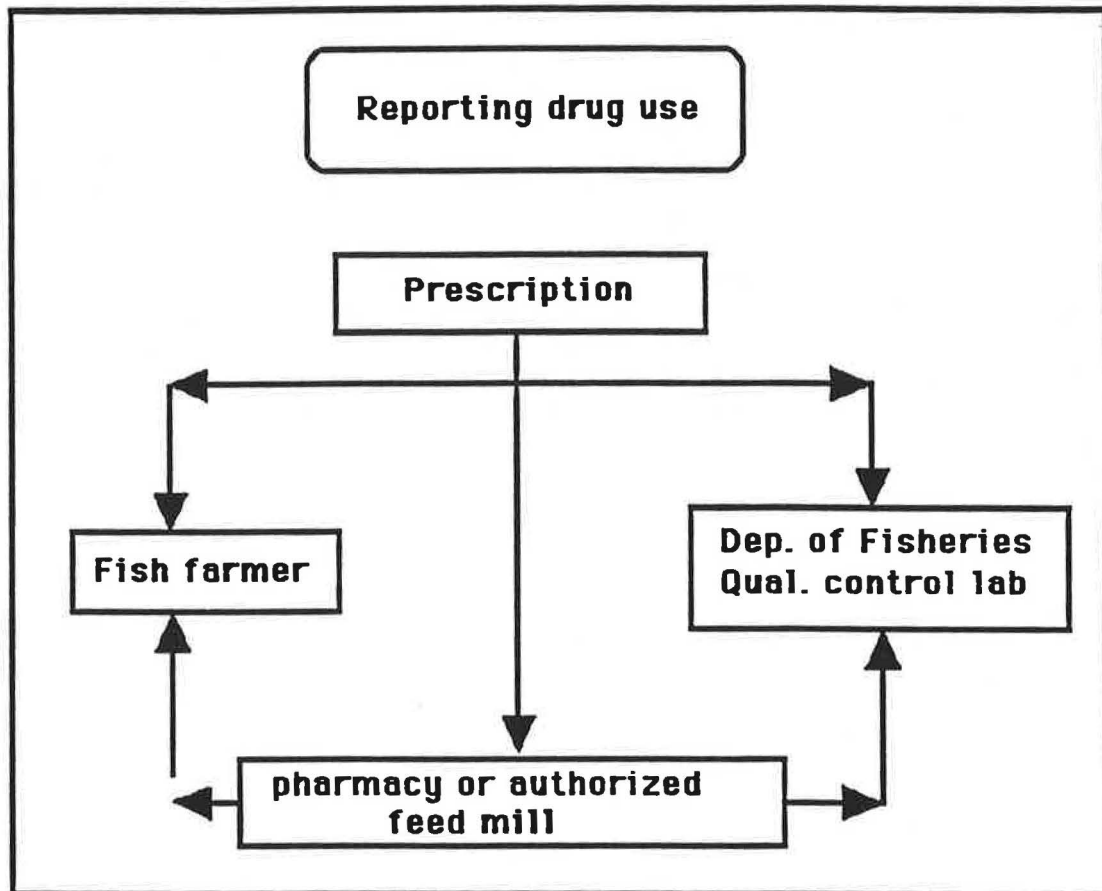


Figure 1: Control of drug distribution and application in Norwegian fish farming. Information routes on prescriptions between farmers, veterinarians, feed mills/pharmacies and the centralized Quality Control Laboratory

ANNEX 7

Statement prepared by the IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) at its Twentieth Session in May 1990:

PROTECTING AND MANAGING THE OCEANS

Underlying Principles and Elements for the Protection and Management of Marine and Coastal Environments

1. INTRODUCTION

The principles of environmental protection, as defined by the 1972 United Nations Conference on the Human Environment (Stockholm 1972), and since amplified by the World Commission on the Environment and Development, have led to the identification of principles and concepts which are now broadly accepted as underlying effective management of the environment and its resources.

Sustainable development implies that the present resources used by the population should neither be degraded nor exhausted to the point where they can no longer support future generations. This further implies that renewable resources which are currently used should be managed on an optimal yield basis.

To achieve sustainable development, therefore, development activities must be analysed from an integrated viewpoint including economic, social, cultural and environmental factors, and activities must be based on the sound use of the global resources. In the light of this it is important to consider the contributions which marine environmental assessment, monitoring, management and planning may make to sustainable development.

This document outlines principles and concepts that provide a rational basis for the sustained use of the marine and coastal environment including marine pollution control measures reflecting the generally accepted principles for marine environmental preservation and protection (e.g., UNCLOS Part XII). They should be considered for the formulation of appropriate strategies for marine protection and management, whether regional or global in scope. The document serves as a background for the development of such strategies.

