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**No. 39**

**REPORT OF WORKING GROUP FOR THE INTERNATIONAL STUDY OF THE  
POLLUTION OF THE NORTH SEA AND ITS EFFECTS ON LIVING  
RESOURCES AND THEIR EXPLOITATION**

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REPORT OF WORKING GROUP FOR THE INTERNATIONAL STUDY OF THE  
POLLUTION OF THE NORTH SEA AND ITS EFFECTS ON LIVING  
RESOURCES AND THEIR EXPLOITATION

SUMMARY

A Working Group to carry out this study was established by the Council in 1971. The Group has endeavoured to assess the input of various pollutants to the North Sea through (a) domestic sewage disposal, (b) industrial discharges both directly and via rivers, estuaries and fjords, (c) dumping and (d) atmospheric deposition. Data on these inputs have been derived by means of an Inputs Questionnaire sent to member countries of the Council, and a summary of the totals as obtained from the replies is given in Table 5.

Whilst the information on the total input of sewage is far more comprehensive than that in the previous report\*, the data on its pollutant content are still inadequate owing to a paucity of analyses of sewage. It has been necessary to assume that the loads of certain pollutants in sewage discharged to the sea around the North Sea as a whole is the same as that found in the few samples analysed from particular areas. Similarly, the data on industrial waste discharges are far from complete, and in some countries are difficult to obtain on the grounds that to publish them would be to breach confidentiality. The data on dumping from ships in the North Sea are probably accurate as far as activities in 1971/72 are concerned, but it is considered that the magnitude of past activities is not properly known.

Table 5 shows that atmospheric deposition may be an important source of pollutants, but it must be borne in mind that the data are of a preliminary nature and based on a few observation points and need to be verified, particularly over the entire North Sea area. Comparison of the magnitude of this input with those from other sources should therefore be made with caution, particularly in view of the inadequacies of the data on which the latter are based. It should also be noted that atmospheric pollution is, in certain cases, largely of industrial origin and hence that industry is contributing through an indirect route to the input of various substances to the North Sea.

The study has included a Base-Line Survey of Fish and Shellfish. This was carried out largely in 1972 and was concerned with organo-chlorine pesticide residues, PCBs, and certain metals. Cod, plaice, herring, shrimp and mussels, of specified age or size, were sampled over the whole North Sea and analysed. The results of the analyses in

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\* ICES (1969): see References.

different laboratories were made comparable by means of an intercalibration exercise, and they show that the level of metals (mercury, copper, zinc, cadmium and lead), organochlorine pesticide residues and PCBs in the species and areas investigated were below the lowest levels established by certain countries as standards for human consumption; and that levels were generally higher in the coastal areas than in the open sea.

Surveys of "dissolved" trace metals in sea water have been carried out. There are still difficulties with regard to the analytical techniques employed, but the results show clearly that levels of "dissolved" copper, nickel, zinc, manganese and cadmium are on the whole much higher in the coastal zones, particularly in the region of river estuaries, than in the open sea. North of the Dogger Bank the values in the central areas away from the coasts are similar to those found in the North Atlantic Ocean, and even in the Southern Bight levels in the central area are close to those found in the open ocean.

To date the Study has concentrated on obtaining a snapshot of present conditions in the water and in fish and has been concerned with the immediate problem of the hazard to human health from fish and shellfish consumption. Other pollution problems have not yet been tackled and there is now a need for the Working Group to turn its attention to the promotion of studies designed to establish the extent to which the inputs of organochlorine pesticide residues, PCBs and trace metals and their existing levels in the marine environment are a hazard to the well-being of the fish stocks of the North Sea, to plankton production and to the marine ecosystem in general.

There is a need to improve even further the information on the input of pollutants from all sources and it is hoped that bodies like the Oslo Commission can assist in this direction. Further work on the atmospheric pathway is urgently required. Analytical techniques have to be improved as quickly as possible, and base-line surveys for other chemical compounds, which may pose a hazard, need to be initiated; these compounds include organochlorine solvents, polynuclear aromatic hydrocarbons, polychlorinated terphenyls, and wastes from the petrochemical and petroleum cracking industries.

The results of current national programmes of work on the distribution of metals etc. in the seabed sediments need to be coordinated and evaluated, and studies are required which aim at giving a better knowledge of current systems, the water budget and flushing time of the North Sea, and the processes which take place at the mouth of estuaries

and fjords and hence determine the rates at which pollutants from freshwater sources are introduced to the North Sea proper.

Finally, the development of the North Sea oil production industry over the last few years has increased the risk of serious oil pollution, and the possible effects of this on living resources need to be investigated. Initial studies have been started in Norway and the UK within the framework of the ICES Study of the Pollution of the North Sea, but increased research facilities in other countries are required if this work is to proceed at a reasonable pace.

# 1 INTRODUCTORY REMARKS

In 1967 the International Council for the Exploration of the Sea (ICES) established a Working Group for the purpose of assembling factual data regarding substances harmful or potentially harmful to fisheries being discharged or likely to be discharged into the North Sea and adjacent seas. The Group was to consist of an expert in the field of marine pollution from each member country concerned and was to be assisted by two experts nominated by the Council's Hydrography Committee. It assembled information on the following aspects of marine pollution in Norway, Sweden, Denmark, the Federal Republic of Germany, the Netherlands, Belgium, France and the United Kingdom respectively:

- (1) legislation controlling pollution of the sea;
- (2) sewage pollution;
- (3) pollution by industrial wastes;
- (4) pollution by pesticides;
- (5) pollution by oil, including oil-removing chemicals.

It also considered (a) toxicity studies, the methods involved therein and the results obtained to date, and (b) the transport and diffusion mechanisms responsible for the dispersal of pollutants in the North Sea. The report of the Group was presented to the Council at its 56th Statutory Meeting in October 1968 and has since been published (ICES, 1969). In addition to the information mentioned above, the report contains an extensive bibliography of papers concerning the pollution of the North Sea.

Following upon its acceptance of the report, the Council urged member countries to intensify their programmes of marine pollution research with special reference to the examination of ecological effects, the measurement of toxicity of pollutants to all stages in the life-cycle (including combined effects of several substances), and the assessment of the effects of sub-lethal concentrations on the physiology, behaviour, growth and breeding of marine life and of the effects of pollutants of all kinds on planktonic organisms. It also asked its Hydrography Committee to initiate further studies of:

- (a) coastal hydrography with special reference to water movements;
- (b) theoretical and experimental studies of diffusion processes;
- (c) the development of mathematical models describing the relationship between environmental factors and the spread of polluting substances.

A series of important international meetings took place at the end of 1970 and the beginning of 1971 at which recommendations were passed concerning the pollution of the North Sea and role of ICES in studying it. At the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing held in Rome in December 1970 it was recommended that as a first step in developing a global system of marine pollution monitoring, which would provide information on the state and trends of pollution of the ocean with a view to facilitating management measures and their enforcement, pilot regional monitoring exercises should be organized, for example by ICES for the North Sea. It also recommended that in semi-enclosed seas like the North Sea pollution control should be organized on a regional cooperative basis and be based on joint scientific evaluation.

Similarly, at the Third Session of the UN Agencies' Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) held in Rome in February 1971 it was proposed that base-line studies of the world ocean be initiated. These studies would be exploratory surveys of the levels of various substances in the water column, atmosphere, organisms and sediments and a necessary prelude to monitoring programmes. Three regions were suggested for the first base-line studies - the North Sea, the Baltic and Puget Sound - and it was proposed that the Intergovernmental Oceanographic Commission (IOC) should be the coordinating body on a worldwide basis and that it should cooperate closely with ICES with respect to the North Sea study. Finally, at the 12th meeting of the Bureau and Consultative Council of IOC held in Bordeaux in March 1971 it was agreed that the Global Investigation of Pollution in the Marine Environment (GIPME) should be established as a major central project within the Commission's Long-Term and Expanded Programme of Oceanic Exploration and Research (LEPCR), that base-line studies and the standardization of techniques and methods should be the first and vital steps towards the surveillance of marine pollution, and that regional studies should form the basis for programme development.

In response to these various recommendations ICES held a series of ad hoc meetings in the spring and summer of 1971 in order to plan an International Study of the Pollution of the North Sea and its Effects on Living Resources and their Exploitation. The first meeting was held in Lowestoft on 25 and 26 March 1971 and it was agreed that the initial stage of the programme should be a base-line survey, as part of which an investigation of pollutant levels in food fish should be given first



priority. It was also agreed that this should be followed by, or if possible accompanied by, measurement of the same pollutants in suitable indicator organisms (locally confined fish stocks and seals were mentioned as possible species), sea water and sediments. Investigations should also be made on the physical, chemical and biological fate of pollutants and their rates and modes of transport in the North Sea. It was also considered that a detailed and accurate knowledge of the rates of input of the various pollutants was essential if a true understanding of their fate was to be achieved.\*

The pollutants to be included in the Study were to include (a) petroleum, (b) chlorinated aromatic hydrocarbons such as DDT and its metabolites, dieldrin and PCBs, (c) halogenated hydrocarbons in general and in particular the chlorinated aliphatic waste products of PVC manufacture, and (d) metals, particularly mercury, lead, copper, zinc and cadmium. It was decided that there was no need to carry out a base-line survey of radioactive materials in the North Sea since it was felt that the discharge of radioactive wastes was rigidly controlled by national legislation, and since both the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) have firm proposals covering the various aspects of radioactive waste management and registration of discharges. Moreover, surveys have been carried out for some years past and a time series of data is steadily evolving.

It was agreed that the limits of the North Sea should be defined as 51°N in the south, 62°N in the north and 4°W in the north-west and should include the Skagerrak and Kattegat. However, it was thought generally that these boundaries should not be considered to be strictly limiting and that the investigations should follow the directions indicated by the scientific problems rather than be limited by

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\* During the series of ad hoc meetings held in 1971 and the meetings of the Working Group no attempt has been made to define the meaning of the word "pollution". The Group has always had in mind the definition adopted by GESAMP, namely: "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, hazard to human health, hindrance to marine activities including fishing, impairing of quality for use of sea water and reduction of amenities". The Group was aware that the GESAMP definition has been subject to criticism, but did not consider it necessary to attempt to improve it or to adopt a different definition.



geographical boundaries. Thus if the investigations indicated the necessity, the area could be extended northwards into the Norwegian Sea or south-westwards into the English Channel. It was generally agreed that, because they were the main areas where pollutants enter the sea, the coastal waters should be studied in greatest detail but not to the exclusion of the offshore areas.

At a later meeting, held at Charlottenlund on 2 June 1971, the inputs of pollutants to the North Sea were considered and it was decided to obtain information about these by means of an Inputs Questionnaire and at another, held at Charlottenlund on 17 and 18 August 1971, the Fish and Shellfish Base-Line Study was planned in detail.

Following upon these three meetings, the Council at its 59th Statutory Meeting, which was held in Helsinki in October 1971, recommended that the International Study of the Pollution of the North Sea should proceed and set up a Working Group to expedite its progress. This Group met at Charlottenlund on 28 and 29 June 1972, on 5-7 March 1973 and on 8 and 9 January 1974: its membership is given in Annex 1.

Replies to the Questionnaire on Inputs of Pollutants have been received from all participating countries. The collated information was considered at the meeting held in March 1973. It is presented in Section 2 of this Report and represents a considerable advance on the information published in ICES (1969). No claim is made for completeness and it must be noted that the information relates to the time when the replies were made to the questionnaire, namely spring 1972: changes may have taken place since then. There is a lack of detailed information on the organochlorine pesticide, PCB and metal content of sewage, and for the purposes of evaluation of replies to the questionnaire estimates have been made on the basis of only a few analyses. The Working Group has therefore recommended that member countries of the Council be encouraged to carry out more analyses of sewages as soon as possible in order to provide better figures than the present estimates: the General Secretary has approached the Delegates of the countries concerned accordingly and arrangements have been made to collate the replies for presentation at the 62nd Statutory Meeting of the Council in October 1974, together with information about the content of harbour dredgings.

The Group has also recognized that, owing to various physical, chemical and biological processes, it is not known how much of the material discharged to estuaries and fjords enters the sea. This is a major gap in the information required to estimate inputs accurately and

so the Working Group has recommended that studies be made to establish the flux of pollutants from estuaries, fjords, etc. into the sea, not only on a normal basis, but also under exceptional hydrographic conditions, e.g. when turnover of estuarine material may occur with release to the sea.

In order to progress the Fish and Shellfish Base-Line Study 1972 the Working Group established a sub-group consisting of the analysts concerned. This met in Charlottenlund on 15-17 January 1973 to study the results of the analyses of fish and shellfish in the light of the results of the analyses of the reference samples, and it then reported back to the main Working Group. The report on the Fish and Shellfish Base-Line Study 1972 is given in Section 3. Having considered it at its meeting in March 1973, the Working Group recommended as follows:

The results obtained in the course of the 1972 Base-Line Survey of organochlorine pesticide residues, PCBs and metals in fish and shellfish provide a useful basis from which monitoring can proceed. A repetition of an international survey of the type carried out in 1972 is not necessary for the time being.

Monitoring should continue at a national level and be coordinated by ICES. Those countries which do not yet have a national programme should be encouraged to establish one as soon as possible. The results of the national programmes should be reported to ICES on an annual basis by a certain date and should after suitable compilation be discussed by the Working Group for the Study of Pollution of the North Sea, which shall report to the Council on the interpretation of the results and indicate which species, substances and sampling areas require special attention in the following years.

