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REPORT OF THE ICES ADVISORY COMMITTEE ON MARINE POLLUTION, 1980

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International Council for the Exploration of the Sea
Palægade 2-4, DK-1261 Copenhagen K
Denmark

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List of Members

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

REPORT OF THE ICES ADVISORY COMMITTEE ON MARINE POLLUTION, 1980

INTRODUCTION

1. The Advisory Committee on Marine Pollution has been established by the International Council for the Exploration of the Sea with the task to formulate on behalf of the Council scientific advice on marine pollution and its effects on living resources to Member Governments and to regulatory Commissions. It is a firm procedure within the Council that reports of other subsidiary bodies must pass the Advisory Committee on Marine Pollution.

2. The Advisory Committee on Marine Pollution consists of a number of scientists acting - when they meet as a committee - 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 are not national representatives. The present membership of the Committee is found on page 1.

3. In the present report, the Advisory Committee on Marine Pollution has prepared one overall report in anticipation that most of the material, even when prepared specifically for one Commission, will be of interest to all three regional Commissions. Thus, information both of a general nature as well as in response to specific requests is contained herein.

STATUS OF INTERCALIBRATION/INTERCOMPARISON ACTIVITIES

Cadmium, Lead, and PCBs in Biological Materials

4. The ACMP noted that, as a result of Council resolutions, two new intercalibration exercises had been initiated in late 1979. One exercise (C.Res.1979/4:16) concerned the analyses of cadmium and lead at their concentrations in shellfish tissues. This exercise is being carried out to identify the degree of comparability of results among laboratories at concentrations which most laboratories can adequately analyze, because earlier intercalibrations have shown that the levels of cadmium and lead in the fish muscle samples used were below the detection limits of most participating laboratories (see also para. 21, below). The other exercise (C.Res.1979/4:15) is being conducted to try to obtain better agreement among laboratories in analyses of organochlorine residues, particularly PCBs, in biota. It is intended that the results of this exercise will provide further clarification of the sources of variability in the residue concentrations reported by different laboratories. The ACMP looked forward to reviewing the reports on the results of these two intercalibration exercises, which will be presented at the 1980 Statutory Meeting.

Intercomparison Study of Petroleum Hydrocarbon Analyses in Sediments and Biological Materials

5. The ACMP took note of the initiation in late 1979 of the first attempt within ICES to intercompare analyses of petroleum hydrocarbons in marine samples (C.Res.1979/4:17). Four samples are included in the study: a crude oil, the same oil divided into two fractions, a sediment sample, and a sample of a biological tissue (mussels). As of February 1980, 24 laboratories in 11 ICES member countries had requested and obtained samples. Although

initially it had been envisaged that it might be necessary to restrict the availability of samples to laboratories using the more advanced techniques of petroleum hydrocarbon analysis, it turned out that an adequate amount of sample material was available to fill all requests for samples. Participants were asked to analyze the samples using as wide a range of techniques as possible and for as many fractions or components as possible. The basic objectives of the exercise were thus seen as establishing (a) the range of techniques in use and the range of capabilities among participating laboratories, (b) the variation in results produced by any one method and between methods, and (c) information useful to the development of firm recommendations on a more narrowly defined exercise in the future. Although recognising that the objectives of the exercise appeared rather vague, this was considered unavoidable if the exercise were to meet the ACMP and others' objections by not being restrictive. It was, however, recognised that in any future exercise it may be necessary to place restrictions on methodologies to be used and components to be determined.

6. The ACMP noted that the deadline for submission of results was set at 1 June 1980 and a detailed report of the results will be available by the time of the 1980 Statutory Meeting. The ACMP expected that a second phase of this study will be necessary and that the summary report for the Statutory Meeting will contain proposals on the conduct of further intercomparison/intercalibration exercises on petroleum hydrocarbon analyses, taking into account the results of the present study.

FIFTH ROUND INTERCALIBRATION OF TRACE METALS IN SEA WATER

7. The ACMP agreed that, notwithstanding the conduct by the Intergovernmental Oceanographic Commission (IOC) of an intercalibration exercise partly based on the ICES fifth-round plans and carried out from Bermuda in January 1980, the need remains for a complete and thoroughly conducted fifth-round exercise to be carried out by ICES. The ACMP noted that, while the IOC had conducted some testing of the influence of sampling bottle types and hydrowires, no testing had been done on pre-treatment methods, storage bottles, nor any of the other variables envisaged for the ICES experiment. The ICES fifth round is therefore required not only to capitalize fully on the previous four rounds, but also to arrive at a position to be able to carry out trace metal baseline surveys in shelf seas and coastal water areas and to respond to requests for advice from the Helsinki, Oslo, and Paris Commissions, who have already asked questions about the role of studying trace metal concentrations in sea water in relation to pollution monitoring programmes.

ISSUES RELATED TO MONITORING

Coordinated Monitoring Programme

8. The ACMP considered a draft report on the 1978 results of the Coordinated Monitoring Programme. The report contained data from Belgium, Canada, England/Wales, the Federal Republic of Germany, France, Ireland, the Netherlands, Norway, and the United States on the concentrations of selected heavy metals and organochlorine residues in certain fish and shellfish. Samples had been obtained from the Barents Sea, the North Sea, the Irish Sea, the coast of Portugal, the Gulf of St. Lawrence and the New York Bight. Noting that this was only the first draft of the report, the ACMP looked forward to seeing the final draft at its next meeting.

9. The ACMP then restated its view that it considers these monitoring reports important and again emphasised the need for ICES member countries to send in appropriate data for these reports by the agreed deadline. The ACMP further noted that a revised monitoring programme is expected to begin in 1981 and encouraged ICES member countries to make preparations to participate.

REVIEW OF FIVE YEARS OF COORDINATED MONITORING

10. The ACMP considered a draft review of the results of and experience gained in the ICES coordinated monitoring activities for fish and shellfish quality over the years 1974-1978. This review also presented proposals for a revised monitoring programme in the future.

11. The ACMP recalled that it had already agreed that the main aims of future coordinated monitoring programmes should be :

(a) to provide a continuing assurance of the quality of fish and shellfish used for human consumption,

(b) to survey wide geographical areas, e.g., the North Atlantic, on an intermittent basis, and

(c) to provide a means of determining trends in the concentrations of selected pollutants in selected species from selected areas.

All of these objectives are important to ICES, which in recent years has coordinated pollution monitoring programmes covering wide geographical areas anda number of pollutants. These programmes also offer a sound basis on which to respond to requests for advice. It was expected that the recommendations for the detailed procedures to achieve the three objectives in the next phase of the coordinated monitoring programme will be finished in time for the new programme to begin in 1981. The ACMP stressed the importance of carefully selecting appropriate methods, e.g., sampling, analytical and other procedures to achieve these objectives, because these methods will differ for each of the three objectives enumerated. The aim should be to select methods which provide the most effective results possible at the least cost.