2. STATEMENTS OF PRINCIPLE

2.1 Implications of sustainable development for marine environmental protection and management

The concept of sustainable development implies that the present use of the marine environment and its resources shall not prejudice the use and enjoyment of that environment and its resources by future generations. Past practices that have neglected this principle are the fundamental cause of many current environmental problems.

2.2 The need for an 'holistic' approach

In order to prevent the transfer of environmental problems from one sector of the environment to another, all sectors need to be managed and protected on a

holistic basis that minimizes the impact of anthropogenic activities on the environment as a whole. It is both scientifically unsound and ethically wrong to take measures to protect one sector of the environment without considering the implications of that action to other sectors or the costs and benefits attendant on that action. Thus, protection of the marine environment must include mechanisms for the comparison of benefits and detriments associated with options in other sectors.

2.3 The global perspective

The oceans constitute one global integrated system. There is consequently a need to consider the effects of anthropogenic activities on near-field and far-field scales. This dictates that any marine protection and management strategy should be regional in design but global in concept.

The scale of impacts resulting from present human activities, such as greenhouse gas production that may adversely affect global systems and processes, emphasizes the need for this global perspective.

2.4 Scientific basis of environmental protection

The effectiveness of management actions to protect the ocean cannot be assessed without scientific analysis and knowledge. Accordingly, comprehensive protection strategies should incorporate scientific principles, however, it is recognized that decision-making frequently involves considerations other than scientific arguments. Close interaction among scientists and decision-makers is essential.

The uncertainties inherent in predicting the consequences or effects of anthropogenic activity may lead to inadequate control measures, ranging from none to overly restrictive ones. However, despite such uncertainties, sufficient data and understanding frequently exist to allow conservative scientific predictions of the potential for environmental damage. Judicious application of available information will generally support the development and implementation of appropriate control measures. Where appropriate data do not exist, additional research is considered essential.

2.5 Important scientific concepts

The concept of assimilative capacity was advanced in the Declaration of the 1972 Stockholm Conference on the Human Environment. It reflects the fact that the environment can accommodate change providing this is not accompanied by deleterious effects. This concept must, however, be augmented with complementary measures to minimize adverse effects on the environment, including reduction of inputs at source, to the extent commensurate with social, economic and political circumstances. It must also be used within a mechanism for sound comparison among alternative options for the disposal of substances; this requires a multidisciplinary approach.

Adoption of the assimilative capacity concept implicitly requires acceptance of a distinction between contamination and pollution with only the latter implying adverse effects on the environment or human health.

The concept of precaution is intrinsic to scientific prediction and allows the inherent uncertainties associated with scientific analysis and assessment to be accommodated. This concept has recently been adopted as a specific instrument of environmental protection policy under the titles of "the principle of anticipatory environmental protection" and the "precautionary approach". The assimilative capacity concept does not conflict with these expressions of precaution;

indeed advice on the application of the assimilative capacity concept previously developed by GESAMP clearly emphasizes the need for the adoption of a precautionary approach using scientific conservatism to allow for uncertainty.

Several recent interpretations of the precautionary principle would seem to imply that protection of the marine environment can be attained solely by progress towards a zero discharge policy. This is a flawed approach, rejection of scientifically based impact assessments will prevent proper allocation of priorities and rational evaluation of alternative options.

3. SCIENTIFIC ELEMENTS OF STRATEGY

3.1 Environmental management and planning

Development inevitably implies environmental change. The challenge for marine and coastal zone management is to balance short-term development needs against the long-term sustainability of ecosystems, habitats and resources such that the range of choices and opportunities available to future generations are not diminished by the consequences of present development choices.

Comprehensive area-specific marine management and planning are essential for maintaining the long-term ecological integrity and productivity and economic benefit of coastal regions. Such management must incorporate comprehensive planning of waste management, including reduction of wastes, beneficial use or recycling of wastes, and treatment and disposal options that result in minimum harm to the environment and human health. It should also include local and regional management plans supported by quality criteria, assessments, monitoring and research.

3.2 The need for cleaner technologies

Considerable degradation of the coastal marine environment has resulted from the use of manufacturing processes now seen to be wasteful and environmentally-hostile. While the problem has been exacerbated by poor waste management, even the best treatment and disposal practices cannot be guaranteed to protect the environment against a constantly increasing quantity of substances and wastes that cannot be productively recycled.