In order that the national programmes for 1974 should be coordinated an Ad Hoc Group of Analysts, supported by Biologists, should be convened as soon as possible after the 1973 Council meeting with the following terms of reference:

To coordinate and suggest possible extensions to national programmes using the 1972 Base-Line Survey data as a basis for its recommendations; it should also take into account any available information on variations in residue concentrations with age, season, etc.

The Ad Hoc Group should report to the Working Group for the Study of Pollution of the North Sea.

The Working Group also agreed that further intercalibration of analytical procedures is essential and that an intercalibration experiment should therefore be carried out in 1973 and that the ICES/SCOR Working Group on the Study of Pollution of the Baltic should be invited to participate. The exercise was started in October 1973.

The Ad Hoc Group of Analysts and Biologists met on 10-12 December 1973 and found that it was not possible at the present time to suggest changes to national programmes because those for 1974, at least, had mostly been finalized, but the Group requested the ICES Secretariat to prepare tables giving details of the various national programmes in a standard format. The Working Group for the International Study of the Pollution of the North Sea studied these tables at its meeting on 8 and 9 January 1974 and agreed that steps should be taken to ensure that they are as comprehensive as possible, and that they should then be made available to the 62nd Statutory Meeting of the Council. The Group also agreed that data from national monitoring programmes should be reported to the Council starting with those for 1974: the data should be reported on an annual basis not later than 1 July in the year following that in which the samples etc. were collected, and priority of data submission should be given to those data which are of direct relevance to the requirements of the Commission set up under the Oslo Convention on the Prevention of Marine Pollution by Dumping from Ships and Aircraft. The Group also expressed the view that further work is required on the variation of the levels of organochloride pesticide residues, PCBs, metals, etc. in fish and shellfish with age and condition, and that the results of such work should be submitted to the Council with the intention of the Secretariat compiling a review in due course.

To complement the Fish and Shellfish Base-Line Study the Council's Marine Mammals Committee has been active in getting work done on the levels of pesticide residues and of mercury in seals. In brief, the conclusions drawn from this work are that, although seals are useful indicators of overall levels of pollution they cannot be used to indicate local levels: some of the variations in the levels of various substances in seals are caused by season and breeding condition and these can be more significant than those variations which are due to differences in environmental levels.

The plan for the International Study calls for the measurement of pollutants in the sea water and the sediments. Progress has been made in both of these fields. Belgium, the Netherlands and the United

Kingdom have been collaborating in studies of the trace metal content of the various water masses in the southern North Sea, and the United Kingdom has also extended its studies into the northern North Sea and supported them by the use of seaweed as an indicator system. A number of countries have also made studies of heavy metals in North Sea sediments. In the southern North Sea there is wide coverage as a result of British, Belgian and Dutch investigations, and there has also been work done off the Swedish, German and north-east English coasts.

An intercalibration programme is at present under way between laboratories in Belgium, the Netherlands and the United Kingdom as far as "dissolved" trace metals in the waters of the Southern Bight are concerned, and the Lowestoft laboratories in the United Kingdom have also carried out intercalibration exercises with laboratories in the USA and elsewhere as part of the GECSECS programme within the International Decade of Ocean Exploration. It has been possible for scientists from Belgium, the Netherlands and the United Kingdom to prepare a report which gives, with a fair degree of reliability, an initial picture of the distributions of certain trace metals in the surface waters of the North Sea as a whole and they are presented in Section 4. This picture will no doubt need to be modified and developed in greater detail as further information on these metals, and on others, comes to hand in other laboratories. The Working Group has recognized the special difficulties posed in determining the levels and speciation of metals in water, suspended matter and sediments and hence has recommended that programmes of work in member countries in these fields of physical chemistry should be expanded.

It is also possible to report some progress on the measurement of hydrocarbons. Norwegian scientists are now taking seawater samples for the measurement of hydrocarbons from different depths along a section extending from Bergen to the Shetlands, whilst the UK is measuring hydrocarbons in the water, sediments, plankton and fish in the Thames Estuary, the Wash and off the east coast of Scotland. Norwegian and British scientists met in February 1973 and established a joint programme of research involving independent experimental programmes and joint monitoring of fish and water quality. Norway will concentrate on water analysis and the UK on fish analysis. The Working Group considers that this is a useful start to its own study of the effects of oil on the marine environment. However, in view of the current high level of activity of oil exploitation and exploration in the North Sea

the Working Group has recommended that member countries should establish analytical facilities as soon as possible and has agreed that in the first instance member countries should participate in the UK/Norway programme by collection of water and core samples for analysis in Bergen.

The Working Group has received information that the levels of phosphate and nitrate in the waters off the Netherlands coast have doubled in recent years and has agreed that an urgent check is necessary to establish whether the increase applies to other areas of the North Sea. The Inputs Questionnaire has shown that considerable quantities of waste material enter the North Sea and the Working Group agrees that the effect of these nutrients, suspended material, organic matter, etc. is not well understood. It has therefore established two Study Groups to review and evaluate the present information on the effects of these substances in the Southern Bight and Kattegat/Skagerak areas. These Study Groups consist respectively of members from (i) UK, Belgium, Netherlands and Germany, (ii) Denmark, Sweden and Norway. Both Study Groups have been instructed to report back to the Working Group with recommendations for further research.

In addition to sponsoring the International Study of the Pollution of the North Sea ICES has been active in tackling other aspects of the marine pollution problem. The Fisheries Improvement Committee provides the forum at which the results of research carried out in member countries on marine pollution, particularly in relation to fish and shellfish, are presented in scientific papers and discussed, and at which ideas and information are exchanged. A number of papers dealing with the levels in fish and shellfish of (a) mercury and other metals and (b) pesticide residues have been presented. These provide important data which supplement those obtained during the Fish and Shellfish Base-Line Study.

Physical and chemical aspects of marine pollution are discussed in the Hydrography Committee, which acts as a source of advice to the Working Group responsible for the North Sea Pollution Study. For example, it is currently advising on how to measure the input of pollutants to the sea from rivers, estuaries, fjords, etc. This Committee promotes international cooperation in the study of advective and diffusive processes in the sea. In 1965 it carried out Operation RHENO in the north-eastern North Sea, the largest dye tracer study of diffusion yet attempted anywhere, and in 1970-71 it established a permanent network of moored current meter stations in the central and

southern North Sea as a first step towards the continuous monitoring of the circulation of the North Sea. Furthermore, at its suggestion ICES held at Aarhus in July 1972 a Symposium on the Physical Processes responsible for the Dispersal of Pollutants in the Sea with special reference to the Nearshore Zone. The proceedings will be published in the Council's Rapports et Procès-Verbaux series.

ICES has also taken steps to initiate a Study of the Pollution of the Baltic Sea and, together with the Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU), it has established a Joint Working Group to prepare a programme of work. This Group is working in close collaboration with its counterpart for the North Sea because the two groups have mutual problems and because of the need to intercalibrate and standardize methods in order to allow the eventual comparison of results. The fact that the two seas are connected through the Kattegat and the Belt Seas, and that a better knowledge of the water exchange between the North Sea and the Baltic is called for, provides a further reason for cooperation. Collaboration between the North Sea and Baltic Working Groups is made easier to provide because countries such as Denmark, Sweden and the Federal Republic of Germany border both seas, so that the same sets of workers are often involved in the meetings etc. of the two Groups.



## 2 INPUT OF POLLUTANTS TO THE NORTH SEA

### INTRODUCTION

The ICES Report on Pollution of the North Sea (ICES, 1969) included a section on the quantity of pollutants entering the North Sea. At that time information was limited to details of flow of sewage and industrial effluents, and for some countries even this information was not available. It was agreed at the meeting of the Working Group held in June 1972 that an essential part of the Study of the Pollution of the North Sea should be the compilation of data on the input of pollutants to the North Sea and that, as a result of greater public awareness and of the impetus created by the publication of the above ICES Report, it would be possible to conduct a more comprehensive study of pollutant inputs than had been possible in 1968.

With this objective in view an Inputs Questionnaire (Annex 2) was devised which each country was asked to complete. Each country was requested to divide its coastline into a number of zones and for each zone to provide data on flows of sewage and industrial effluents, together with details of the quantities of several recognized pollutants, e.g. nutrients, metals and PCBs. In addition, details were requested of any dumping activities conducted in the North Sea, and information about programmes designed to monitor atmospheric inputs was called for, together with details of the results obtained.

The replies were all completed by March 1973. All the data can be considered as being accurate at that time, except for the information with regard to dumping; that is only accurate up to the spring of 1972. The replies have been compiled into summary Tables 1-4 and Figure 1. Most countries were able to provide data on flows to open coasts and to estuaries and several provided detailed information on pollutant contents of these discharges. Where full information was not provided estimates have been made on the basis of information provided by other countries, and when this has been done the fact is noted in the explanatory footnotes provided after each table. It will be noted from a careful study of Tables 1 and 2 and the footnotes that the pollution content of a discharge varies according to country; this is partly due to the different water consumption per head of population, but also results from different national occupations and is particularly dependent upon the degree of separation of domestic and industrial effluents, which in its turn is largely dependent upon the percentage of treatment effluents. Wherever possible the estimates have been made on the basis of data

available for a country of similar national character e.g. the Dry Weather Flow (DWF) for Sweden was estimated on the basis of Norwegian data. However, in some cases this was not easy, and overall estimates have been made, usually on the basis of the comprehensive English and Swedish data. In agreeing to such estimates the Working Group consider that, although they are in some instances based on rather few analyses, they do in most cases give at least a first order approximation of the input of pollutants. However, the Group also considers that it is important that more comprehensive data be provided as soon as possible so that the validity of the estimates may be checked.

The input data were also of varying completeness in respect of the discharges to rivers and estuaries. The Working Group recognizes that the fate of material discharged to an estuary or fjord is uncertain and that much more work is necessary in order to determine what proportion of pollutant entering an estuary or fjord reaches the sea, either immediately or in the long term. With this uncertainty in mind, several countries had difficulties in completing the questionnaire; some (e.g. Sweden and England) assumed that the majority of a discharge made directly to an estuary or fjord would ultimately reach the sea, but others provided only data on the discharges directly entering the sea or the outer reaches of estuaries. The input from some major continental rivers (e.g. Schelde) is clearly underestimated, because of all the rivers entering the North Sea the Thames appears from the tables to introduce the greatest load of pollutants, whereas it is clear from the Base-Line Survey that pollutant levels are as high on the eastern shores of the Southern Bight as on the western shores, and in some cases are higher. This anomaly has been recognized by the Working Group and work is now in progress in an attempt to establish more accurately the flux of pollutants through these major estuaries.

Most countries were able to provide reasonably complete data on the types of industry and quantities of effluent discharged to the marine environment. However, in most cases the amount of information available on the pollutant content of these effluents was very limited and, owing to the complex variability of industrial effluents, it has not been possible to estimate the inputs from one country on the basis of the inputs quoted by another.

Data on the introduction of pollutants from the atmosphere are being collected by most countries for rainfall over the land and these can be extrapolated to provide data for the sea. However, in most cases the



information being obtained is confined to sulphur dioxide, dust, etc. and no country provided actual data on these substances. A limited amount of information was provided by the United Kingdom on the input of metals and these data are discussed in detail later.

The input of pollutants from direct dumping of waste in the North Sea was disclosed by the questionnaire and details of the replies are provided in Table 4. From this it appears that the input is very small, although it was admitted at the Working Group meeting in March 1973 that certain replies may be incomplete. However, it was agreed that it would be difficult to update and correct them retrospectively in the light of the articles of the Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, which requires submission to a Commission of returns on quantities dumped since the entry into force of the Convention. It was accordingly agreed that the section on dumping should stand as an approximation of the situation in the spring of 1972.

#### INPUTS OF POLLUTANTS IN SEWAGE

The replies to the questionnaire are summarized in Table 1 with respect to sewage discharges. The proportion of industrial effluent accepted into town sewerage systems varies according to country and local circumstances. Thus in Norway, where industries mostly have separate sewer systems and do not discharge into the sewers from urban districts, the proportion of domestic sewage is recorded as 100% in two areas, but for the industrial city of Bremen in Germany it is as low as 17%. The total number of people whose town's sewage enters estuaries or the open sea is quoted as almost 31 million of whom 19.3 million or 62% live around the southern sector of the North Sea (south of latitude  $53^{\circ}30'$ ). The volume of sewage effluent entering the North Sea per day is  $7\,345 \times 10^3 \text{ m}^3$ , of which  $3\,614 \times 10^3 \text{ m}^3$  per day or 49% enters the southern North Sea. This is a smaller percentage than that of population because the average volume of water used per person is lower in countries around the southern North Sea (e.g. in England it is  $0.178 \text{ m}^3/\text{day}$  compared with  $0.391 \text{ m}^3/\text{day}$  in the Scandinavian countries). In some tourist areas, notably the Belgian coast, the quantity of sewage discharged directly to the sea or estuaries varies considerably with season. Where this occurs the figures quoted are averages for the whole year and a note is provided after the table giving the seasonal figures.