12. The ACMP recognised that any new programme should not only aim to keep under review the situation in areas where it has been agreed that the levels of contaminants justify regular monitoring, but the programme should also contain sufficient coverage of relatively uncontaminated areas to provide an adequate basis for comparison. It was agreed that the selection of areas and species for trend monitoring will require particular attention, as this part of the programme promises to demand the highest degree of analytical support in terms of both quantity and quality.

13. It was noted that the final draft of the five-year review of the coordinated monitoring programme and the recommendations for the future phases will be submitted to ACMP at its next mid-term meeting with a view to acceptance for publication.

14. In closing consideration of this topic, the ACMP noted that the officers of the Council and officers of the Oslo and Paris Commissions would be meeting to discuss the monitoring programmes of the organisations with a view to identifying possible overlaps in coverage and considering how to avoid duplication of effort.

MUSSEL WATCH AND RELATED PROGRAMMES

15. A note was presented which summarised the experience gained in the United States in the Mussel Watch programme and the related Coastal Environmental Assessment Studies project. It was noted that an overall report, covering three consecutive years of monitoring activity, would be published by 1 July 1980. This report will contain information relevant to trend monitoring, intercalibration activities, selection of species for monitoring and biological effects monitoring methods. The ACMP requested that a summary paper covering the major issues in this report be submitted for the 1980 Statutory Meeting for consideration by the Marine Environmental Quality Committee and the ACMP.

16. It was noted that mussel watch-type programmes are being considered or carried out in several ICES member countries. The possibility of including results from these programmes as part of the new Coordinated Monitoring Programme was indicated.

ATMOSPHERIC AND RIVER INPUTS

17. The ACMP considered a background note on the atmospheric deposition of pollutants into the sea. This note provided a brief review of several studies in the Northeast Atlantic and concluded that the estimates given in these studies indicate that a significant contribution, comparable with that from other sources (run-off), is made by atmospheric input to the sea for such metals as manganese, iron, nickel, copper, zinc, lead, and for PCBs and possibly also for other pollutants. Additional information on studies in the Baltic Sea was provided orally.

18. The ACMP also took note of the fact that GESAMP (the Joint Group of Experts on Scientific Aspects of Marine Pollution) would soon publish a report on the interchange of pollutants between the atmosphere and the oceans. This report will contain a summary of current sampling methodologies for atmospheric deposition and will provide guidelines for an oceanic measurement programme.

19. The figures available so far for the input to the ICES area indicate the importance of the atmospheric pathway for some pollutants, but much uncertainty still exists. The ACMP felt that additional information was desirable and thus arranged to have a summary prepared of existing data with a view to stimulating relevant research.

20. On the subject of river inputs, the ACMP noted that the Marine Chemistry Working Group is considering the issue of identifying appropriate sampling methodologies to determine the input of contaminants to the marine environment via rivers. Both the gross transport of contaminants from the river through the estuary to the open sea as well as the net fluxes of these contaminants will be considered. The result of this work is expected to be a document describing procedures by which river inputs of contaminants might reliably be measured. The ACMP looked forward to seeing this document and agreed to discuss the issue further when the document becomes available.

POSSIBILITIES OF IMPROVING DETECTION LIMITS FOR THE ANALYSIS OF CADMIUM AND LEAD IN BIOLOGICAL MATERIAL

21. The ACMP received a paper on this subject and took note of the problems of analysing low levels of cadmium and lead in biological material. It agreed that methods exist for the determination of low levels (0.001 mg/kg) of these metals in fish muscle, but are demanding and expensive and should only be deployed where essential. For example, in a routine monitoring programme carried out for public health purposes it might be necessary on occasion to analyse for actual levels of these metals. However, it would

normally be sufficient to show that predetermined levels of detection, which have been agreed by the appropriate public health authorities as providing sufficient safeguards for publich health, have not been exceeded. Alternatively, concentrations can be measured in other organisms (or tissues) which contain a higher concentration and thus afford an easier opportunity for measurement, always provided that the relationship is known between this concentration and that in the organism (or tissue) of interest. In the case of trend monitoring, however, actual amounts will have to be measured, though in this case it will be usual to select an organism where concentrations are high enough to be easily measurable.

PRINCIPLES IN DERIVING CRITERIA AND SETTING STANDARDS

22. The ACMP recalled that, at its 1979 mid-term meeting, it had considered the first draft of a paper which presented an idealised framework for the derivation of criteria and the setting and application of standards for the regulation of environmental quality (see para. 5, Coop. Res. Rep. No. 92 (1980)). A revised draft of this paper was now available for further review. After suggesting some minor amendments and the addition of practical examples, the ACMP approved the paper and agreed to recommend it for publication during 1981. In closing discussion on this subject, the ACMP recalled that an earlier paper on a related subject, entitled "Monitoring in Relation to Pollution of the Marine Environment" had already been published (as Annex 1 to Coop. Res. Rep. No. 84 (1979)).

PROGRESS ON STUDIES OF POLLUTANTS IN SEDIMENTS

23. The ACMP reviewed the Report of the Coordinating Group on Sediments and Pollution (contained in Annex 1), which Group had been set up by the Council at the 1979 Statutory Meeting to initiate the pilot sediment survey developed by the Workshop on Sediment and Pollutant Interchange (Texel, September 1979). Noting that the Coordinating Group had divided the pilot survey into a four-step exercise, the ACMP felt that the second step should be particularly encouraged. This step, involving the analysis of selected pollutants in sediment cores and obtaining the historical record of pollutant deposition via radiometric dating, was felt to be especially useful since it will improve the identification of sedimentation basins where a continuous sedimentation sequence with minimum disturbance can be found. Finally, on the basis of an overall consideration of the issues mentioned in the Coordinating Group report and the obvious interest in this work on the part of scientists from a number of disciplines, e.g., sedimentology, chemistry, pollution, physical oceanography, the ACMP felt that there was a need for further integration of sediment studies into the work of ICES.

PROGRESS IN THE WORK REQUESTED BY THE OSLO AND PARIS COMMISSIONS

24. At its 1979 mid-term meeting, the ACMP accepted a programme of work which had been requested by the Oslo and Paris Commissions on the advice of the Joint Monitoring Group (see para. 23, Coop. Res. Rep. No. 84 (1979)). After that meeting, requests for two additional items had been received: (a) advice on the use of specimen banking in environmental monitoring programmes, and (b) a summary report on the results of the ICES Workshop on Monitoring the Biological Effects of Pollutants in the Sea. The ACMP accepted these additional tasks at its October 1979 meeting. The progress in each task was considered separately.