Progress in the fields of industrial design and chemical engineering now afford the opportunity to use manufacturing technologies that substantially reduce waste production and facilitate the containment of harmful substances. These technologies are applicable both to the development of new processes and the up-grading of existing ones. Their application must be seen as an integral part of national and international programmes for the protection of the marine and all other sectors of the environment. To this end, greater attention must be given to the establishment of advisory services for the transfer of clean technologies into national programmes for industrial development. Such services should be linked to regulatory systems that provide for periodic waste audits and environmental impact assessments for all major industrial developments. A number of information centres on clean technologies have already been established.

3.3 Impact prediction and assessment

Impact prediction is an essential component of the broader Environmental Impact Assessment (E.I.A.) process.

The concerns regarding the effects of anthropogenic activities on the environment and human health comprise: physical alteration and disturbance of the natural environment, modification of natural biological systems, and the dispersion, fate and effects of chemicals in the environment. Impact prediction is the process whereby the potential effects or risks of anthropogenic activities on the marine environment are defined and quantified. Factors that need to be considered in an effect or risk prediction are: the scale (load) of the disturbance (physical, biological or chemical), identification of the critical components and processes of the system, and determination (modelling) of the fate and effects on the components which are potentially affected (hazard assessment). All of these factors embody a degree of uncertainty which usually can be quantified, and conservatively allowed for, in the assessment. Such predictions can be used to compare different development options on a common basis.

When an assessment reveals a potential problem, the relative scale of impact must be compared with those of alternative options. One of these options will be that of the abandonment of the proposed development. The assessment also provides a basis for a clearly defined and well-focussed monitoring programme for ensuring that the consequences do not exceed those predicted.

Periodic reassessment of potential impact and of prevailing conditions in the affected environment is essential.

3.4 Classification of substances

Substances vary widely in the concentrations at which they can exert toxic effects on organisms. Their potential for transfer through food chains to predators, including humans, depends in part on their capacity for bioaccumulation. The extent to which a substance is distributed in the environment depends in part on its persistence. The three properties of toxicity, bioaccumulation and persistence in combination represent the hazardous properties of a substance and can be used as the basis for classification systems.

Such systems can be enlarged to include the risk of the substance appearing in certain environmental compartments at significant concentrations; relevant factors are the production, use, disposal and environmental distribution of the substance.

Existing classification systems vary in the extent to which these various properties and factors are utilized. Sub-division into classes is achieved by using arbitrary boundary criteria. Difficulties in allocation occur with chemicals whose attributes lie close to a class boundary. The accuracy of the relevant data available for each substance may be limited.

Classification systems provide only very crude guides to the potential harmfulness of substances. The classification of individual properties may be useful in the context of labelling, packaging and transport of substances, but inadequate as a basis for their environmental control and regulation. For this latter purpose, the totality of the relevant information on the individual properties and potential loads of each substance has to be subjected to critical scientific evaluation before an allocation to any grouping within a regulatory framework can be made.

3.5 Comparison of options

Marine environmental management implicitly requires that choices be made between various actions. Any decision to adopt a particular management strategy, technology or procedure should be preceded by a comparison of the advantages and disadvantages of realistically available alternatives. This does not mean that every conceivable alternative should be subject to detailed assessment.

While emphasis needs to be placed on the environmental advantages of the options considered, comparisons must also take account of economic and socio-political factors. This will require a systematic evaluation of scientific and technical alternatives and the integration of the findings of this evaluation with non-technical evaluations. This involves careful balancing of the overall costs and benefits taking account of inherent uncertainties. Preferred options will be those which provide for sustainable uses of the environment and resources while ensuring adequate protection of the environment and human health.

Actions designed to protect or manage the marine environment should also be evaluated for their potential to affect other sectors of the environment. Such evaluations should also take into account measures that prevent transfrontier pollution or the unequal sharing of costs and benefits among neighbouring States.

It must be accepted that the relative state of knowledge on alternative approaches or technologies will vary. For this reason, direct comparisons between environmental and economic and socio-economic factors may sometimes prove difficult or impossible. These imbalances and associated uncertainties, as well as the steps required to reduce them, should be addressed within the comparative assessment process.

3.6 Monitoring

Considerable advances have been made in developing chemical and biological effects monitoring techniques. However, the potential for technically efficient and focussed monitoring has not yet been fully exploited.

Many current monitoring programmes have neither provided the required information on the state of the marine environment nor adequately determined the effects of anthropogenic activity that they were ostensibly designed to do. A further criticism is that monitoring programmes often continue without the periodic scientific and administrative reviews essential for ensuring their effectiveness.