The majority of the sewage discharged to the North Sea is not given any form of treatment. In some areas 100% of the volume discharged is untreated. Where treatment is given it is usually confined to settlement

and screening of solid particles. In Sweden 33% of the total volume receives biological treatment in addition to settlement, but in other countries biological treatment is provided only for major discharges to estuaries where deoxygenation problems would otherwise result, e.g. the Netherlands-Rotterdam area and the England-London area treat 61 and 70% respectively. Occasionally biological treatment is also provided in amenity areas or shellfish-producing areas in order to reduce bacterial pollution. Only a minute proportion of the sewage discharged to the North Sea receives tertiary treatment: 3% in Norway and 8% in Sweden, and very small quantities (less than 1% of total national flows) in Germany and England.

The oxygen demand posed by the volume of sewage entering the North Sea was calculated by each country and given as an estimated figure for BOD or COD. Not all countries quoted the basic figure of oxygen demand per head per day, but the quoted values for BOD are fairly similar and range from 54 to 70 g oxygen/head/day. Due to complications introduced by seasonal variations in population and treatment it has not been possible to calculate the remaining values accurately, but the assumed per capita oxygen demand value is given in the notes following the table.

The oxygen demand as expressed by the BOD figures amounts to an annual total of 545 740 tonnes/year and probably provides a more accurate estimate of the oxygen demand from sewage than the COD values, which in all cases were calculated from the BOD figures but with a conversion factor ranging from 2.5 for Netherlands through 2.0 for Belgium to 1.5 for all other countries. Although the total BOD value may seem very large, there are no reported instances of seawater oxygen levels outside estuaries and fjords being reduced in the North Sea area. When the demand is considered in the light of the probable facility for oxygen transfer across the air-sea interface and the fact that each  $10^7 \text{ m}^3$  of sea water ( $1 \text{ km}^2 \times 1 \text{ m}$  deep) contains 70 tons of oxygen, the lack of effect is hardly surprising.

The inputs of nutrient nitrogen and phosphorus in sewage were again estimated according to national values and the basic figure used is quoted in the notes following the tables. Where estimates had not been made the value used for England was assumed. For the nitrogen input the quoted values range from 10 g/head/day for Netherlands to 13 g/head/day for Sweden and amount in total to  $199 \times 10^3$  tonnes/year. For phosphorus the range of values used to calculate the input cover a wider range, from 4 g/head/day for Sweden to 1.6 g/head/day for England. Because the

latter value was used to calculate the input from over half the population discharging sewage to the North Sea, the total of  $35.9 \times 10^3$  tonnes/year may be a little low. However, this is probably compensated for by the fact that other countries assumed a single value regardless of the degree of treatment given to the sewage before discharge. In fjords and estuaries part of the nutrient load is removed by biological activity. There is also evidence that part of the nutrient load entering an estuary or fjord is deposited in the sediments before reaching the sea (James and Head, 1972). Although no effects have been noted which might indicate a danger of eutrophication arising in the North Sea, there is some evidence of increases in nutrient levels in the waters of the southern North Sea in recent years and these may be linked with increasing amounts of sewage discharged directly to sea. The Working Group has further work now in progress with a view to substantiating the recent evidence of increases in nutrient levels.

Data on the content of organochlorine pesticide residues and PCBs in domestic sewage were almost totally lacking, and England was the only country to provide an estimate of the input of organochlorine pesticides and PCBs in sewage. This estimate was based on results of analyses of a small cross section of the major sewage discharges from England to the North Sea. However, the Working Group considered that even this was better than no estimate at all and the inputs for all other countries have accordingly been estimated on the basis of these figures. The total quantities of organochlorine pesticides and PCBs entering the North Sea in sewage amount to approximately 657 kg and 6 570 kg/year respectively, but these figures should be regarded as a first-order estimate only. More work is currently under way to determine the accuracy of these values.

There was also a lack of information on the input of metals with sewage effluents, although the presence of a number of heavy metals in sewage effluents is well known. Only Sweden had been able to provide figures for the input of a few selected metals in sewage on a country-wide basis, although Norway was able to provide similar input data for the Oslofjord area. In order to provide a first-order estimate of inputs of metals in sewage, it was therefore agreed that the Swedish data should be used for all the remaining areas. To do this the data were arranged to provide a figure representing the quantity of each metal per unit of 1 000 population. The quantities entering the North Sea as a whole were thereby estimated. The figures produced by this

process suggest that the total quantities of zinc, copper and manganese entering the North Sea in sewage amount to  $2.5 \times 10^4$ ,  $3.9 \times 10^3$  and  $6.1 \times 10^4$  tonnes respectively. The only additional data available were for mercury in respect of sewage discharges for the London area, which probably introduce 7.65 tonnes of mercury to the North Sea each year. If this figure is assumed to be representative for the entire North Sea area, the total quantity of mercury entering the North Sea from sewage would be approximately 22 tonnes of which 62% or 13.6 tonnes enter the southern North Sea.

Two further items in the questionnaire were designed to reveal the general pattern of industry discharging waste to the North Sea via town sewers. Most countries were able to provide information on the main types of industry present in the various town areas, but the replies to the second question revealed a major lack of information as to the nature of the effluents such industries would produce. Thus, although the lack of replies to the two questions is not important in quantitative terms, it may be indicative of a general failure to appreciate the potential input of waste from industry. At the very best, it indicates that on the subject of the composition of sewage effluents discharged to sea there is a general lack of interest on the part of many municipal authorities.

#### INPUT OF POLLUTANTS IN INDUSTRIAL WASTES

The replies to the questionnaire in respect of industrial effluents are summarized in Table 2. Most countries were able to provide estimates of the quantity of industrial effluent discharged directly into the coastal waters. Two countries, Denmark and Belgium, stated that they had very few discharges of industrial effluents directly to the sea, and that where information on industrial inputs was available it had accordingly been included in their replies to the sewage section of the questionnaire.

The total flow of industrial effluent to the North Sea amounts to some  $4\,918 \times 10^3 \text{ m}^3/\text{day}$  which compares with  $7\,345 \times 10^3 \text{ m}^3/\text{day}$  for domestic sewage. Although this figure seems relatively small in comparison to the sewage input, it is an underestimate of the total volume because no data on flows were provided by Germany, Denmark or the Netherlands. Also, where flow data were provided, in many cases the quoted flow rates related to the original consents rather than the actual volumes currently discharged. Most countries excluded pure cooling water discharges, such

as those from electricity generating stations, since their only input is thermal energy, which in the North Sea is not normally considered to be a pollutant. However, many industries use large quantities of water for washing and cooling purposes (e.g. the steel industry and the chemical and pharmaceutical industries). Although in a few instances these may be discharged separately from more highly contaminated waste waters, they are more usually discharged in admixture with other effluents for dilution purposes so as to reduce risks of acute toxicity to marine life. It can therefore be assumed that a proportion of the volume recorded in the total flow column is of cooling water and that certainly in some cases this will be of marine origin.

All countries were able to list the major industries which discharge effluent directly to their coastal waters, and in most cases were able to provide a breakdown of the total flow according to type of industry. The distribution of the various types of industry is, as expected, partially related to national resources. For example, Norway and Sweden reported more pulp paper production than most other countries and Norway, with cheap electrical power, has a well-developed aluminium smelting industry. Industries such as iron and steel and the chemical industry are, however, to be found in all countries, although oil refining and petrochemicals are concentrated in the Netherlands-Rotterdam area and on the English coast. A number of countries recorded the presence of major food-processing plants but, although these must impose significant BOD loading in the area of their discharge, quantitative data were lacking. Titanium dioxide production was singled out from other chemical industries, at least by France and England, on account of the large amounts of acid waste involved and the high concentration of iron in this waste. However, titanium dioxide production facilities also exist in the coastal zones of Norway, Germany and the Netherlands and their discharges may be included under more general headings. In other cases this waste is taken to sea in barges and dumped. The input from this route is recorded separately (see Table 4).

Only two countries, Denmark and the Netherlands, reported the presence of pesticide manufacturing sites discharging directly to coastal waters, and it is perhaps interesting to note that both of these have in the past been implicated in wildlife kills as a result of accidental discharges of quantities of pesticides. England reported that pesticides were known to enter the Humber Estuary via rivers draining an area with a large number of woollen mills, but no quantitative data were available.



As mentioned earlier in relation to the food-processing industries, data on the BOD or COD loading of industrial effluents were not readily available to most countries when completing the questionnaire. Although Sweden was able to provide comprehensive data on this parameter, it has not been possible to estimate the loadings, where these were not given, as was done for the sewage inputs. This is because the BOD will vary considerably according to the type of industry, the volume of cooling water included in the discharge, and the degree of treatment of the effluent. The total quantity of  $459 \times 10^3$  tonnes/year is therefore only a fraction of the true total, although even this amount is similar to the load imposed by sewage. However, with the exception of a few areas of restricted water exchange such as the Thames Estuary and Oslofjord, oxygen levels in sea water do not appear to be reduced even when wastes of high oxygen demand are discharged; the lack of quantitative data is therefore not too important.

There was an almost complete lack of information on the amount of inorganic mineral material discharged by industry to coastal waters. Gypsum arising from fertilizer manufacture featured in the replies from the Netherlands and the United Kingdom. Apart from this mineral, the UK reported that a total of 14 300 tonnes of colliery waste was dumped daily, either directly into the sea by aerial ropeways or by lorry on to the foreshore.

In addition to providing the general information on total flows, BOD loadings and inputs of mineral materials, each country was asked to provide data on the inputs from industrial sources of persistent materials such as metals, pesticides, PCBs and chlorinated aliphatic compounds. No data were available in any country for the input of either pesticides or PCBs. Sweden and Norway were the only countries to be able to provide data on the input of chlorinated aliphatic compounds, which from all sources amount to 0.3 and 0.6 tonnes/day respectively for Sweden and Norway. This item was included following fears expressed by some members of the Working Group that large quantities of waste chlorinated aliphatic compounds, particularly those arising from the manufacture of PVC, might be discharged to the North Sea. Although other countries were not able to provide any information in their replies to the questionnaire, most of the Working Group members have been able to state verbally that they knew of no such discharges from their countries. It is, however, known that large quantities of chlorinated solvents are used in industry each year for cleaning

purposes and that most of the annual purchase for this purpose represents total loss. However, much of this appears to be to the atmosphere and the amount involved in discharges of effluent is unknown.

The only country to be able to provide reasonable comprehensive data on the quantity of metals discharged to the North Sea in industrial effluents was Norway. Scotland provided data for the major sources, but stated that numerous smaller sources contribute a further unknown quantity. Sweden also provided some data on metal inputs from certain areas, together with total consumption data for all areas for those industries expected to discharge most metals, i.e. electroplating and block making. However, as the degree of effluent treatment provided by each industry was not given, it has not proved possible to provide a reasonable estimate on an entire coast basis. The quantities of metal quoted for the Netherlands under the heading River Rhine are the total average annual input of metals from the River Rhine and should not be interpreted as applying to Dutch industrial effluents alone.

Several countries provided limited data on the inputs of other potential pollutants (e.g. fluoride, acids, phenols and cyanides) but in no case was this information complete and it must be regarded as far from comprehensive and therefore of limited value.

It is clear from the replies received to the questionnaire that data on the composition of industrial wastes are not readily available and the Working Group considers that every effort should be made to remedy this situation. In many cases it is considered that the relevant data might be of a confidential nature and that this might present difficulties. However, since the detail required for assessing inputs on a coastal areas basis is limited and by definition would not reveal individual discharges, the Working Group considers that confidentiality need not be at stake and urges that all countries should endeavour to obtain and release all relevant information.

#### INPUTS BY ATMOSPHERIC DEPOSITION

As was stated above, a number of countries replied in the questionnaire that they had programmes of investigation in progress or planned to determine the quantities of pollutant which might be transported by the atmosphere. Of the countries taking part in the study only Germany and France reported that they had no information on atmospheric deposition programmes. All other countries replied that they had programmes under way designed to measure quantities of dust, sulphur dioxide and

certain metals (e.g. calcium and sodium). However, no results were provided for any of these parameters.

The United Kingdom reported on a programme which is intended to provide an assessment of the relative importance of the atmosphere as a pathway for the introduction of a range of up to 29 elements to the North Sea. Results obtained from this programme have subsequently been provided and are recorded in Table 3.

The programme, which is carried out under contract by the Atomic Energy Research Establishment (AERE), Harwell, involves the sampling of both wet and dry deposition of selected metals and their concentrations in airborne dust at a site in the Shetland Islands (Lerwick), two coastal sites in southern England and at an adjacent operational gas platform in the North Sea. Sample collection is continuous and monthly samples are analysed for a range of metals, including aluminium, arsenic, cadmium, cobalt, chromium, copper, iron, manganese, nickel, lead, antimony and zinc. Mercury has recently been added but no data are yet available.

Results to date show that there is little difference in metal concentrations in air at any station, although sodium and chloride concentrations are of course higher at the gas platform and Lerwick. All metals are higher in the wet and dry deposition samples at the platform. Unfortunately, the airborne dust samplers discriminate against particles greater than 60  $\mu\text{m}$ , and it seems possible therefore that the higher concentrations seen in wet and dry deposition at the platform site may be due to particles greater than 60  $\mu\text{m}$ . From the known sodium and chloride concentrations in the wet deposition samples and a knowledge of the local surface seawater concentrations of some of the metals, it is possible to estimate the concentration in the sample due to sea water. In most instances the observed concentration is  $10^3$ - $10^4$  times greater than the calculated one. It is probable that this enhanced seawater concentration is present in the sea surface microlayer, and that the wet and dry deposition samples are contaminated with an aerosol derived from this layer.