INTERCALIBRATION EXERCISES

25. The ACMP had reviewed the results of the intercalibration exercises on analyses of trace metals and organochlorine residues in biological materials at its October 1979 meeting and had approved the reports, subject to further minor amendments by the coordinators of these two exercises. It was noted that the report on the results of the trace metal intercalibration had now been completely finalised for publication and could be transmitted directly to the Oslo and Paris Commissions. For the organochlorine intercalibration, due to problems experienced by the late reception of results, the coordinator had been required to perform a second statistical analysis of the data and he had, in addition, performed a detailed study of the influence of the various analytical methods used on the results obtained. The additional sections to the report arising from these studies had recently been considered and approved by the Marine Chemistry Working Group and it was hoped that the final report would be available shortly. The ACMP expressed its appreciation to the coordinators of these exercises, Dr G. Topping for heavy metals and Mr A.V. Holden for organochlorines, for their excellent work.

26. Turning to the sea water intercalibrations, the ACMP noted that the intercalibration exercise on cadmium analyses in sea water had been carried out according to the plans proposed at the 1979 meeting of the Marine Chemistry Working Group. The exercise included analysis of (a) natural sea water (b) sea water plus a low spike, and (c) sea water plus a high spike. Samples were sent either acidified or deep-frozen and participants used methods of their own choice. The report on the exercise provided details on sample preparation, circulation of samples, analytical techniques and results. The statistical analysis of the results included mean values, standard deviations and percent recoveries. The results obtained using the different analytical techniques and the two preservation methods were also compared.

27. The participation included 29 laboratories from 15 countries. The results showed a very good distribution of data and the mean values obtained by the participants were in very good agreement with the actual spikes. This study seems to show an improvement in the analytical capability of the laboratories involved and definitely demonstrates that the reliability of the sea water sampling method and the sample preparation technique are just as important as the analytical technique used. The ACMP noted that this exercise did not include intercalibration of sampling techniques, which will introduce another step that needs to be considered when comparing the results from studies conducted by different laboratories. However, the fifth round of the heavy metals intercalibration in sea water is intended to study this problem, which becomes a major issue now that the analytical performance of ICES laboratories seems to have reached a high level of agreement.

28. The ACMP then considered the final report of the results of the intercalibration exercise on the analysis of mercury in sea water. This report contained details on the intercalibration samples, the analytical methods used, the results reported and a statistical analysis of these results. The three samples circulated consisted of UV-irradiated, acidified natural sea water and the same sea water with two different levels of mercury spikes. Results were received from 32 out of the 37 participants. These results, when compared with previous mercury intercalibrations, showed a substantial improvement. As the errors demonstrated in low level determinations are mainly of a systematic nature, individual laboratories can now review their procedures with a view to

minimising such errors. It should be noted that sampling and sample treatment methods were not tested and the effects of these steps on the overall results should not be underestimated, particularly in monitoring programmes involving estuarine or coastal regions. These steps will be considered in the fifth round intercalibration for heavy metals in sea water.

29. In considering the intercalibration results for individual laboratories, the ACMP noted that some laboratories do not appear to have the necessary capability to analyse for mercury in sea water and cautioned that they should improve their procedures before participating in sea water monitoring programmes. The ACMP closed its discussion on this subject by expressing its appreciation to the coordinators of these two intercalibration exercises, Dr Y. Thibaud for cadmium and Mr J. Ólafsson for mercury, for their excellent work.

TREND MONITORING USING MARINE ORGANISMS

30. Acknowledging that the issues regarding the use of marine organisms to monitor trends in the levels of contaminants in the marine environment are very complex and require further study, the ACMP agreed to the summary statement of the basic issues contained in the next three paragraphs.

31. There are a multiplicity of factors determining the body burden of pollutants in marine organisms. Studies have therefore been continuing to establish the role and importance of some of these variables with a view to determining the feasibility of controlling critical variables through appropriately designed sampling programmes and, thus, of utilising selected organisms, or individual tissues of organisms, as a basis for monitoring the trends in concentrations of particular pollutants in the marine environment.

32. The basic assumption has been that the concentration of contaminants in biota does reflect the absolute level of these contaminants in the environment and therefore, inter alia, the input of these contaminants to that environment. The question to be resolved, therefore, was how to screen out the "noise" introduced through the influence of other variables occurring randomly, or without sufficient control, in the sampling procedures. Among the variables known or thought to play an important part were age, weight, length, sex, season, condition factor (weight at a given length) and these were among the variables first tested.

33. A number of statistical techniques have been used to analyse the data, including cluster analysis, multiple regression analysis and linear regression analysis. But there is as yet no clear agreement among the statisticians as to which is the best technique. It is probable that slightly different questions have been addressed. For example, samples have been collected on different bases, such as, a single age group, a span of age groups, 25 fish to more than one hundred fish, etc. Some groups studying this problem appear to have been pursuing the objective of maximum supression of background noise and have specified sample size and various constraints in the enumerated variables accordingly. Others have been concerned with identifying which variables should be constrained within what limits for a fixed sample size, in order to provide a given confidence in detecting a 30% change in concentration. A closer dialogue between statisticians, chemists and biologists is to be arranged to resolve the problem. However, it has already been established that the controlling sets of variables probably differ according to pollutant, species and area. They may also differ, in the case of some pollutants, with the magnitude of the body (organ) burden. It is thus evident that a case by case approach will probably be necessary to determine the variables that require control in individual sampling campaigns designed to establish trends in concentrations.

PROCESSES CONTROLLING THE MOVEMENT OF CONTAMINANTS IN THE MARINE ENVIRONMENT

34. The ACMP considered a paper entitled "An Overview of Mercury in the Marine Environment" which had been prepared by Dr G. Topping and Dr H.L. Windom. The paper presented an overview of the physical, chemical, and biological processes which control the movement of mercury between the various compartments of the marine environment from the point of input to the ultimate sink. It had been reviewed and accepted by the Marine Chemistry Working Group and the Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic.

35. After discussion, the ACMP agreed with the perspective of this paper on the factors affecting the transport and distribution of mercury in the marine environment and considered it a good general paper. However, it wished to draw attention to the fact that the standing crop of biomass, although small as a compartment in the total marine system, especially in comparison with the water and sediment compartments, may have a very substantial flux associated with it. Furthermore, in terms of environmental impact it may well be the most important compartment. For example, in the case of mercury, all the evidence available suggests that the greatest degree of impact following the introduction of mercury to the marine environment is its bioaccumulation as methyl mercury and the public health consequences of this accumulation in the tissues of fish and shellfish used for human consumption.

36. This propensity for bioaccumulation can lead to localised problems which may, if not recognised and suitably controlled, lead to major public health problems, such as occurred at Minimata in Japan. While the introduction by man of enhanced quantities of mercury is not now upsetting the global balance of the marine biogeochemical cycle of mercury, it can and undoubtedly has led to serious localised problems in inshore waters, e.g., in the vicinity of mercury cell chloralkali plants, and therefore needs to be kept under careful surveillance in those areas where problems may arise.

37. With these additional remarks, the ACMP approved the document (contained in Annex 2) for transmission to the Oslo and Paris Commissions and expressed appreciation to the authors, Dr G. Topping and Dr H.L. Windom, for their work in preparing the paper.