Greater emphasis needs to be given to the specification of goals and objectives, the formulation of testable hypotheses, consideration and linkages between environmental compartments, quality control procedures and the statistical design of monitoring programmes.

When a well-designed monitoring programme results in unanswered questions about environmental impacts or early warnings of likely effects are detected, supportive research needs to be provided.

Monitoring programmes must also be tied to an a priori commitment for action when pre-determined consequences appear likely to be exceeded. Monitoring programmes must also be subject to regular assessment as to their effectiveness and revised or terminated if this is warranted.

4. ORGANIZATIONAL ELEMENTS OF STRATEGY

4.1 Institutional arrangements

The effective implementation of any strategy, or elements thereof, for marine environmental protection and management, at regional, national or international levels, depends upon cooperation and coordination among many agencies and jurisdictions.

Implementation of the strategy requires clear national policies based on international obligations, a sound legal basis, and opportunities for wide input and participation from all sectors of society. It must involve processes for planning and consultation between parties both at the onset and throughout the conduct of coastal management programmes.

Agreement between parties on the objectives and design of parts of the strategy is essential for achieving its goals. This is especially true for scientifically based parts of the strategy such as monitoring.

A lead agency and committed cooperating agencies in each country, responsible and accountable for all policies, programmes and actions leading from the strategy, are also clearly required.

4.2 Public awareness and participation

The ability of the public to distinguish between the relative importance of marine environmental issues needs strengthening. It is equally important that decision-makers are fully aware of public aspirations.

Many wrongly assume that public participation means decision-making by the public. On the contrary, the roles of the public and decision-makers are distinct.

Public participation in the process of decision-making should be encouraged and facilitated. Those who receive public input have an obligation to publicly indicate whether, how, and to what extent, public views have been taken into account when the final decisions are made.

4.3 Data and information management

Effective marine and coastal environmental management requires the acquisition, storage, retrieval, exchange, quality assessment and application of appropriate data and information.

Information management facilitates the storage and access of data and reduces duplication and loss. It provides opportunities for the use of standard procedures of measurement and the efficient collection, compilation and storage of data, preferably in electronic form. It must incorporate quality assurance, the adoption of compatible data formats and ensure data retrieval in a form suitable for synthesis, evaluation, reporting and planning.

Integrated environmental databases, especially Geographic Information Systems (GIS), are essential for long-term coastal zone management. They readily assist in the translation of data of various types into accessible information useful for decision-makers.

4.4 Legal obligations and enforcement

The obligations to protect the marine and coastal environment assumed by States through existing national legislation, as well as through regional and global agreements, must be implemented and enforced in a more effective way.

ANNEX 8**RELEVANT DOCUMENTS AVAILABLE FROM OTHER ORGANIZATIONS**

The ACMP notes the availability of the following documents:

"Standard and Reference Materials for Marine Science", published by the National Status and Trend Program of the U.S. National Oceanic and Atmospheric Administration, which catalogues the available standards and reference materials for quality assurance procedures. A copy of this document had been given to each participant in the May 1990 quality assurance workshop (see Section 14.7 of the report).

A manual on the measurement of petroleum hydrocarbons in sediments is soon to be published by IOC/UNEP and a manual on the measurement of organochlorines in sea water has been published by IOC in June 1990.

A manual entitled "Contaminant Monitoring Programmes Using Marine Organisms: Quality Assurance and Good Laboratory Practice" is currently available from UNEP as Reference Methods for Marine Pollution Studies No. 57, UNEP 1989.

IOC Secretariat
UNESCO
7, Place de Fontenoy
75700 Paris
France

UNEP Secretariat
P.O. Box 30552
Nairobi
Kenya

ANNEX 9

OVERVIEW OF INTERCALIBRATION/INTERCOMPARISON EXERCISES COORDINATED BY ICESTrace Metals in BiotaFirst ICES Intercalibration Exercise on Trace Metals in Biological Tissue
(1/TM/BT) 1972

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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.

Report on results in preparation.

Trace Metals in Sea WaterFirst 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. Bowers, 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. Bowers, P.A. Yeats, S.S. Berman, D. Cossa, Canada; C Alzieu, P. Courau, France.

Samples : (a) sea water samples, filtered and acidified, for analysis of metals except Hg; (b) sea water samples, natural and spiked, for analysis of Hg. In addition, 6 laboratories participated in an intercomparison of filtration procedures for coastal sea water samples.

Metals analysed: Cd, Cu, Pb, Zn, Ni, Fe, Mn.

Participation : 59 laboratories from 15 ICES member countries plus Monaco.