The figures given in Table 3 for annual deposition over the North Sea were obtained by applying the average washout factors ( $\mu\text{g}/\text{l}$  in rain  $\div \mu\text{g}/\text{kg}$  in air) for the two English sites to the measured air concentrations on the platform. By this means it is possible to derive a predicted concentration in rainfall at the platform which corrects



for the marine contribution. This was then assumed to be the true deposition on the sea surface and the annual deposition was calculated on the basis of an average rainfall of 80 cm/year and a surface area of  $5.75 \times 10^5 \text{ km}^2$ .

Using measurements of the "dissolved" cobalt, iron, manganese, nickel, lead and zinc in sea water, as determined by the Lowestoft laboratories (see Section 4) in order to calculate a mean concentration, it is possible to estimate the annual metal outflows from the North Sea corresponding to a water outflow of  $2.55 \times 10^4 \text{ km}^3$  (Wallauschek and Lutzen, 1963).<sup>\*</sup> For cobalt, iron, manganese, nickel, lead and zinc respectively these amount to  $5 \times 10^2$ ,  $1.5 \times 10^5$ ,  $1 \times 10^5$ ,  $5 \times 10^4$ ,  $1.5 \times 10^4$  and  $1.5 \times 10^5$  tonnes/year. If these estimates of loss rates are compared with the estimated deposition rates, it can be seen that the input of lead and iron via aerial deposition may be a major route of introduction. Possibly the same applies to zinc, although here there is some doubt about the validity of the data because the results from the gas platform may be biased due to the influence of its extensive areas of galvanized surface. The iron data are probably authentic, since others have also shown the importance of atmospheric dust as a source of iron to the open sea.

This work is continuing and will be reported in more detail later by AERE, Harwell. No data of a similar nature are yet available for pesticides or PCBs, but a similar programme is to be started for measurement of these pollutants.

#### INPUTS BY MARINE DUMPING

The replies to the section of the questionnaire relating to dumping are summarized in country order in Table 4. They were received earlier than the replies for the other sections and are accurate up to the spring of 1972 only. The table includes data for dumpings in the period from 1965 to 1970, as well as those being conducted at the time of the reply to the questionnaire. Those which took place prior to the reply and which were not current at the time when the reply was made are marked with an asterisk.

Only one country, France, submitted a return which included harbour dredgings, although members of the Working Group have stated verbally that in most other countries harbour dredgings are dumped in the sea. One country, Sweden, reported that although there had in the past been

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<sup>\*</sup> The calculations on which this water outflow figure is based are open to criticism, but it is the only estimate available at present.

some dumping of wastes at sea, all such dumping was now banned and dumping of wastes at sea (other than sewage sludge and harbour dredgings) was unlikely to take place from Sweden. Denmark, France and Norway all reported that no dumping of industrial wastes took place from their countries, although Norway did permit dumping of sewage sludge outside Oslofjord.

Of the remaining countries (i.e. Belgium, Germany, the Netherlands and the United Kingdom) all reported dumping of some industrial wastes in the North Sea. The Netherlands' reply separated those wastes dumped directly from Dutch industry from those dumped for other countries through Dutch ports. Three of the 14 industrial wastes dumped by these four countries were of mineral origin and were dumped from the United Kingdom. The remaining 11 wastes included 5 wastes from titanium dioxide production plants in Germany and Belgium. The remaining wastes were described as being from synthetic fibre or resin manufacture and enzyme production, or simply as waste acid or alkali. In some cases the waste acid contained large quantities of organic material which would cause a major BOD problem for inland disposal or treatment facilities.

Total amounts of titanium dioxide waste dumped amounted to approximately  $2.3 \times 10^6$  tonnes/year, whilst sewage sludge amounted to approximately  $4.5$  to  $5 \times 10^6$  tonnes/year and the remaining chemical wastes to only 80 000 tonnes. No country reported plans for any major increase in dumping of wastes in the North Sea, although both the Netherlands and the United Kingdom provided details of some planned increases. All countries reported that dumping was controlled and registered with their national authorities.

In relation to the replies to the questionnaire concerning dumping, Norway provided information on the composition of the contents of drums recovered from the North Sea by fishermen (Berge, Ljøen and Palmork, 1970; Greve, 1971), and on the waste from vinyl chloride production and waste substances containing polynuclear aromatic hydrocarbons (Palmork and Wilhelmsen, 1972; Palmork et al., 1973; Palmork, Wilhelmsen and Neppelberg, 1973).

## CONCLUSIONS

The exercise on estimation of inputs to the North Sea via sewage, direct industrial discharge and atmospheric deposition has been comparatively successful and represents a significant advance on the state of knowledge recorded in the earlier ICES Report on Pollution of the North Sea (ICES, 1969).

Most countries were able to provide fairly comprehensive data on the inputs of sewage effluents and their composition. Where the data were incomplete, it has been possible to extrapolate the data supplied by other countries and to estimate the input of a particular pollutant from sewage. In certain cases the data on which such estimates were made were not very comprehensive and it is necessary that further work be carried out in order to ensure that the calculations made provide a reasonable estimate of the situation.

Data on the input from industrial sources were in general not as complete as those for sewage. No doubt to some extent this reflects the confidential way in which composition data are treated by many countries. However, the Working Group considers that it is essential to have these data if a full picture is eventually to be obtained of inputs to the North Sea. In most instances the data available were confined to a description of the type of industry discharging waste and the total volume of waste discharged. Norway and Sweden, which do not regard such information as confidential, were able to provide fairly complete data on the content of industrial wastes. Apart from the data from these two countries, only scattered bits of information were available on the quantities of waste discharged in individual areas. Unfortunately, in the absence of data on effluent treatment and water usage it has not been possible to extrapolate from the replies which were made for a few areas to all other areas. Thus there is a major gap in our knowledge of inputs of pollutants to the North Sea.

The atmosphere as a pathway for the entry of metals has been shown to be of importance for at least the two elements iron and lead, and, possibly for a third, zinc. Marine dumping activities in the North Sea were, however, shown to be of relatively minor importance in terms of total pollutant inputs and to be confined to minerals such as colliery wastes or harbour dredgings with some dumping of chemical waste, primarily of waste acid from the production of titanium dioxide. The only other major waste which is dumped at sea is sewage sludge.

Table 5 provides a summary of all the data provided by the questionnaire replies. Some of them are incomplete due to inadequate replies, particularly in respect of industrial discharges, and this is indicated by an asterisk. Probably one of the most interesting features is the apparently large input of metals from the atmosphere although, of course, the direct industrial input is larger than appears from the table.

### 3 REPORT ON THE FISH AND SHELLFISH BASE-LINE SURVEY, 1972

#### INTRODUCTION

The programme of work reported on here stemmed from the decision taken by ICES early in 1971 that, as part of the proposed Study of Pollution of the North Sea, there should be an assessment of the levels of selected pollutants in fish caught in the North Sea area. With this objective a meeting of Analysts and Fishery Biologists was held in August 1971 and it was proposed that each participating country should collect, within a given period, an agreed number of cod, plaice, herring, shrimps and mussels of stipulated age or size etc. Each sample should be analysed at least for organochlorine pesticide residues, PCBs and mercury, but in addition it was agreed that other metals, aliphatic chlorinated hydrocarbons, and hydrocarbon oil should be determined wherever facilities, time and expertise permitted. It was further agreed that an intercalibration programme was essential and specific proposals were made for this.

These proposals were formally accepted at the 1971 Council meeting and work was commenced immediately by analysts in Norway, Sweden, Germany, the Netherlands, Belgium, France and the United Kingdom. A progress report was submitted in October 1972 to the 60th Statutory Meeting of the Council and it listed the approximate numbers of samples collected and gave details of progress up to July 1972. Certain difficulties had been encountered in the collection of some samples and also in completing the analyses within the allotted time, but it was hoped that all the analytical results would be available by early 1973. Accordingly the Council agreed that the Analysts should meet in January 1973 to discuss the results of their Base-Line Survey.

This meeting duly took place but unfortunately not all the survey results were available due to unforeseen analytical delays. However, a valuable discussion was held on all aspects of the work, ranging from the compatibility of the results obtained by different laboratories to the interpretation of the results as a whole. There was some discussion as to the accuracy of certain of the reported values both for the intercalibration exercise and the fish analyses. Most of these have subsequently been changed following repeat analyses carried out in the light of these discussions. The Analysts agreed details of how the full set of results should be tabulated. On the basis of the results available at the January meeting the Analysts drew several conclusions from the survey,

and a number of recommendations were made to the Working Group for the Study of Pollution of the North Sea which approved them and, with minor changes, submitted them to the 61st Statutory Meeting of the Council in October 1973. The final Working Group recommendations are given in the introductory chapter to this Report, but it is appropriate at this point to record the conclusions of the Analysts involved as to the levels of pollutants found and their particular recommendations for future work.

(i) In the light of the generally low and uniform level of metals, organochlorine pesticides and PCBs found in the Base-Line Survey, the Meeting of Analysts (January 1973) consider that little would be gained from a repetition of the 1972 international fish and shellfish survey in the North Sea as a whole in the immediate future. This recommendation is based on the low concentrations found in relation to the levels which are currently known to present a hazard to human health and/or marine life.

(ii) The areas of the North Sea identified as having highest pollutant levels are certain coastal waters, and monitoring of these areas is in general already being carried out within national programmes. It is agreed that these national programmes should be continued, in order to provide adequate information on the level of pollutants in the coastal waters of the North Sea; that intercalibration of the analytical methods used should be maintained and that the results of surveys within national programmes should be reported to ICES as the coordinating body.

(iii) Considering that the chemical manpower and expertise available in pollution studies is very limited, the Analysts wish to emphasize the importance of directing part of these analytical facilities towards supporting studies, both short and long term, which are needed to provide a realistic assessment of the biological significance of the levels of pollutants found in the Base-Line Survey.

(iv) In order that results of analyses from different countries will continue to be meaningful and comparable, the Analysts recommend that additional intercalibration exercises should be carried out from time to time. It is also considered that individual laboratories should be encouraged to carry out constant checks on their analytical methods by examining standard reference materials (e.g. those from the US National Bureau of Standards) and, where possible, by exchanging natural samples.

(v) The Analysts consider that a further intercalibration exercise would be valuable and recommend that this be carried out under ICES auspices during the period June-December 1973 using samples of fish flour and fish oil, preferably from new sources, according to the principles outlined in their report. The Analysts consider that a meeting of analysts involved in the proposed intercalibration exercise might be necessary early in 1974 to discuss the results of the analyses. (In the event this exercise was delayed and did not start until October 1973.)

The conclusions of the Analysts relating to the meaning of the results obtained have been incorporated in the sections which follow. Although all the survey results are now to hand and amount to approximately twice those available in January 1973, the basic conclusions drawn by the Analysts have not been affected.

The results of the intercalibration studies using a sample of fish flour for metals and two samples of fish oil, one spiked with known amounts of organochlorine pesticides and PCB, are given in Tables 6 and 7 respectively. These tables include results submitted by laboratories which did not participate in the Base-Line Survey; therefore two sets of mean and standard deviation values are given. The first applies only to the results submitted by the laboratories which took part in the Base-Line Survey and the second to all the results recorded in the table.

The results of the Base-Line Survey are given in Tables 8 and 9 and each table consists of separate sections for the five different species. Details of the sample positions are given in brief by reference to ICES statistical rectangles. The manner in which results are reported in the tables has been standardized as far as possible, but it has not always been possible to give minimum, maximum, mean and standard deviation values for the fish analyses because some laboratories used bulk homogenates made up of fillets from each of the fish in the sample. Whenever possible the results are expressed to two significant figures for metals but for organochlorine pesticides they are given to two or three decimal places as appropriate. The results are also summarized in Figures 2-11, which show the mean values obtained for each ICES statistical rectangle in which a sample was collected: values for samples from the selected year-class or size range are underlined. Where more than one sample was taken in a rectangle the value for the larger sample is sometimes given instead of the mean of the samples.



## INTERCALIBRATION EXERCISE

### Metal analysis: Methods

All laboratories carrying out analyses for metals used the atomic absorption technique. In most cases a standard air/acetylene flame was used for metals other than mercury, but the carbon furnace technique was used by the Belgian analysts. Mercury analysis was usually conducted by the flameless cold vapour technique but one laboratory, which did not participate in the Base-Line Survey, analysed the fish flour exchange sample for mercury by neutron-activation. A few laboratories utilized background correction for analysis of certain metals, especially cadmium, lead and mercury, but not necessarily for every sample and in one instance only for the exchange sample.

A number of both wet and dry digestion procedures were used by the different participating laboratories and varying sample weights and solution volumes were taken. These have led to a wide variety of detection levels and this is responsible for some of the apparent discrepancies between results. A summary of the various digestion procedures with details of analytical methods and standards is given in Table 10.

### Metal analysis: Discussion of results of intercalibration exercise

By comparison with other intercalibration exercises for metal analysis the results reported in Table 6 are reasonably good (IDOE, 1972) for mercury, copper, zinc and cadmium. The results for lead were extremely variable and for the other metals only a few results were reported. Except where otherwise stated, the following comments on the results apply only to those reported by the analysts participating in the Base-Line Survey.

In discussing the results of the intercalibration exercise at the Analysts' meeting it was generally found impossible to link particular values with the type of digestion procedure or other analytical step and, as the sample used for the exercise was of unknown composition, no decision could be made as to what the true concentration values were. It was agreed that this was an inherent feature of any natural sample and that the follow-up exercise should include the use of a solution of a mixture of metal ions in known concentrations. It was agreed that the use of a natural sample with and without known additions of metals would be impractical because of difficulties of ensuring homogeneity of addition.