38. The ACMP noted that further consideration would be given to the general topic of transport processes at the 1980 Statutory Meeting. The Mini-Symposium will be on the topic "Transport Processes in Estuarine and Near-Shore Zones". Additionally, one special topic to be considered by the Marine Environmental Quality Committee will be environmental quality in coastal and estuarine systems and the Hydrography Committee will have as a central theme open ocean meso-scale and slope edge processes.

SPECIMEN BANKING

39. The ACMP discussed this subject on the basis of several papers and provides here its present views on the subject. It urged caution when considering the practical application and implementation of a specimen banking programme. There is danger in that the idea has strong attraction as a panacea, since it is conceptually sound and has great academic appeal. However, attempts to translate the concept into applied programmes soon demonstrate the logistical, economic and facility requirement constraints. Some ACMP members expressed doubt at the feasible application of marine specimen banking.

40. The following suggestions were made :

a) Specimens chosen for banking could come from on-going monitoring programmes, perhaps in conjunction with relevant ICES intercalibration activities.

b) Initial efforts could be made using perhaps one or two species in a test situation. The cod Gadus morhua and the mussel Mytilus edulis are suggested because each is directly consumed by man and currently being monitored within ICES.

c) The feasibility could be considered of setting up an ad hoc group within the Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic to advise on the development of such a programme.

d) Perhaps agreements could result in the establishment of banks on a national level for limited numbers of selected species which could be held by individual laboratories. These banks could operate on a cooperative basis within ICES member countries to enable a more comprehensive collection of specimens for banking purposes.

e) The scope of specimen banking activities might be narrowed by judicious selection of coastal sampling areas, for example.

f) Disease could be included as a parameter, among others, for assessing the biological condition of the specimens at the time of storage.

41. The ACMP stressed that these represent its present views on the subject. It will reconsider the issue when further information is received from the Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic.

BIOLOGICAL EFFECTS MONITORING

42. The ACMP had before it a detailed report of the ICES Workshop on Monitoring the Biological Effects of Pollutants in the Sea (Beaufort, N.C., 1979), together with the comments on the report by the Marine Environmental Quality Committee, the Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic, and the ICES/SCOR Working Group on the Study of Pollution of the Baltic.

43. The ACMP considered that there was now a firm scientific basis for biological effects monitoring, and that substantial progress had been made in identifying particular methods. It was, however, recognised that techniques which were useful in detecting specific contaminants were usually difficult to assess in terms of biological relevance, while, on the other hand, those approaches which clearly suggested adverse ecological effects were in most cases generalised responses which could not easily be attributed unambiguously to a single cause. It was accepted that at present no single biological monitoring procedure would in itself be adequate, but that a suite of techniques should be put together and that the complete package must be supported by both chemical residue analysis and appropriate hydrographic observations.

44. Some techniques, particularly those involving pathobiology, bioassay and physiology, seemed to offer a good balance between contaminant specificity and ecological relevance. However, the ACMP felt that rather than focus on particular techniques at this stage, it should draw attention to the full report of the Workshop which would be published by ICES in the summer of 1980, and recommend that appropriate selections be made from the numerous techniques discussed therein. Within ICES member countries, selection and testing of techniques are underway and reports of the results to ACMP would form the basis of later advice.

45. Finally, it was noted that the ICES Workshop was concerned with the identification and evaluation of techniques, while a Working Group of GESAMP has examined the strategy for deploying effects monitoring procedures. A report of this latter activity is in press as a GESAMP Reports and Studies. Taken together, the ICES and GESAMP reports should provide a useful guide to the inclusion of biological techniques in monitoring programmes.

INCINERATION AT SEA AND OTHER MATTERS RELATED TO DUMPING

46. In order to make an assessment of the harmful effects of incineration of toxic wastes at sea, the ACMP had requested information on the nature and possible effects on the marine environment of non-combusted toxic substances and of the physical conditions that determine the input of such substances to the sea. At the request of ACMP, the first point had been discussed by the Marine Chemistry Working Group, which had arranged for the preparation of a paper on the composition of exhaust gases resulting from incineration at sea. Concerning the second point, the Chairman of the Hydrography Committee had prepared a paper on physical conditions relevant to the deposition of exhaust gases into the sea, which he presented to the ACMP. After discussing the principle of incineration at sea in relation to possible effects on marine organisms, the ACMP decided to postpone further discussion until the report by the Marine Chemistry Working Group members was available.

47. With respect to possible advice to be given by ACMP on deep ocean dumping of waste, the ACMP was informed that the Working Group on Oceanic Hydrography was preparing an inventory of relevant hydrographic activities, which would be updated regularly. This Working Group, however, looked for further guidance if it is expected to play a more active role in this work, particularly concerning the interdisciplinary aspects of the issue. The Chairman of the Hydrography Committee offered to take up this matter with his Committee during the 1980 Statutory Meeting, where there would be a good opportunity for further discussion when the special topic on "Open ocean meso-scale and slope-edge processes" would be considered.

STWG/ICES PROJECT "ASSESSMENT OF THE EFFECTS OF POLLUTION ON THE BALTIC"

48. The ACMP recalled the background to this project (see paras. 32-36, 1979 ACMP Report, Coop. Res. Rep. No. 92 (1980)), in which the Interim Baltic Marine Environment Protection Commission had invited ICES to assist in the preparation of an assessment of the effects of pollution on the Baltic Sea, especially on its living resources. To coordinate this project, a five-member STWG/ICES Editorial Board had been set up.

49. The ACMP had before it the first rough draft of the overall assessment document, which described the physical, chemical and biological characteristics of the Baltic Sea and provided available information on the influence of these characteristics on pollution levels in the Baltic and the known effects of pollution on biota. In addition, there was a preliminary first draft of the overall conclusions extracted from the full document. These documents were presented to inform the Committee of the progress in the work and obtain comments and advise on the approach being taken.

50. After giving a general consideration to these documents, the ACMP accepted the approach presently being taken, with part 1 the scientific document, part 2 the conclusions based on part 1, and part 3 an executive summary. The ACMP further agreed that responsibility for the contents of parts 1 and 2 must rest on the Editorial Board and the contributing authors. The ACMP would, however, accept the responsibility of reviewing the executive summary with a view to approval. This executive summary should be prepared for the use of administrators making decisions on environmental matters and could be divided into three sections. The first section could contain clear, general statements on the levels or effects of pollutants in the Baltic Sea as a whole or any of its regions. The second section could present problem issues for which there are unresolved differences of opinion or interpretation. In the third section, matters could be identified which, although previously considered a potential or actual problem, have been found not to present a problem at this time.

The ACMP further noted that the amount of material submitted for the preparation of this document had been considerably larger than had originally been expected and this could be reflected in the time schedule for completion of the work.