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

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

Cadmium

Coordinator : Y. Thibaud, France.

Samples : (a) Natural sea water, (b) sea water with a low Cd spike, and (c) sea water with a high Cd spike.

Participation : 33 laboratories from all 13 member countries of the Oslo and Paris Commissions plus Canada and Monaco.

Mercury

Coordinator : J. Olafsson, Iceland.

Samples : (a) two samples of natural sea water, (b) sea water with a low Hg spike, and (c) sea water with a high Hg spike.

Participation : 36 laboratories from all 13 member countries of the Oslo and Paris Commissions plus Canada, Japan and the United States.

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

Trace Metals in Marine Sediments

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

Coordinator : D.H. Loring, Canada.

Samples : (a) Estuarine calcareous sandy mud sediment, (b) harbour sediment, and (c) Baltic mud sediment "MBSS" (from Baltic Sediment Intercalibration Exercise)

Metals analysed: Cd, Cr, Cu, Ni, Pb and Zn.

Optional metals: Ti, Fe, Mn and Al.

Participation : 40 laboratories from 11 ICES member countries.

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

Baltic Sediment Intercalibration Exercise

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

Coordinators : L. Brüggmann, 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. Brüggmann, 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 (Phase 1) (1/TM/SPM-1) 1989

Coordinator : H. Hovind, Oslo
 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.

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 Cooperative Research Report No. 80 (1978).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Results to be published in Cooperative Research Report series.

ICES/IOC/JMG 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.

Report on results to be published at end of 1990.

Hydrocarbons in Marine Samples

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

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

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

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

Coordinators : J.W. Farrington, A.C. Davis, J.B. Livramento, C.H. Clifford,
N.M. Frew, A. Knap, United States.

Samples : (a) Three samples of frozen, freeze-dried mussel homogenate, (b)
reagent grade chrysene, (c) methylene chloride solution of n-
alkanes, (d) methylene chloride solution of aromatic hydrocarbons,
and (e) Arabian Light Crude Oil standard.

Analytes : Aliphatic hydrocarbons (nC_{15} - nC_{32}) and selected aromatic hydro-
carbons.

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
1988/1989

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 is in preparation.

Nutrients in Sea WaterFourth 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,
(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 will be published at the end of 1990.

ANNEX 10

RECENTLY PUBLISHED RELEVANT COOPERATIVE RESEARCH REPORTS

No.	Title
151	Results of 1985 Baseline Study of Contaminants in Fish and Shellfish
152	ICES Sixth Round Intercalibration for Trace Metals in Estuarine Water (JMG 6/TM/SW)
154	Report of the <u>ad hoc</u> Study Group on "Environmental Impact of Mariculture"
155	The Status of Current Knowledge on Anthropogenic Influences in the Irish Sea
156	Marine Environmental and Water Quality Models
160	Report of the ICES Advisory Committee on Marine Pollution, 1988
162	Statistical Analysis of the ICES Cooperative Monitoring Programme. Data on Contaminants in Fish Muscle Tissue (1978-1985) for Determination of Temporal Trends
163	Baltic Sea Patchiness Experiment -- PEX '86 -- Volumes 1 and 2
165	Current Meter Data Quality
166	Methodology of Fish Disease Surveys
167	Report of the ICES Advisory Committee on Marine Pollution, 1989
170	Report of the ICES ¹⁴ C Primary Production Intercomparison Exercise

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ACRONYMS

ADP	-	Automatic Data Processing
BCR	-	Community Bureau of References of the Commission of the European Communities
BMP	-	Baltic Monitoring Programme of the Helsinki Commission
CBs	-	Chlorobiphenyls
CMP	-	Coordinated ICES Monitoring Studies Programme
GEEP	-	IOC/UNEP Group of Experts on the Effects of Pollutants
GESAMP	-	IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution
IOC	-	Intergovernmental Oceanographic Commission
JMG	-	Joint Monitoring Group of the Oslo and Paris Commissions
JMP	-	Joint Monitoring Programme of the Oslo and Paris Commissions
MMP	-	Monitoring Master Plan of the North Sea Task Force
NSTF	-	North Sea Task Force
PAH	-	Polycyclic aromatic hydrocarbons
PEX	-	Joint Multi-Ship Investigation on Patchiness in the Baltic Sea (1986)
QA	-	Quality assurance
QSR	-	Quality Status Report
SKAGEX	-	Joint Investigation of the Skagerrak Area (1990)
SPM	-	Suspended particulate matter
UNEP	-	United Nations Environment Programme

INDICATION OF SPINE COLORS

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

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