In evaluating the means and standard deviations all the results in Table 6 were used except where they differed by a factor of 5 or more from the mean of the other results. When compared in terms of means and

standard deviations the results reported by the Base-Line Survey analysts compare very closely with those for the entire group of reporting analysts; for cadmium and lead they are somewhat better.

With the exception of the one very high result, which was neglected in calculating the mean, the mercury results fall into two groups in the range 0.08-0.11 mg/kg and 0.17-0.23 mg/kg. The analysts considered that there was a possibility of loss at the post-reduction pre-aeration stage in the flameless technique and that the results might be low as a result. This view is supported by Reimers, Burrows and Krenkel (1973) in their review of available mercury analysis procedures. However, the lower results appear to be associated with digestion procedures which either use no nitric acid or are unlikely to have much carry-over of nitric acid to the determination stage (see Table 10). This might explain the two groups of figures, since it has been reported that the presence of oxides of nitrogen can lead to enhanced response and erroneously high concentrations. Repeat analyses carried out at the Burnham-on-Crouch Fisheries Laboratory using their normal mercury procedure, both with and without deuterium background correction, produced values of 0.17 and 0.20 mg/kg respectively, suggesting that the higher group of reported concentrations may be too high by a factor of at least 15%.

The results for copper were in extremely good agreement and, if the one low value reported by France is neglected, the mean concentration is 19 mg/kg with a standard deviation of only 1.4 mg/kg (7.4%). The results for zinc were less satisfactory (standard deviation for the nine participants 35%) and there does not appear to be any link between methods of dissolution of sample or use of background correction which might explain the differences in reported values. There are, however, a group of six values which are quite close to the mean of 75 mg/kg (66-80 mg/kg with a standard deviation of only 7.2%) and it seems likely that the true concentration lies within this range. For cadmium, where the overall standard deviation was 41%, there are again two groups of results, 1.0-1.8 mg/kg and 2.4-3.3 mg/kg. No explanation could be found for the difference but it seems likely that the lower group embraces the true value since some of these values were obtained using background correction.

The results for lead were disappointing, with a standard deviation of 61% and a range of 1-12 mg/kg. In discussing these results the Analysts concluded that the most probable reasons for the variation in reported results lay with one or more of the following causes: inherent insensitivity of the lead line, contamination of reagents - high result;



non-atomic absorption - high result; loss during digestion, particularly dry-ashing - low result. The two low values can certainly be linked to the loss on ashing since the Norway laboratory used dry-ashing at 450-500°C and the Belgian laboratory used the carbon furnace, which is liable to lead to losses at the evaporation and ashing stages prior to the atomization process. Without these two results the mean is 8.4 with a standard deviation of 2.4 mg/kg (28%).

#### Organochlorine pesticides and PCB analysis: Methods

All the laboratories analysing the fish oil samples used a clean-up procedure and gas liquid chromatography (glc) analysis with electron capture detection (using either tritium or nickel-63 sources). A variety of solvents was used for initial extraction of the fish tissues or dilution pre-extraction of the fish oil intercalibration samples. The clean-up method used by all the laboratories as routine involved some form of column procedure, although one laboratory reported they had used a liquid-liquid partition for some samples. In order to separate PCBs from organochlorine pesticides most laboratories used a silica column, but one laboratory used a rather more complex procedure involving three eluate fractions. In most instances confirmation of residue identity was achieved solely by use of dual column identification and heavy reliance was placed on the analyst's experience. Some laboratories did, however, report that they had carried out a variety of confirmatory procedures for certain samples. One laboratory (Sweden) reported PCBs by four different methods stating their preferred value (given in Table 7). These ranged from 8.5 to 12 mg/kg. Generally, however, PCB quantification was carried out by use of peak height summation of a stated number of the major peaks, and Aroclor 1254 was used as the standard by all laboratories, except Norway which used the similar Clophen A50 and Scotland which occasionally used other Aroclor formulations as appropriate. All laboratories reported that they had used the same analytical procedure for the intercalibration samples and for the fish and shellfish samples. Details of the procedures of extraction, clean-up, separation, glc analysis and confirmation techniques are given in Table 11.

#### Organochlorine pesticides and PCB analysis: Discussion of results of intercalibration exercise

One laboratory, Belgium, reported very low concentrations for the intercalibration sample. This laboratory had taken part in the Base-Line Survey and its results on the fish samples were, if anything, higher than those reported by some of the other laboratories. It therefore seemed

probable that there had been some error associated solely with the intercalibration sample pre-treatment rather than errors associated with inaccurate standards or methodology. Discussion of these results at the Analysts' meeting revealed that an error had been made in which the samples had been excessively diluted. Subsequent re-analysis gave values in much better agreement and these are recorded in Table 7.

Except where otherwise stated the comments which follow refer only to the results reported by the Analysts participating in the Base-Line Survey.

Agreement among the analyses of the spiked fish oil was very good with generally low standard deviation values ( $\gamma$ -BHC, 11%; Dieldrin, 6.9%; ppDDE, 21%; ppTDE, 17%; ppDDT, 10%; and PCB, 11%). Agreement among the analyses of the unspiked fish oil was also good although some of the standard deviation values were rather high. The standard deviations for each residue indicated that the results were better than the 1967/68 OECD intercalibration exercises (Holden, 1970) although they were not quite as good as the results of the 1969/71 OECD exercise (Holden, 1973). However, the results were considered to be very encouraging in view of the fact that for many of the Analysts this was their first intercalibration exercise. As with the fish flour sample, no decision could be made as to the true residue concentrations in the fish oil. It is therefore much more meaningful to consider the recoveries obtained for the various pesticides added in known amounts to the fish oil. These were all within the range 88% ( $\gamma$ -BHC) to 133% (opDDT). opDDT was, however, only quantified by two analysts and if this is disregarded the range is 88 to 106% (ppDDE). Perhaps the most encouraging result of all was the very good measure of agreement achieved for PCB (standard deviation 11%) and the good mean percentage recovery (100), range 88-118. In view of the generally good results there was little discussion on possible causes of difference in results at the Analysts' meeting in January 1973, but a careful appraisal of the results in relation to the methods used (Table 11) reveals no obvious associations between high or low results and particular methods.

#### BASE-LINE SURVEY

The results of the Base-Line Survey are given in Tables 8 and 9 and in summary form in Figures 2-11: they are discussed in some detail below. For most of the metals, pesticides and PCBs studied in the survey basic data on possible variations with season, age, etc. are sparse or non-existent, and it was for this reason that the meeting of Analysts and Biologists held in August 1971 agreed on the species to be examined and

a programme of sampling designed to eliminate as many of these potential variables as practicable. Unfortunately several participants experienced some difficulties in obtaining samples of all the selected species, and even greater problems were experienced in obtaining samples of the agreed size or age, although most participants did manage to collect the samples at or about the agreed time.

These problems were generally associated with lack of commercial fisheries and/or available expertise in determining the age of fish. When the sampling programme was agreed such difficulties were apparently not envisaged and they indicate that in any future exercise of this type it is essential that all participants ensure they have cooperation from skilled marine biologists before embarking on the collaborative exercise.

In general the problems over sampling have merely led to undesirable gaps in the areas surveyed. Most of the analyses are in fairly close agreement and it does not appear to have made much difference that the fish collected were of different ages or the shellfish were of different sizes.

For the purposes of the Base-Line Survey the North Sea was defined as including the Kattegat and Skagerak and as extending from  $51^{\circ}\text{N}$  in the south to  $62^{\circ}\text{N}$  in the north and  $4^{\circ}\text{W}$  in the north-west. However, it was agreed at the meeting of Analysts and Biologists that samples could also be taken from outside this area as appropriate. Both Norway and France included in their programmes samples from outside the defined North Sea area but, in order to allow for ease of tabulation and chart preparation, the results of analyses of these samples are not included in Tables 8 and 9.

#### Metal analyses

The results for each species of fish are considered separately below but it is possible to make a few generalizations from an overall assessment of the data for all five species.

The results reported for copper and zinc by Norway are generally higher than those reported by other Analysts by a factor of about 2. Similarly the results reported by Sweden for cadmium and lead are also higher than those reported by other Analysts, in some instances by a factor of 10. From the results reported by these two laboratories for the intercalibration sample there is no reason to suppose that the values quoted are inaccurate. However, in view of the magnitude of some of the differences for lead and cadmium in fish from the Kattegat and Skagerak compared with elsewhere, some doubt must remain as to whether

fish or shellfish from these areas really do contain more lead and cadmium than fish or shellfish from other areas. Discussion at the Analysts' meeting in January 1973 on the apparent differences between cadmium and lead results reported by different laboratories, in fact, strongly suggested that the differences were not real but were due to different detection limits, the high values being reported by Analysts using small samples with consequently higher detection limits.

Unfortunately not all the participating laboratories were able to carry out analyses for a full range of metals. Most reported results for zinc, copper, cadmium and lead, and all except Germany reported concentrations for mercury. Some data were presented for chromium, cobalt, iron and manganese but these are so limited that they are merely included in the tables and no comment is made. Only one laboratory (Netherlands) analysed for methyl mercury. Their results confirm that 80-100% of the mercury present is in the methyl form. In shellfish the average proportion tends to be lower (40-80%). Similarly, only one country reported data for Carcinus maenas and so only limited comments are made on these results. It was intended that the fish samples should be analysed on an individual basis and, where this has been done, in addition to the mean concentration, the minimum, maximum and standard deviation values are included in the tables.

Comments are for simplicity confined to the mean concentrations since, on an overall fish population basis and from a human consumption standpoint, this figure is of most significance. From an examination of the statistical data it is apparent that for all the metals in all the species the distribution is slightly skew with a prevalence of values lower than the mean. In most cases the detection limits of the methods used are low enough for it to be fairly certain that this skewness was not caused by truncation at the lower end of the range due to the artificial block of detection limit. In most cases the standard deviation values lie within the range 15-50%, i.e. a similar range to that found for the intercalibration sample but greater than that which could be expected from analytical error (5-15%).

Cod:

The mean concentration of mercury in cod reported in the course of the Base-Line Survey ranged from 0.03 to 0.48 mg/kg. The values reported for the Kattegat and Skagerak areas are all below 0.1 mg/kg and in common with many of the other results can be regarded as typical of cod from waters subject to minimal mercury pollution from man-made sources

(MAFF, 1971). Although the highest value (0.48 mg/kg) was reported for a sample of cod from the central North Sea, this area appears to be associated generally with the lower reported concentrations and it is therefore possible that this value is erroneous, although it may simply reflect the influence of mercury carried by the Rivers Elbe, Ems and Rhine. There is some evidence of elevated levels along the Netherlands and Belgian coasts and also along the Norwegian coastline, especially in the extreme north. The overall mean concentration of 0.13 mg/kg is, however, low by any standard. From the results reported by Norway and Belgium there is some evidence of accumulation of mercury with increase in age, a similar phenomenon has been reported in fresh-water fish (Bache, Gutenmann and Lisk, 1971; Scott and Armstrong, 1973).

The mean concentrations of zinc and copper are variously reported as being between 2.4 and 7.0 mg/kg and 2.6 to 1.1 mg/kg respectively and compare very closely with the average concentrations (5.2 mg/kg and 0.65 mg/kg respectively) reported by Portmann (1973) for cod from the North Sea. The reported cadmium concentrations cover a wide range but all are low (0.02 to 0.5 mg/kg). A similar wide range (0.1 to 3.0 mg/kg) is reported for lead but, with the possible exception of the fish from the Swedish west coast, Skagerak and Kattegat, there is little evidence of serious contamination of cod by either cadmium or lead in the North Sea.

#### Plaice:

The mean concentrations of mercury in plaice range from 0.02 to 0.26 mg/kg with an overall mean of 0.12 mg/kg. However, this is heavily weighted by a large number of samples collected along the Belgian coast where the levels were generally in excess of 0.1 mg/kg, whereas elsewhere the reported concentrations were below this value. Unlike cod there is no evidence that plaice from the Norwegian coastal zone contained more mercury than those taken elsewhere.

The mean concentrations of zinc and copper generally fall within a similar range to that found in cod and, although the maximum values are slightly higher (8.3 mg/kg zinc compared with 7.0 mg/kg; 1.8 mg/kg copper compared with 1.5 mg/kg), it is doubtful if the differences are significant. Again the values compare closely with those previously reported (Portmann, 1973) to be typical of plaice from the North Sea (mean 5.7 mg/kg zinc and 0.85 mg/kg copper). As with cod, the concentrations of cadmium reported to occur in plaice are all low (maximum 0.7 mg/kg), and although there is a spread of more than tenfold in the

results, this is most probably due to analytical differences. All the lead results are low, with the possible exception of the Swedish west coast, Skagerak and Kattegat areas.

#### Herring:

The mean concentrations reported for mercury in herring were between 0.02 and 0.24 mg/kg but the overall mean was 0.06 mg/kg; much lower than that found for cod and plaice. The highest concentrations were reported in herring taken along the coasts of the Netherlands, south-east England and northern France, i.e. all in the southern North Sea. With the exception of a few samples from these areas all the herring contained less than 0.1 mg/kg mercury.