51. In conclusion, the ACMP expressed its appreciation to the Editor and members of the Editorial Board for the impressive amount of work they had conducted in a short time frame and looked forward to reviewing the executive summary of the document.

BIOLOGICAL DATA REPORTING FORMAT

52. The ACMP took note of a Biological Data Reporting Format which had been prepared at the request of the Interim Baltic Marine Environment Protection Commission for the exchange of biological data obtained in the Baltic Monitoring Programme. Among others, the Working Group on Marine Data Management had assisted in the preparation of the format and had given a general acceptance of it. The ACMP accepted the format and expressed its appreciation to the many people who had assisted in its preparation.

PROGRESS IN THE SCIENTIFIC STUDIES OF THE BALTIC SEA

53. As part of its annual review of the progress in the activities of the ICES/SCOR Working Group on the Study of Pollution of the Baltic, the ACMP took note of the information contained in the following paragraphs.

Development of the BOSEX (Baltic Open Sea Experiment) results

54. The analysis of the large set of physical and chemical data is progressing satisfactorily, with several papers appearing. These are concerned with the development of air-sea interactions, the development of inertial currents, vertical mixing and erosion of the thermocline, the coherence between currents observed at

different stations, a comparison between analysis of nutrients and oxygen content, patchiness and variability of nutrient distributions, and nitrogen cycling. Both the distributions in the BOSEX area and the large-scale distributions in sections connected to the area are being studied. An important basic result is the observation of the large variability which may be referred to as patchiness, in the distributions as well as the impact on the vertical structure of the severe storms passing the area during the experiment. The heavy metal analysis of sea water has been completed. The situation regarding the analysis of the less extensive biological data set is not so promising. A final BOSEX workshop is planned for 2 days in October 1980, where an attempt will be made to integrate the results and summarise the experience gained.

Further developments

55. Results from BOSEX show that the distributions of nutrients and other variables are very "patchy" and that this imposes great difficulties in the interpretation. This is also likely to be the case for observations taken at intervals at the same position. On the basis of these results and others, plans are being developed for a coordinated interdisciplinary patchiness study in the central Baltic. This could be carried out in conjunction with one of the international monitoring stations. A planning group is formulating the programme for such a study which tentatively is being proposed for 1981/82.

56. The exchange between the coastal zone and the open sea, although not part of an international study effort, has been discussed by the Working Group on several occasions. It is felt that this is a very important problem and that knowledge is required not only of the transfer of substances from land to the sea, but also on how much material is being retained in the coastal zone or transferred to the open sea areas respectively, and on what time scales. It is also necessary to understand the dynamics of the coastal zone, among other things, in view of the biological activity there and the possible large vertical fluxes occurring in that zone. Thus, studies in this zone should be encouraged as well as the presentation of the results to an international community, such as within ICES.

57. The biogeochemical cycling of substances is receiving considerable attention and it is the intention to stimulate further work on this in the Baltic, taking the cycling of nutrients and the role of sedimentation as an example, by establishing contact among scientists from different disciplines working in this field.

58. Recently, considerable efforts have been devoted to the question of the feasibility of including biological effects monitoring in the presently conducted primarily chemical monitoring programmes. Recognising that no single strategy can be recommended at this stage, it was nevertheless considered important to establish contacts among scientists involved in relevant studies with the view of collecting experience and information on results of localised programmes. Accordingly, this will be pursued by a sub-group of the Working Group.

59. The ACMP noted these developments and endorsed the planned activities. The ACMP also agreed on the need for a continuation of the coordination of the scientific and pollution studies in the Baltic Sea.

SCIENTIFIC STUDIES IN RESPONSE TO AN OIL POLLUTION INCIDENT

60. The ACMP had before it a draft document which sets forth a programme of scientific studies which should be conducted to investigate the immediate and long-term effects of significant oil spills or blow-outs. It was noted that this document had been under development for two years and during that time a number of ICES member countries had prepared their own programmes on a national basis. However, the ACMP agreed that this document could serve as a useful guideline. It was thus agreed that the document should be published, but as several amendments were considered necessary, the document would be reviewed again at the October 1980 ACMP meeting. In closing the discussion, the ACMP expressed its appreciation to the editors of this draft document, Dr J.B. Pearce and Dr A.D. McIntyre, for their work.

RED TIDES AND EUTROPHICATION

61. The ACMP recalled that this issue first arose when the former Fisheries Improvement Committee had posed a question to the former Plankton Committee on whether a relationship could be found between eutrophication and unusual plankton blooms, especially red tides. A Working Group had considered the issue in 1976, looking at the effect of the discharge of nutrients from major rivers on the occurrence of red tides, however no action had been taken on the recommendations made by that group. As the issue still remained unresolved, the ACMP had decided at its previous meeting that relevant information should be collected in order to determine whether work on the subject should be encouraged.

62. The Chairman of the Biological Oceanography Committee reported on the discussions held within this Committee at the 1979 Statutory Meeting and recommended that ACMP be more specific in its question. For example, is the enquiry related to eutrophication and resultant algal blooms or is it to determine the factors responsible for and documentation of the occurrence and distribution of unusual phytoplankton blooms. A paper was then presented which outlined recent observations of phytoplankton blooms near the Swedish coast. Another paper described the experiences along the coastline of Poland. The meeting also noted that the question will be discussed in the document "Assessment of the Effects of Pollution on the Natural Resources of the Baltic Sea". On the basis of these papers, it was suggested that a system be developed on an ICES area basis to report and document unusual occurrences of phytoplankton blooms.

63. An account of the 1974 and 1978 International Conferences on Toxic Dinoflagellate Blooms and a comment on the Canadian situation with respect to phytoplankton blooms were also presented. In the discussion of this material, it became apparent that much more effort was required to study the taxonomic, oceanographic and biological aspects responsible for major phytoplankton blooms and that increased efforts should be devoted to improving the predictive capabilities. It was suggested that certain localities where blooms frequently recur should be monitored on a continuing basis to improve documentation on the subject. A network of laboratories involved in phytoplankton research might provide a suitable basis for developing a systematic means of recording the incidence of red tide or toxic phytoplankton blooms.

MATTERS OF INTEREST ARISING FROM THE STANDING COMMITTEES

64. It was noted that at the 1979 Statutory Meeting, the Marine Environmental Quality Committee had discussed in particular questions of environmental quality in estuaries and coastal regions and also problems of biological effects monitoring. Further contributions on both of these topics have been arranged for the 1980 meeting with a view to producing integrated comments and proposals on monitoring matters. Arrangements have also been made to advance the knowledge and information on sediments in the context of pollution. Finally, the problems of pollution in relation to marine mammals had been discussed and, as a result of the serious issues pointed out, the Council had passed C.Res. 1979/4:19 encouraging ICES member countries to support scientific studies on the levels of contaminants in marine mammals and the effects on their biology.

65. It was reported that the first meeting of the Working Group on Primary Production Methodology would take place in summer 1980. This Group has been established to develop a detailed proposal for measuring primary production according to the ^{14}C method, including the evaluation, inter-calibration and, possibly, standardisation of both *in situ* and incubator techniques. The conclusions of the Working Group meeting will be discussed by the Biological Oceanography Committee at the 1980 Statutory Meeting. The ACMP emphasised the high priority of the work of this Working Group and will follow closely the results of its deliberations.

ANNEX 1

REPORT OF THE COORDINATING GROUP ON SEDIMENTS AND POLLUTION

At its Statutory Meeting in 1979, the ICES Council adopted the following resolution (C.Res.1979/2:8):

> It was decided that a Coordinating Group should be established, consisting of the Convenor of the Sediment Workshop, who should act as Chairman, the Chairman of the Hydrography Committee, the Chairman or a nominee of the Marine Chemistry Working Group, the Chairman or a biologist nominee of the Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic, Dr L Niemistö (a Baltic sedimentologist), and Dr D Eisma (Netherlands sedimentologist). This Group should meet as soon as possible, at national expense, preferably not later than January 1980 to:
>
> (i) coordinate the initiation of a pilot survey according to the plan developed by the Workshop/ Symposium on Sediment and Pollution Interchange, and summarised in Document C.M.1979/E:71,
>
> (ii) give preliminary consideration to an integration into the framework of other marine science disciplines within ICES of problems of a sedimentological nature relevant to the work of ICES, and
>
> (iii) the Coordinating Group should report progress and results to the next meeting of ACMP and to the Marine Environmental Quality Committee.

The Group met in the Netherlands Institute for Sea Research, Texel, on 25 and 26 February 1980. Participants were H Postma (Chairman); J Skei (Secretary); L Otto (Chairman, Hydrography Committee); A Jensen (member, Marine Chemistry Working Group); A Preston (Chairman, Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic) and D Eisma (Skagerrak ad hoc Working Group); L Niemistö was absent.

1. Pilot Survey

At the Sediment Workshop in Texel in 1979, five different sites in the North Sea area were proposed for carrying out a pilot survey:

German Bight SE of Helgoland
Zeebrugge area
English coast near the Yare
Outer Silver Pit area
Skagerrak and Norwegian Deep.

The Coordinating Group recommends that the number of sites be reduced to two, the German Bight and the Skagerrak-Kattegat area. These two areas provide between them an opportunity (a) to establish the pollution record in sediment cores especially in the Skagerrak-Kattegat area and (b) to examine in detail the dynamics of sediment behaviour, especially in the German Bight area. This would imply less effort and resources but still be sufficient to outline some of the problems of a larger pilot survey. If necessary other sites could be included at a later stage in the survey.

It was strongly felt that these pilot surveys should be looked upon as a stepwise exercise:

1) Obtain a list of institutions and personnel already working with sedimentological and hydrographical problems in the actual areas.

2) Carry out a short-term exercise on the two sites. This should include sediment sampling of a few 3 m cores and the same number of box cores and analysis of selected heavy metals, organic carbon, lead-210, ^{14}C (possibly Cs-137) and organic pollutants such as PCB, DDT and PAH. From the historical record of pollutants, obtained in these cores by radiometric methods, an assessment of the flux of pollutants to the sediments at these sites could be made.

3) If the preliminary exercise were successful, a grid-system of sediment sampling could be established to look at the representativity of the data. From this exercise, budget calculations of total amount of pollutants accumulated in the sediments at the sites could be made. This would be the first step towards a monitoring approach, as proposed by the Sediment Workshop.

4) A long-term project could be initiated to study fluxes of pollutants and suspended matter at the sites. This would require a considerable effort and contribution from physical oceanographers. This long-term study would depend on the outcome of the short-term exercise. It would also require an extensive discussion on methodology.

The Coordinating Group would like to encourage scientists within the field of sedimentology, hydrography and marine chemistry to work within the framework of an interdisciplinary project in the North Sea area. It is, however, necessary to deal with this in various stages. This implies that no fixed programme for the entire pilot survey can be given yet.

Since the sediment survey is closely related to marine chemistry, the Coordinating Group recommends that this project be further developed by a study group under the Marine Chemistry Working Group. With respect to flux measurements, there is need for contribution from the Hydrography Committee. It was pointed out that a discussion paper should be presented where problems related to measurements of fluxes of suspended matter were focused. The Chairman of the Hydrography Committee was asked to arrange for such a paper.

2. Monitoring of Sediments

The Group was not asked specifically by ICES to discuss again the matter of monitoring of sediments, but was informed about the discussion of the subject in the Marine Chemistry Working Group and the Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic, as well as the plans of the Joint Monitoring Group of the Oslo and Paris Commissions for intercalibration of heavy metal analyses in sediments. In view of these activities the Coordinating Group wants to make the following comments.

The Group is of the opinion that monitoring of sediments is a useful exercise for following pollution history, since this is recorded in the sediment over a prolonged period. It is thus possible, by sampling deeper layers, to find a base level and, by projection into the future,

to make certain predictions. Moreover, mass balance studies will provide an insight into the amounts retained and accumulated in near-shore areas, the amounts deposited in offshore regions of net sedimentation ("sinks") and possibly the amounts that escape from the North Sea. Finally, patterns of pollutants in sediments are essential background information for selection of potential dumping sites and for the policy to be followed for storage of pollutants on land.

The Group wants to point out, at the same time, a number of difficulties. First of all, especially in a turbulent and biologically active area as the North Sea, the sedimentary record is probably nowhere fully preserved. Besides by largely unknown patterns of deposition and erosion, a disturbing influence is exerted by bioturbation which vigorously mixes sediments in the upper decimeters; this bioturbation is further accelerated by the trawl fishery. This causes pollutant distribution to be often very irregular and difficult to interpret in a monitoring context. Secondly, sources of pollutants are often difficult to trace and local processes mostly determine their fate. This means that local monitoring of restricted and well defined areas as, for example, river mouths, fjords, estuaries and offshore mud fields may be more successful than of larger regions. This is one of the reasons why the Texel Workshop preferred selection of one or two specific areas for a pilot project. Finally, at greater distances from sources, the excess concentrations due to pollution in the sediments are often difficult to determine.

The Group further discussed sediment sampling, intercalibration and processing. It concluded that the methodology to be followed depends on the aims that are pursued. For monitoring purposes as discussed by the Joint Monitoring Group, a simple procedure consisting of drying and homogenizing a sample may be sufficient and this will facilitate intercalibration of subsequent analyses, though attention will have to be paid subsequently to variations introduced by sampling and sample treatment. The Group expressed its readiness to cooperate in this project with the Marine Chemistry Working Group and proposes that they give joint consideration to outlining a sequence of intercalibration studies taking into account the results of the Joint Monitoring Group exercise, for approval at the 1980 Council Meeting.