The mean concentrations of zinc and copper were reported to lie between 3 and 17 mg/kg and 0.6 and 3.6 mg/kg respectively. In both cases this is somewhat higher than for the two demersal species examined. This may be a reflection of different feeding behaviour or of the higher lipid concentration in the flesh of herring compared with cod or plaice. Work by Lunde (1973) and Windom et al. (1973) suggests that both zinc and copper are accumulated more by fish with a high lipid content in their muscle. The higher copper and zinc levels found in herring relative to cod and plaice may also be a reflection of the different levels of accumulation in red and white muscle: a much higher proportion of the herring muscle analysed would be red muscle.

The cadmium content of herring was reported to range from 0.02 to 0.7 mg/kg with the highest concentrations being reported for herring caught in the Swedish sector. A wide range of concentration (0.2 to 5.1 mg/kg) was also reported for lead. Generally, the concentrations were below 1.5 mg/kg, although all the herring from the Swedish sector were reported to contain more than this; the other area with herring possibly contaminated by lead being the central North Sea away from the English and Scottish coasts.

#### Mussels:

The results reported for mussels, especially for lead, were rather more variable than those reported for the fish and the Analysts concluded at their meeting in January 1973 that there were various reasons for this, including the variable condition of the mussels and the fact that in most instances the analysis included an unknown amount of particulate material from the shell cavity and gut contents. Interpretation of the results therefore requires some care, and the comments made below should



be considered along with those for the other species and not in isolation.

Most of the mussel samples were reported to contain less than 0.1 mg/kg mercury (overall mean 0.13 mg/kg). A single sample from Norway, in the extreme north, contained more than this (0.31 mg/kg) and this may indicate an industrial point source or possibly one of geological origin. The concentrations reported for mussels from the Netherlands coast were both high, 0.50 and 0.68 mg/kg, but relatively high concentrations were also reported from the Thames Estuary area of the coast of England (0.31 and 0.26 mg/kg), with some evidence of slightly raised levels in the area south of the Tyne and Tees industrial centres.

The highest concentration of zinc (60 mg/kg) was reported in mussels from the outer Thames Estuary and, as this area is known to be relatively polluted, it is probably a true reflection of the water quality. No zinc values are available for the mussels with a high mercury content taken from the Netherlands coast. The remainder of the zinc concentrations ranged from 14 to 40 mg/kg, somewhat higher than the concentrations found in the fish species examined. The copper concentrations were also higher than those found in fish (range 1.6 to 13 mg/kg).

All the participants reported cadmium to be present in mussels in excess of the detection level of their methods, whereas most of the fish samples contained cadmium at or around the detection level. The reported concentrations ranged from 0.10 to 0.50 mg/kg with a single exceptional value of 1.3 mg/kg. This high concentration was found in mussels from the Thames Estuary: these also contained the highest mercury and zinc concentrations. It should be pointed out that this sample was, in common with many others, used purely for the purposes of the survey and did not come from a stock of mussels used for commercial purposes. As mentioned earlier, the concentrations of lead were very variable, ranging from 0.3 to 7.2 mg/kg overall, but were also variable within the samples taken from any one country.

#### Shrimps:

The concentrations reported in Table 8e refer to the whole animal and should not be interpreted as being the concentration in the edible portion: only the tail meat is normally eaten and there is some evidence of lead being concentrated in the exoskeleton and cadmium in the digestive organs (MAFF, 1973). The shrimps analysed by the Norwegian laboratory were all larger than the required size and there is some

doubt that they were of the same species: direct comparison of the data is therefore difficult.

The concentration of mercury found in the shrimps was generally low (overall mean 0.10 mg/kg), although shrimps from the Wash on the English coast contained 0.23 mg/kg. The concentration of zinc found in shrimps was similar to that found in mussels (range in shrimps 6.3-40 mg/kg; range in mussels 14-60 mg/kg) but the copper content was higher at 7.2-41 mg/kg or, if the results from Norway are excluded, 7.2-23 mg/kg. The concentrations of cadmium were generally reported to be in excess of the normal detection limits (0.02 mg/kg) but in no case did they exceed 1 mg/kg. Lead concentrations, excluding those reported by Norway, were highest for any of the examined species (overall sample mean 4.6 mg/kg). However, with one exception, all the lead concentrations were within a narrow range 3.4-4.5 mg/kg and only one area showed any evidence of elevated levels relative to those found elsewhere, namely the Wash (6.8 mg/kg).

#### Crabs:

Although not included in the official list of species for the survey, Norway collected and analysed a number of samples of crabs (Carcinus maenas). The results of these analyses are given in Table 8f.

The concentrations of copper and zinc found in the crabs appear to be very similar to those found in shrimps from other parts of the North Sea. In fact, the range of concentrations reported for all five metals was similar to that reported by other laboratories for shrimps, and the mean concentration of mercury (0.10 mg/kg) was almost identical to that found in shrimps from the whole North Sea area (0.11 mg/kg). However, the lead and cadmium concentrations both appear to be lower than those found in shrimps, although this may simply be attributable to differences in analytical technique, since the Norway results for these two elements were lower than the average for the intercalibration sample.

#### Conclusions from the metal survey:

At the meeting of Analysts held in January 1973 it was concluded on the basis of the results then available that there was little evidence of metal pollution of the North Sea and that fish and shellfish from the North Sea did not contain higher concentrations of metals than those caught elsewhere. None of the results submitted since then has caused this conclusion to be altered.

One of the main objectives of the Base-Line Survey was to establish whether any of the metal levels in fish or shellfish approached those concentrations generally acknowledged to be undesirably high from the human consumption point of view. For mercury some countries have established a maximum safe concentration in fish. This figure differs from country to country but the lowest is 0.5 mg/kg (National Institute of Public Health, 1971). None of the fish samples contained more than 0.48 mg/kg, and with the exception of this one high value, on which some doubt has been cast, all the concentrations were below 0.26 mg/kg.

There appear to be no standards for copper and zinc in foodstuffs but the reported toxic dose for man of copper is 100 mg (McKee and Wolff, 1963) and for zinc it is likely to be even higher (Browning, 1969). These are much higher than those encountered in any of the fish or shellfish analysed in the Base-Line Survey, and there is some evidence that fish, at least, can regulate their body burdens of copper and zinc. Cadmium concentrations in fish were all at or about the detection level of the methods used but low concentrations were readily detectable in the shellfish. However, these appear to be normal for those species and there was little evidence of abnormally high concentrations. The concentrations of all the metals in cod were found to be very similar to those found in plaice, but the concentration of copper and zinc found in herring was somewhat higher than in cod and plaice, possibly reflecting the higher lipid content and/or red muscle of the herring.

Although the mercury content of all fish was low by any of the accepted standards, there was some evidence of higher levels along the coasts of Belgium and the Netherlands. As this could possibly be linked to centres of population and industry it might be expected that similar concentrations would be found along the south-east coast of England. Unfortunately, the Base-Line Survey did not include samples of fish from that area. However, previous work (Portmann, 1973) did show higher mercury concentrations in fish from this area, especially in the outer Thames Estuary. Although there is this limited evidence of pollution in the coastal area of the southern North Sea, there is no evidence that it extends beyond the coastal area, and the central southern North Sea area away from the coasts appears to be as uncontaminated as the rest of the North Sea area.

When the Base-Line Survey was arranged it was recognized that the areas most likely to be polluted were the coastal zones, and in an effort to quantify this mussels and shrimps were selected as indicators.

In spite of some disadvantages detailed in the appropriate sub-sections, this decision appears to have been valid. The mussel and shrimp data confirm the tentative findings of the fish survey and reveal that the coasts of south-east England, northern France, Belgium and the Netherlands are affected by metal pollution presumably derived from the industrial and population centres draining into the southern North Sea. The levels of metals found were not high by any of the normally accepted standards for the species concerned, but they were higher than those found in the same species collected around the coasts of the northern and central North Sea.

Generally, the metal concentrations reported were below the lowest levels established by certain countries as standards for human consumption, although individual fish occasionally exceeded the 0.5 mg/kg standard for mercury adopted by some countries. All were low when compared with concentrations in fish or shellfish of the same or similar species taken from areas known to be polluted from point sources (EMSO, 1971, 1972, 1973; Portmann, 1973; Windom *et al.*, 1973). Nevertheless, as recommended by the Analysts, some monitoring of the coastal regions appears to be justified. Very little is known about the effects of slightly raised metal levels upon marine animals in their natural environment. Monitoring should therefore be supported by long-term sub-lethal toxicity testing aimed at understanding the significance, if any, of elevations in metal concentrations within a species.

There is some evidence that fish, at least, can regulate metal levels in their muscle tissues and that the main storage organ is the liver which, because it is also the centre of detoxification mechanisms, is liable to show (a) higher levels and (b) greater variability according to the input. There is also a suggestion that adverse effects attributable to the liver burden of metal can be detected in fish livers. On these grounds future monitoring programmes should probably include analysis of fish liver as well as fish muscle.

#### Organochlorine pesticide residue and PCB analyses

In general, the fish analysed for organochlorine pesticides and PCBs were the same as those analysed for metals, but this did not always apply and in some instances more samples were analysed for organochlorine residues and PCBs than for metals and vice versa. The results for each species are considered separately below but a few generalizations can be made.

Most analysts determined dieldrin, ppDDT, ppTDE, ppDDE and PCB although, because their separation and clean-up method incidentally destroyed any dieldrin, this residue was not reported by Sweden or Norway. The Netherlands and England reported results for  $\alpha$ -BHC and  $\gamma$ -BHC respectively and Norway reported data for opDDT: these results are included in Table 9 but, since there are only single sets of data, no comments are made. In all cases the concentrations reported were low. At the time of the Analysts' meeting in January 1973 the results submitted by Germany were considerably higher than those reported by other countries for fish or shellfish, both generally and for samples from the same general area as ones taken by other countries. It was found that the results had been affected by a previously undetected source of contamination and the samples were reanalysed. The results of the reanalysis are given in Table 9. They are still slightly higher than many of the other results, but they do refer to fish which were taken from areas which previous work had indicated might be relatively more polluted than the North Sea as a whole. Moreover, from the results of the intercalibration sample analyses there is no reason to suppose that this or any other laboratory would report consistently high or low results due to a systematic analytical error, and it can therefore be safely assumed that any differences are real.

All the results are reported on a wet weight basis and in most cases analyses were made, as agreed, on the individual fish comprising a sample. Where this was done the results include minimum, maximum and standard deviation values but the value recorded for percentage fat content is the mean for the entire fish sample. Most of the fat contents were low but for herring they reach 13.5% and, as agreed at the Analysts' meeting, the results for herring are also tabulated on a fat basis. This eliminates variations due to variable moisture losses (e.g. on freezing and thawing) and, assuming that all the fish were in roughly the same maturity and condition state, should allow a good comparison of pollutant variations.

As with the metal analyses, comments in the sub-sections are largely confined to a discussion of the mean values. From an overall examination of the statistical data it is apparent that for most of the residues reported the distribution within any fish sample/population exhibits the same skewness towards the lower concentrations that was noted with the metal data. As this is particularly marked with the higher results, where all the concentrations reported were well clear

of the detection limit (e.g. PCBs), the skewness is evidently a real feature. A similar feature was noted by Holden (1970) in reporting the OECD first survey results. The standard deviation values, which range from 30% to over 100% of the mean, are considerably greater than those which might be expected to arise from laboratory sources or than those observed with the intercalibration sample.

Cod:

All the concentrations reported for organochlorine pesticide residues and PCBs in cod muscle were low; in fact, in no case did the mean concentrations reach 0.1 mg/kg for all pesticide residues combined. This was not entirely unexpected in view of the low lipid content of cod muscle (0.01-0.6% in the present survey). The main concentrations of these substances in cod are usually found in the liver which may have mean concentrations of 10 mg/kg or more.

Dieldrin concentrations appear to be highest along the entire eastern shore of the North Sea from France to Denmark, although the highest mean value was only 0.023 mg/kg. This type of distribution may be a reflection of the pattern of use of dieldrin because its use has been severely restricted in the United Kingdom since 1965. The highest total DDT concentrations were reported for the Swedish west coast, Skagerak and Kattegat areas and by Germany for the area off Denmark and the German west coast. Most of the other concentrations were lower by a factor of 3 to 5, the single exception to this being a value of 0.02 observed off the coast of Norway at Kalvåg. When concentrations are as low as those reported for cod muscle it is extremely difficult to distinguish any clear pattern of preponderance of DDT or its metabolites. Generally the concentrations of TDE were lower than those of DDE or DDT, but there was certainly no clear indication of much of the DDT in cod being present as the DDE metabolite.

Almost without exception the concentration of PCB was reported to be greater than that of total DDT, generally by a factor of at least 2. All the cod samples were reported to contain PCB above or about 0.01 mg/kg except those taken off the coast of Norway, where the three samples analysed for PCB were all found to contain less than 0.001 mg/kg PCB. The maximum concentrations of PCB were found in fish taken from the southern sector of the North Sea, as indicated by the results reported by Belgium, the Netherlands, Germany and England. The highest individual concentration recorded was 0.84 mg/kg in a fish caught off the German



coast (L8), although the average PCB concentration for this sample was 0.099 mg/kg.