For a pilot survey as envisaged by the Texel Workshop, such a procedure will not be sufficient. For sampling it was deemed necessary to use techniques - coring and box sampling - which do not disturb the sediment layers so that these can be dated and analysed separately. Regarding dating it was suggested that a combination of dating methods will provide an insight into older and recent rates of sedimentation and into the importance of turbation. A number of separation techniques and analyses have to take place already on board ship and intercalibration will have to occur in close connection with the field work.

To understand processes in the sediments, their function in the boundary layer and the relation between deposits and sediment transport, it is necessary to disturb the structure in first instance as little as possible. Important parameters to be studied on the undisturbed sample are water content, sediment structure , microlayers, grain size and possibly physical properties.

ANNEX 2

AN OVERVIEW OF MERCURY IN THE MARINE ENVIRONMENT

Preface

At their 1978 meetings, the Oslo and Paris Commissions requested assistance from ICES on a number of scientific topics relating to marine pollution matters. This report deals with one of these requests and was prepared by two members of the Marine Chemistry Working Group, Dr G Topping, DAFS Marine Laboratory, Aberdeen, and Dr H L Windom, Skidaway Institute of Oceanography, Savannah, Georgia.

This report has been reviewed and approved by the Marine Chemistry Working Group and the Working Group on Marine Pollution Baseline and Monitoring Studies in the North Atlantic. Thereafter it was considered by the Advisory Committee on Marine Pollution which, taking into account the comments in paragraphs 35 and 36 of the 1980 ACMP Report, approved the paper for transmission to the Oslo and Paris Commissions. The Advisory Committee on Marine Pollution wishes to express its great appreciation to Dr Topping and Dr Windom for their efforts in preparing this report.

Introduction

This report deals with the examination of the physical, chemical and biological processes which control the movement of mercury between the various compartments of the marine environment from the point of input to the ultimate sink.

The subject of mercury in the marine environment has been systematically reviewed on a number of occasions over the last decade. The authors feel that another review would serve little purpose in the context of the request by the Oslo and Paris Commissions. They have therefore decided to produce an 'overview' paper which represents their current views on the movement of mercury in the marine environment.

Forms of Mercury in the Marine Environment

Discharges of mercury to the sea from natural and anthropogenic sources are thought to be primarily in the form of inorganic mercury (Hg°, Hg^{2+}). The bulk of mercury in the marine environment appears to be either associated with soluble and particulate carbon compounds as Hg^{2+} complexes or in solution as $HgCl_4^{2-}$. Surprisingly, however, a large fraction of the total mercury found in marine organisms, particularly vertebrates, is present as methyl mercury compounds (CH_3, HgX).

Although there is an extensive list of publications dealing with the synthesis and degradation of methyl mercury, the subject does not appear to be well understood, particularly in terms of quantifying the role of methyl mercury in the overall movement of mercury in the marine environment.

Experimental studies have shown that when mercury, as Hg^{2+}, is added to sea water it is quickly associated with any soluble and particulate carbon compounds present in the sea water. Conversely, in the absence of organic material most of the added mercury remains in the 'reactive' form, i.e., the uncomplexed form of mercury which can be easily converted to Hg° using a reducing agent such as $SnCl_2$.

Processes affecting the Movement of Mercury in the Marine Environment

It is thought that the behaviour, movement and fate of mercury in the marine environment is influenced by two processes:

(a) the adsorption onto particulate matter and its subsequent release from this material, and

(b) the accumulation by, and excretion from, marine biota.

These two processes will be examined in the context of the open ocean and inshore waters.

Open Ocean

Recent surveys have shown that the concentration of mercury in the open ocean sea water is ca. 0.005 µg/litre and that a significant, but variable, fraction of this mercury is associated with particulate matter. Because of the difficulty of measuring changes in concentration of mercury at this level, it has proved difficult to assess the movement of mercury between the soluble and particulate phases. In theory, however, the transfer of particulate matter from the mixed layer of the ocean to the bottom waters could be an effective mechanism for the movement of mercury in the marine environment. To date no estimate of this transfer has been made.

It has often been claimed that the accumulation of mercury by phytoplankton is an effective mechanism for the vertical transport of this element between surface and bottom waters. To our knowledge none of these claims have ever been supported by either the relevant measurements in the field or a theoretical calculation of this loss. We present below our calculation for this potential loss mechanism.

In the calculation below, the following data are used:-

1) A phytoplankton primary production rate of 50 $gC/m^2/yr$ ($\equiv$ 100 g dry $wt/m^2/yr$),

2) A euphotic zone of 100 metres,

3) A concentration factor (from water to plankton) of 10^4, and

4) A concentration of mercury in sea water of 0.005 µg/litre.

The amount of mercury removed annually by this phytoplankton in a water column whose dimensions are 100 m x 1 m^2

$$= 100 \times \frac{0.005}{10^3} \times 10^4 \ \mu g = 5 \ \mu g$$

The amount of mercury present in this water column = 500 µg.

It can be seen from this calculation that only 1% of the mercury in this water column is removed annually by the resident phytoplankton.

In view of the results of this calculation, it is difficult to accept that the accumulation of mercury by phytoplankton is important in quantitative terms for the movement of mercury in the marine environment.

Since the annual production of other forms of marine life, e.g., zooplankton, fish, is considerably smaller than phytoplankton production and the concentrations of mercury in these organisms are similar to those found in phytoplankton, it follows that the annual accumulation of mercury by these organisms is even less significant. In Table 1 we present data for the amounts of mercury associated with phytoplankton and fish in the world's oceans and compare them to the total amount of mercury in open ocean water and sediment. For information and comparison,

we also give recent data on the amount of mercury entering the open ocean from the atmosphere and rivers, since these are the principal inputs to the open ocean.

Table 1 Quantity of mercury (tonnes) in the various compartments of the open ocean.

Compartment	Annual production or quantity in each compartment	Conc. of mercury	Total mercury (tonnes)
PLANKTON	50 g $C/m^2/yr$	0.05 ppm	1800
FISH	240 x 10^6 tonnes/yr	0.1 ppm	24
SEAWATER	1370 x 10^6 km^3	0.005 µg/l	6 850 000
SEDIMENT	361 x 10^6 km^2 (x 1 mm)	0.1 ppm	36000
RAINFALL	4.2 x 10^{17} litre	10 ng/l	4200
RIVERS	3.2 x 10^{16} litre	10 - 30 ng/l	320 - 1000

Inshore Waters

The main inputs of mercury to inshore waters, particularly estuaries, arise from rivers, industrial and domestic discharges through pipe outfalls, and dumping of waste material, e.g., sewage sludge. The relative importance of these types of input will depend on the size of population, the degree of industrialisation and the mineral deposits in the rainfall catchment area. Although mercury is deposited in inshore waters from the atmosphere in most areas it represents a relatively small, if not insignificant, input.

The behaviour, movement and fate of mercury in estuaries is thought to be influenced by the following processes:-

(a) adsorption onto particulate matter

(b) deposition of the suspended particulates onto sediments

(c) movement from sediments to either the water column or to the benthic biota

(d) removal from the water column by plankton or by filter feeding organisms, e.g., bivalves

(e) loss to the atmosphere through volatilisation

(f) transfer to the open sea via the surface outflow.

The great affinity of mercury for particulate matter, especially organic material, and the settlement of this material to the sediment are probably the two most important processes responsible for the behaviour, movement and fate of this element in estuaries. Because of these processes,

mercury tends to accumulate in sediments shortly after its input. Some estuaries, which act as sediment traps for settlement material, are effectively 'sinks' for mercury.

In the absence of biota the transfer of mercury to the sediment would remove it from further interaction in the estuarine ecosystem. There is ample evidence, however, to demonstrate that benthic plants and animals will accumulate mercury from pore water, bottom detritus and suspended particulates in areas receiving inputs of mercury. Unfortunately, few investigators have tried to quantify this accumulation in terms of the potential transfer of mercury to other parts of the ecosystem. Following measurements of the concentration of mercury in various parts of a salt marsh ecosystem which was receiving inputs of mercury, one investigator estimated that ca. 0.5% of the total mercury in the sediments was transferred annually to the macro invertebrate population through feeding on bottom detritus and benthic algae. It is interesting to note from this work that no methyl mercury was detected in the sediments and plants whereas it was found in significant amounts in the macro invertebrates, i.e. 10 - 72% of the total mercury body burden was present as methyl mercury. Measurements of mercury concentrations in bivalves, particularly mussels (Mytilus edulis), have shown that body burdens of mercury clearly reflect the gradient of mercury concentrations in water and suspended matter along the length of the contaminated estuary. There is also clear evidence that mercury concentrations in fish feeding in these areas reflect the gradient of mercury in these waters.

In some estuaries, particularly very shallow ones, i.e., 5 - 10 m deep, it is theoretically possible for phytoplankton to make significant changes in the mercury content of sea water. In the following calculation, we have assumed a phytoplankton production of 100 g C/m^2/yr (≡ 200 g dry wt/m^2/yr), a water column of 10 m, a concentration factor of 10^4 and a mercury concentration of 0.01 µg/litre in sea water.

Quantity of mercury removed from a water column of 10 m x 1 m^2 each year = 20 µg.

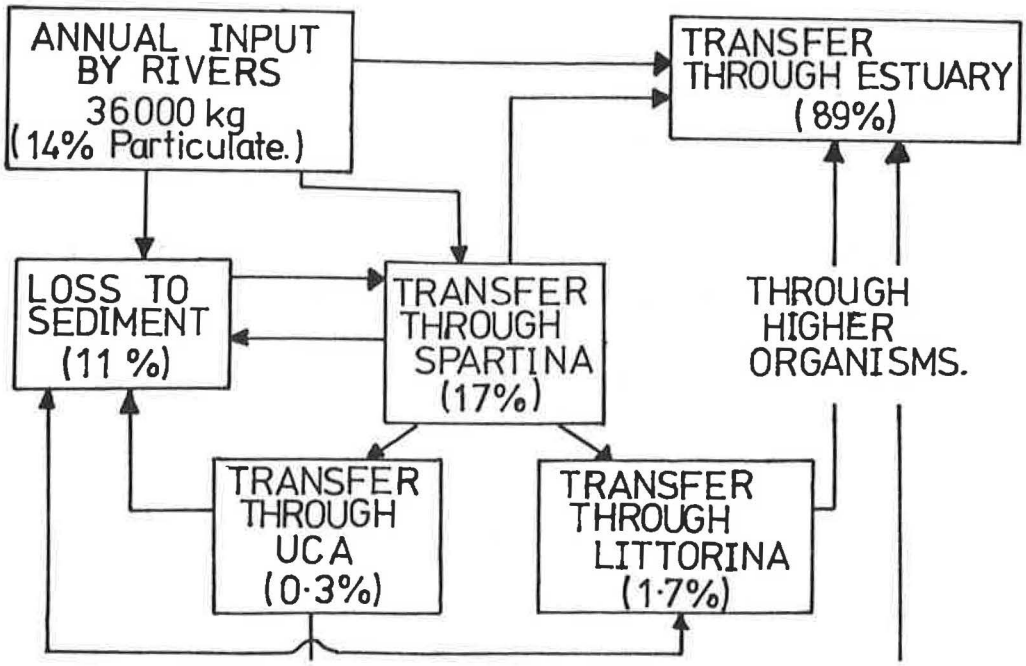
Quantity of mercury in this water column = 100 µg, therefore % removal = 20%.

In practice this change in concentration would probably not be observed since the water in most estuaries is exchanged at frequent intervals throughout the year and this would effectively mask by dilution any changes brought about by phytoplankton uptake.

Experimental studies of losses of mercury from sea water through volatilisation show that losses are directly related to the concentration of 'reactive' mercury in solution. In the presence of suspended matter, the percentage of mercury present as 'reactive' mercury can be as low as 5%. It is considered, therefore, that transfer of mercury out of estuaries by volatilisation is not significant in the overall movement of mercury in the marine environment.

The transfer of mercury from an estuary to the open sea will depend on the characteristics of the particular estuary and the concentration of suspended solids in the outflowing layer. For some inshore systems like the St. Lawrence Estuary/Gulf of St. Lawrence, where suspended load in outflowing water to the Atlantic is low, the transfer of mercury by this process will be small. It can be seen, however, that this process is significant for salt marsh estuaries along the southeast coast of the U.S.A. (Figure 1).

Figure 1. Transfer pathways of mercury through a salt marsh estuarine ecosystem.



Summary and Conclusions

(1) In quantitative terms the movement of mercury within the marine environment is controlled primarily by the rate of deposition of suspended particulates.

(2) The transfer of mercury from the water column to sediment takes place very quickly in some estuaries and those with sediment traps may 'lock up' over 90% of all mercury discharged to it for a considerable length of time (100 - 1 000 years).

(3) In the open ocean, losses to the sediment appear to be smaller, i.e., < 5% of the mercury in the open ocean is lost to the sediment over a period of 100 - 1 000 years.

(4) In global terms the transfer of mercury from sea water to biota every year probably represents less than 0.2% of the total mercury in the sea, whereas in inshore areas, particularly estuaries, the biomass may be responsible for the annual movement of as much as 5% of the total mercury in the water column and sediments.

(5) Although sediments represent the major site of accumulation of mercury in inshore and coastal waters, the monitoring of current inputs of mercury to these waters is readily accomplished by the measurement of body burdens of mercury in biota, which by careful selection will reveal the spatial and temporal trends of these inputs.

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The list of scientific papers, reviews and textbooks covering this subject is extensive. Most of the key references used in the compilation of this overview are given in the publications listed below.

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Indication of spine colours

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

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