Plaice:

As with the cod samples, the levels of pesticide residues reported in plaice were generally very low and in no case did the mean concentrations exceed 0.1 mg/kg for all residues combined. The highest concentrations of dieldrin were reported in samples of plaice taken along the eastern shoreline of the southern North Sea and as far north as the Danish coast, thus demonstrating a similar pattern to that found with cod. The highest residues of total DDT and metabolites were reported by Germany, the Netherlands and Belgium and suggest that the southern North Sea is slightly more contaminated with DDT and its metabolites than the northern sector. The samples collected by England did not cover the south-western shore of the North Sea and all the residue levels reported by England are low. However, from other work carried out as part of a national programme it can be stated that levels on the English side of the southern North Sea are in line with those reported by the other countries for that sector. The results for plaice taken off the Swedish west coast were no higher than those found in the southern North Sea. As with the cod, no definite pattern of metabolite preponderance can be discerned from the data for plaice. Neither is there any evidence to indicate that consistently most of the total DDT present is in the form of metabolites, although in the one individual sample where total DDT exceeded 0.1 mg/kg (Djupa rännan, Sweden) most of the DDT was present as DDE.

As with cod, the PCB concentrations were always higher than those for total DDT by at least a factor of 2. Occasionally they were as much as ten times higher, but on average three to five times. As with the pesticide residues, the highest concentrations of PCB were found in fish taken along the shores of the southern North Sea as indicated by the results for samples from this area reported by Germany, the Netherlands, Belgium and England. The highest individual concentration (0.56 mg/kg) was found in a fish caught in the middle of the southern North Sea (G4: H4), but high concentrations were also found along the Netherlands coast and in the central North Sea. By comparison with the residues found in fish from these areas, the fish from the Swedish West Coast contained low concentrations of PCB more in line with those found in fish taken off the unpolluted Norwegian coast or off the north coast of Scotland.

Herring:

As was to be expected in the light of the much higher lipid content of herring muscle compared with that found in cod and plaice muscle, the concentrations of pesticide residues found in herring were higher than those reported for other fish species. Over half of the mean concentrations of combined residues exceeded 0.1 mg/kg on a fresh weight basis. The residue concentrations found in herring are also given on a fat weight basis in Table 9c(ii). These were evaluated on an individual fish basis wherever possible, and the values quoted are the maximum, minimum and mean concentrations so calculated. The value given in the percentage fat column is also a mean but is merely a guide figure: it was not used to convert directly the values quoted in Table 9c(i) to those in Table 9c(ii).

The number of samples of herring analysed was not as large as for the other two fish species, but on the basis of the few dieldrin figures available it appears that the concentrations reported for dieldrin follow the same pattern of higher concentrations along the eastern shoreline as was noted with cod and plaice. To some extent there appears to be a pattern in which the highest total DDT concentrations on a wet weight basis are associated with high fat concentrations. Since fat concentration varies with season it is probably important that all the fish be caught at the same stage in their life cycle. Unfortunately, this fact was not recognized and the herring were all collected early in February 1972. Because the different stocks spawn at different times their conditions were very different: the fat contents range from 13.5 to 2.7% and comparisons on either a fat or fresh weight basis are therefore difficult. However, on both bases the highest concentrations of total DDT residues were found in herring caught off the Swedish West Coast. As with the other fish species, there was no clear evidence of metabolite preponderance, although generally the highest total DDT was associated with high DDE concentration.

PCB concentrations on a fresh weight basis ranged from 0.001 to 0.48 mg/kg with the highest concentrations (all over 0.4 mg/kg) being found off the south-east coast of England (E2) and the coasts of the Netherlands and Sweden (Djupa rännan). Owing to the variable fat content, the pattern of high concentrations is less clear on a fat weight basis, but the lowest concentrations were still recorded for herring taken off the coast of Scotland and north Norway. With a few exceptions

PCB concentrations exceeded those of DDT and metabolites by two to five times.

Mussels:

Although a good number of samples of mussels were collected and analysed, coverage of the coastline of the North Sea was not complete because no samples were collected by Belgium, France or Scotland. Generally the total pesticide residue concentrations were low and compare in order of magnitude with those found in cod and plaice. In no case did the total pesticide residue concentration exceed 0.1 mg/kg. Dieldrin concentrations in mussels taken along the coasts of Germany and the Netherlands were in all cases higher than those reported in mussels from the coast of England, when in no case did the concentrations exceed 0.001 mg/kg. Concentrations of total DDT ranged from a minimum of 0.003 mg/kg, which was reported from the Swedish West Coast, to a maximum of 0.088 mg/kg, which was also reported from the Swedish West Coast, although most of the concentrations were less than 0.03 mg/kg. The highest concentration of 0.088 mg/kg was found in mussels from the Seläter area in Sweden, an area recognized as being heavily polluted. Other high concentrations also appear to be associated with areas which are known to be affected by pollution from areas of high industrial or population density (e.g. H2, Netherlands off the Rhine and Schelde; E2, England off the Thames). However, unlike the results from the analyses of fish, there was no evidence that the mussels taken from the shores of the southern North Sea contained higher concentrations of pesticides than those taken along the Norwegian coast. Unlike the total DDT residues reported in cod, plaice and herring, there was clear evidence of rapid metabolization or excretion of DDT. Sweden reported that DDT was not found in any of the samples of mussels collected along the coast of Sweden, and in most instances the content of DDT found in the samples taken along the shores of Germany, the Netherlands and England was lower than that of either DDE or TDE.

The concentrations of PCB recorded in mussels ranged from 0.02 to 0.39 mg/kg, and, as with the fish species, were generally higher than total DDT residues. The highest concentrations found were consistently reported for mussels taken along the coast of the Netherlands. Two of these mussel samples had an exceptionally high fat content and this might perhaps explain the high PCB concentration. However, the pesticide concentrations were no higher than those found in most of the other samples

and a third mussel sample, which contained a normal amount of fat, was found to have a similarly high PCB concentration. With the exception of the Netherlands samples there was no evidence of generally high PCB levels along any section of the North Sea coastline, and the incidence of concentrations of PCBs above a background level of around 0.1 mg/kg appears to be very localized.

#### Shrimps:

Only five countries were able to report results for shrimps and, as there is some doubt that the shrimps analysed by the Norwegian laboratory were the same species, comparison can really only be made of the results reported by Germany, the Netherlands, Belgium and England. Generally, the concentrations of both pesticide residues and PCBs were lower than those found in mussels. Dieldrin levels, although extremely low, were consistently higher than the common detection level of 0.001 mg/kg in the samples collected along the eastern shoreline of the North Sea, whereas in no case did they reach the detectable level in shrimps from the English coast. Most of the DDT concentrations were below the level of detection of the method used, and it is therefore extremely difficult to make any assessment of the few reported concentrations. Where there is a full set of data the concentration of DDT is generally lower than that of other metabolites.

The PCB concentrations were greater than those for total DDT by a factor of 2-10. They were generally higher in shrimps taken along the coasts of the Netherlands and Belgium, but two high values were yielded by samples collected by Germany in the region of the Elbe Estuary. The highest concentration reported in shrimps taken on the English coast was found in a sample collected in the Humber Estuary (0.06 mg/kg), but even this was only equal to the average for all samples.

#### Crabs:

In addition to the species selected for the Base-Line Survey, Norway collected and analysed a number of samples of crabs (Carcinus maenas). The results of these analyses are given in Table 9f.

All the pesticide residue concentrations were low; generally lower than the levels reported for shrimps collected along the coast of Norway. Unlike with mussels and shrimps, there was no clear evidence that DDT was either preferentially excreted or metabolized. In fact, DDE was reported to be absent in over half of the samples. The PCB concentrations reported were, with one exception (0.19 mg/kg), all within the range 0.02 to

0.08 mg/kg, and as such were very similar to those reported for shrimps from Norway. Generally, the concentrations of PCB were higher than those reported for DDT.

Conclusions from the organochlorine pesticide residue and PCB survey:

At the meeting of Analysts held in January 1973 it was considered that, on the basis of the results then available, the levels of organochlorine pesticide residue and PCBs found in fish and shellfish caught in the North Sea were on the whole consistently low and were certainly not higher than those found in fish caught elsewhere: some of the levels found in fish and shellfish from certain coastal areas were, however, noticeably higher than the others. None of the results submitted since the Analysts' meeting has caused this conclusion to be altered, and comparison with data on fish caught elsewhere, e.g. the Baltic and USA (Butler, 1973; Jensen *et al.*, 1973; Ernest and Benville, 1973), shows the North Sea fish to contain relatively low concentrations of PCB and organochlorine pesticide residues.

As with the metal survey, one of the main objectives of the Base-Line Survey of organochlorine pesticide residues and PCBs was to establish whether or not any of the levels of these materials found in fish or shellfish from the North Sea approach the levels which might pose a hazard to man. Of the pesticides analysed by all the laboratories, DDT and its metabolites have a low toxicity to man and the oral toxicity of PCBs to man is also low. Only dieldrin has a high mammalian toxicity and it is generally recommended that food should not contain more than 0.1 mg/kg on a wet weight basis (Egan, 1967). The maximum concentration of dieldrin recorded in any of the fish samples was only 0.040 mg/kg (in herring from the Netherlands) and for shellfish the maximum was even lower, 0.019 mg/kg (in mussels from the coast of Germany). It can therefore be concluded that, as far as the species so far investigated are concerned, the levels of PCBs and organochlorine pesticide residues found in fish muscle or shellfish from the North Sea pose no hazard to the consumer.\*

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\* It should be noted, however, that fish, except salmon and flatfish, from a small area off the mouth of the Swedish River Viskan (Kattegat) have been declared unfit for human consumption due to their high dieldrin content. Cod liver from the Göteborg archipelago has also been declared unfit for consumption on account of its high PCB content.

Although the concentrations of organochlorine pesticide residues and PCBs pose no hazard to man, certain patterns of distribution were revealed by the survey. The concentrations of dieldrin in both fish and shellfish were consistently higher along the eastern shore of the southern North Sea, and this is probably a reflection of the very low usage of dieldrin in the United Kingdom and the fact that dieldrin is manufactured mainly in the Netherlands at Rotterdam where any contaminated effluent would be discharged into the Rhine Estuary and hence affect the coast of the Netherlands and possibly Germany and Denmark. In both fish and shellfish the levels of organochlorine pesticide residues and PCBs were highest in samples collected in or around the Southern Bight of the North Sea, thus showing a similar pattern to that observed for metals. Unfortunately, no cod or plaice samples were collected along the south-eastern shoreline of England which would show conclusively that levels there were similar, but earlier work carried out at the Burnham-on-Crouch laboratory strongly suggests that this is so, and the analyses of herring and mussels from the Thames Estuary area confirm this fact.

Mussel and shrimp samples were originally selected as locally-confined indicator species for the coastal areas, which it was assumed would be relatively more at risk from pollution than the more open areas away from coastal discharges and land run-off. In spite of the difficulties mentioned in the discussion of the metals' results, this choice appears to have been fully justified. In general the residue concentrations found in the shellfish species were no higher than those found in the fish, but they did show local centres of pollution, e.g. along the north Yorkshire and Durham coasts of England and along the coast of the Netherlands, in one coastal area of Sweden, etc.

Although herring proved to be a useful species in corroborating the results for other species and generally contained the highest residue concentrations, use of herring alone could provide misleading data. The residue levels found in some samples taken off the Norwegian coast were, at least on a fresh weight basis, equivalent to some of the higher concentrations found in the southern North Sea and off the Swedish West Coast. However, this suggested pattern of equal pollutant levels in the northern sector was not confirmed by the data for shellfish, cod and plaice, and is probably related either to migration patterns of herring from the Baltic or to the very high lipid concentrations reported for the samples in question.



As with metals, fish livers tend to contain higher concentrations of organochlorine pesticide residues and PCBs. As the liver is the centre of the detoxification mechanism for many of these compounds, it is liable to more rapid changes in concentration and may therefore provide a more accurate indication of the levels of pollutant recently encountered by the fish. Future monitoring programmes should therefore consider inclusion of fish liver analysis as well as fish muscle analysis.

There are few experimental data on what tissue levels of PCBs or organochlorine pesticides affect the well-being of marine fish or shellfish. The levels found were, however, well below those recorded for certain areas off the USA (Butler, 1973; Ernest and Benville, 1973) or the Baltic (Jensen et al., 1973) and are at least a factor of 10 below the concentrations reported to affect breeding success in marine species (Butler, Childress and Wilson, 1972). On the basis of this information, it might reasonably be assumed that the levels of organochlorine pesticides and PCBs found in the course of the Base-Line Survey would be unlikely to affect fish or shellfish in the North Sea. This tends to be confirmed by the statistics on landings at least of cod, plaice, herring and mussels. Nevertheless, as recommended by the Analysts, there does appear to be justification for continued monitoring of the coastal areas, especially in the southern North Sea, and particularly for sub-lethal toxicity testing coupled with tissue analysis to be carried out.

#### 4 REPORT ON THE DISTRIBUTION OF TRACE METALS IN THE WATER

##### INTRODUCTION

Regular surveys of the distribution of selected trace metals in the waters of the North Sea have been conducted by laboratories in Belgium, the Netherlands and the United Kingdom. A preliminary examination of the results had shown differences in the mean level of "dissolved" metals measured by the three groups. An international intercalibration programme was therefore established early in 1973 to investigate this problem. An Ad Hoc Working Group met during December 1973 to examine these apparent anomalies, to agree on data to be presented in this report and to decide on the format to be used.

The Belgian trace metal surveys have been conducted as part of the Belgian National North Sea Programme and have involved several laboratories. The Netherlands investigations have been made by the Texel laboratory of the Netherlands Institute of Sea Research. The UK contribution has come from the Lowestoft Fisheries Laboratory and Fisheries Radiobiological Laboratory of the Ministry of Agriculture, Fisheries and Food (MAFF).

All groups have measured the metal content of both filtered water samples and suspended particulate material. However, owing to difficulties in interpreting the data on the metal content of particulate material, it has been decided to confine this report to the distribution of metals measured in filtered sea water.

The UK investigation covered a large part of the North Sea. The Netherlands and Belgian surveys, however, consisted of a network of much closer sampling stations, mainly confined to the eastern part of the southern North Sea. In those regions of the North Sea where surveys by the three groups coincided geographically, the levels of most metals recorded by the Belgian investigation were in general higher than the UK values and the Netherlands data occupied an intermediate position. There is evidence, however, that these apparent anomalies may be attributed to variation in the fraction of metal passing the membrane filter after sample collection. Prior to analysis seawater samples were filtered through membranes of pore size 0.22, 0.45 and 0.80  $\mu\text{m}$  by the UK, Netherlands and Belgian laboratories respectively. Because the pore size was directly related to the mean levels of metal reported, there is a strong suggestion that the filtrate from the membranes with the larger pore size contained a fraction of metal that was measured during analysis,

but which would have been retained on a membrane with a smaller pore size. However, different analytical procedures were followed by the various laboratories involved and the possibility of discrepancies arising due to analytical differences cannot be ruled out. The overall spatial trends in the distribution of "dissolved" metals reported by the three groups were, however, similar in those regions where the data overlapped. Because the UK had surveyed the largest area their results are summarized mainly in the form of distribution charts (Figures 12-15). In the case of mercury, however, data from the Belgian investigation have been combined with the UK results since both surveys gave comparable values. The results of the Belgian and Netherlands investigations are summarized separately.

## RESULTS

The data presented in this report refer to values in the near-surface samples (0-5 m). There is evidence that at some localities vertical stratification occurred below this level, particularly near the sea bed. However, more data are required to evaluate this phenomenon.

### UK surveys

Four surveys of selected metals in the southern North Sea and off the coast of north-east England were made during April-June 1971, February 1972, March 1973 and June 1973. In addition, samples for trace metal analyses were collected aboard the German research vessel METEOR in the northern and central North Sea during June 1972.

After collection and filtration filtrates were stored deep-frozen until analysis. Most metals were analysed by atomic absorption spectroscopy. However, both cobalt and lead were estimated by pulse polarography after a manganese scavenge (Harvey and Dutton, 1974) and a dithizone extract respectively. "Dissolved" cadmium, copper, manganese, nickel and zinc from the 1971 and 1972 (METEOR) surveys were analysed by an extraction technique using APDC/chloroform (based on Preston et al., 1972). "Dissolved" cadmium, copper, nickel and zinc during the remaining investigations were measured by an extraction method employing APDC/MIBK (based on Brewer, Spencer and Smith, 1969). The MIBK extract was aspirated directly into the flame; the chloroform extract was evaporated to dryness and the metal complex dissolved in methanol before aspiration. An intercalibration of the two techniques has given good agreement. The seawater samples used for mercury analysis were not the same as those used for analysis of other metals and were unfiltered.

Total mercury was analysed by concentrating the metal with an ion exchange resin followed by a flameless cold vapour measurement.

Charts have been prepared showing the distribution of copper (Figure 12a), nickel (Figure 12b) and zinc (Figure 13a) based on the arithmetic mean value of each metal at each station calculated from all values obtained during the four surveys listed above. The cadmium data showed a discontinuity between the surveys of 1971/72 and 1973. Mean distribution charts of this metal have therefore been prepared by grouping the 1971/72 data (Figure 14a) separately from the 1973 values (Figure 14b). The distribution of manganese (Figure 13b) relates only to the 1971 and 1972 surveys, since this metal was not measured during the other investigations. The distribution of total mercury (Figure 15) relates to the METEOR survey of 1972 and to Belgian samples obtained during the same year. The latter were analysed by means of a warm  $\text{KMnO}_4$  oxidation followed by a cold vapour measurement.

The results of these surveys show features common to most of the metals measured. Bands of relatively high values occurred along both English and Continental coastlines, with the maximal concentrations coincident with the estuaries of the major river systems. With the exception of mercury, the actual maximal values recorded for the whole series of surveys all fell within the coastal regions and were as follows:  $2.8 \mu\text{g Cd/l}$  (mouth of River Humber, March 1973),  $3.5 \mu\text{g Cu/l}$  (off the Yorkshire coast, March 1973),  $9.3 \mu\text{g Ni/l}$  (mouth of River Humber, March 1973),  $15.9 \mu\text{g Mn/l}$  (Wash, May 1971),  $0.07 \mu\text{g Hg/l}$  (central southern North Sea, April 1972) and  $18.3 \mu\text{g Zn/l}$  (off Hook of Holland, February 1972). Offshore values in the central part of the southern North Sea and in the major portion of the central North Sea were relatively low and probably approached the natural background level of oceanic water (Preston, 1973). One may thus infer that the higher levels recorded in the coastal zones were a result of discharge from terrestrial sources, but that this influence did not extend to any great distance offshore.

With the exception of cadmium, no obvious trends were apparent from one survey to the next, thus suggesting that the level of metals discharged had remained relatively constant. No obvious reason is apparent for the marked fall in cadmium levels between the investigations of 1971/72 and the two surveys of 1973. However, both distribution charts are presented in this report since evidence from the Texel laboratory suggests that the phenomenon may be real and related to differences in

the amount of suspended material in the water between the surveys. The values of total mercury were relatively low over the whole area, with no obvious gradients across coastal regions. The METEOR data have been combined with the Belgian values because of their compatibility. A very recent survey by the Lowestoft laboratories (September 1973) has indicated total mercury values of approximately  $0.01 \mu\text{g/l}$  over a large area of the southern North Sea. Such low levels may have resulted from the removal of dissolved mercury on to particulate material in this relatively highly turbid area, coupled with the use of  $0.22 \mu\text{m}$  membrane used for filtration. Total mercury in unfiltered water from the north-east corner of the North Sea has been measured by Topping and Pirie (1972) at the Department of Agriculture and Fisheries for Scotland's laboratory at Aberdeen. Their technique was based on concentrating the metal in an acid permanganate solution followed by a cold vapour measurement. Their range of values lay within  $< 0.010$  to  $0.055 \mu\text{g Hg/l}$  and are therefore in good agreement with the METEOR samples from the same area. One may thus infer that the amount of particulate mercury in the water of this region is small.

UK values of "dissolved" lead in the North Sea are sparse, and the problem of contamination during sample collection and analysis is very severe. The results of four samples collected in the western area of the northern North Sea ranged from  $< 0.05$  to  $0.8 \mu\text{g Pb/l}$ . The Lowestoft laboratories have also measured "dissolved" cobalt in the north-western North Sea and have obtained values ranging between  $0.007$  and  $0.025 \mu\text{g/l}$ . Bevan (personal communication) has measured cobalt regularly throughout a year in the Thames Estuary, using a neutron activation technique, and has recorded values between  $0.022$  and  $0.133 \mu\text{g/l}$ .

Comparisons between the levels of metal measured in the North Sea during the above surveys and values from other sea areas must be made with care because of the factors discussed above. However, selected metals were measured in the Irish Sea by Preston *et al.* (1972) using a similar technique to the one employed above. There is evidence that the general level of trace metal in the Irish Sea was higher than in the North Sea.

#### Belgian surveys

Figure 16 depicts the station grid of the Belgian CIPS sampling positions. After collection and filtration, the filtrates were stored deep-frozen until analysis. Most analyses were made by anodic stripping

(AS), but some samples were analysed by graphite furnace atomic absorption (AA) after concentration of the metal by chelex 100 ion exchange resin.

The range of values (in  $\mu\text{g/l}$ ) found were as follows:

Cadmium	1971	0.05- 0.56
	1972	0.09- 1.01
Copper	1971	0.61-10.43
	1972	2.6 -34.3
	"	0.4 -15.2*
Lead	1971	0.58- 6.21
	1972(a)	0.50-17.6
	" (b)	4.09-21.15
	" (c)	0.22-12.28*
Zinc	1971	0.2 -21.8
	1972	1.03-78.6

All the values given above refer to samples filtered through membranes of pore size  $0.8 \mu\text{m}$ , except for those marked with an asterisk which refer to samples filtered through membranes of pore size  $0.22 \mu\text{m}$ . In general the higher values were observed in the coastal zone and the lower values towards the centre of the Southern Bight.

The Belgian values of copper and zinc were generally higher than those reported by the UK. However, the cadmium values for 1971 were similar to those reported by the UK for 1971, although the Belgian values for the following year were lower than the UK value for 1972. The Belgian figures for lead were generally higher than those reported by the UK. However, the latter are from a different area and are too few in number to make a viable comparison. When comparing the Belgian and UK data as a whole it must be remembered that the former investigation contains a much higher proportion of inshore stations than the latter survey. One may therefore expect this feature to be reflected in a comparison of the ranges of values for each metal. However, the Belgian data do give positive evidence of the influence of membrane pore size on the "dissolved" metal content of filtered sea water. The copper and lead content of samples filtered through  $0.22 \mu\text{m}$  membranes gave generally lower values than those filtered through a  $0.8 \mu\text{m}$  pore size. Occasionally, abnormally high values were recorded during the Belgian investigation. The possible association of these high values with waste dumping grounds cannot be overlooked.



### Netherlands surveys

The Texel laboratory has measured "dissolved" copper and zinc during September-October 1973 on five sections in the southern North Sea normal to the Continental coast between the Straits of Dover and Ymuiden (Figure 17). Samples were filtered through a 0.45  $\mu$ m membrane and analysed for "dissolved" copper and zinc by atomic absorption after an APDC/MIBK extraction. The higher values were observed in the coastal zone and the range of values along each section was as follows:

Section	$\mu$ g/l	
	Copper	Zinc
1	1-5	4-14
2	2-6	6-24
3	2-6	8-19
4	2-6.5	7-23
5	3-7.2	8-26

A comparison of these data with the distribution of copper and zinc measured by the UK surveys (Figures 12a and 13a respectively) shows the range of the Netherlands values to be greater than the UK values for that part of the North Sea common to both surveys. A comparison of the Netherlands results with those of the Belgian investigation shows the range of Belgian values for copper to be greater than those recorded by the Netherlands. The difference in range of zinc values between the two investigations is not so marked. The maximum zinc values from the Belgian survey of 1971 were similar to those of the Netherlands investigation, but the minimum values of the latter were higher than those recorded on the Belgian survey. However, the range of zinc values measured during the Belgian investigation of 1972 was greater than the range recorded during the Netherlands survey.

The data for copper and zinc from the Netherlands investigation generally show values falling between the levels recorded by Belgium and the UK in that region common to all three surveys. The relevance of this feature to the pore size of the membrane used for filtration has already been discussed above.

### GENERAL CONCLUSIONS

All three sets of data show similar trends in that the highest "dissolved" metal levels were generally found close inshore. There remains a need, however, for further investigation into the influence of membrane

pore size on the apparent "dissolved" metal content of filtered water. The complete set of results from the intercalibration exercise between Belgium, the Netherlands and the UK is not yet available, but already a need for further such tests is apparent. This exercise will therefore be continued and expanded during 1974, involving tests of different analytical methods in addition to studies with filter membranes of varying pore size. There is also an urgent need for basic investigations into the nature of the partition of metals between the soluble and particulate phases in sea water in order to evaluate both the fate of metals discharged into the marine environment and the cycle of naturally occurring metals in unpolluted water.

## 5 FUTURE WORK

The aims of the base-line studies have been to show the present level of certain substances in fish, shellfish and sea water in relation to the assessment of the inputs of various pollutants and as a basis for future monitoring. In concentrating on the levels of persistent, toxic substances in fish and shellfish, attention has been focussed upon the most pressing need, namely to establish the levels of pollutants in fish and shellfish so that the possible hazard to human health through their consumption can be established.\* These studies, together with the surveys of trace metals in the water and the sediments, allows the patterns of these various substances to be seen in relation to the life histories of commercial fish species in that the levels in spawning and nursery areas and on feeding grounds have been established. Armed with this knowledge it is possible to proceed to studies designed to see to what extent, if any, pollutants are affecting the abundance of the North Sea fish stocks.

It appears from the Base-Line Survey of fish and shellfish, and this is supported by the studies of "dissolved" metals in sea water, that the coastal areas, for example in the southern North Sea, are those most likely to be affected by pollution. The nursery grounds of certain important commercial species of fish and shellfish are generally found in the coastal areas and so there is a requirement for continued monitoring of them and an urgent need for an increased amount of laboratory and field work on the lethal and sub-lethal effects of the conditions found within them on the eggs, larvae and young stages of the fish and shellfish. Studies of the biological significance of pollutant levels in fish and shellfish should be encouraged and they should include studies of all aspects of biological significance in the marine environment. They should embrace studies which involve not only whole organisms but also the physiological processes and individual organs, over both long- and short-term exposures to high and low concentrations, and the chemical and biological degradation of pollutants.

There is also need to establish the respective roles of the load of organochlorine pesticide residues, PCBs and trace metals, on the one hand, and of the nutrient levels and suspended matter on the other, with regard to the level of primary production in these coastal zones. Two groups of

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\* As agreed at the meeting of the WHO (Regional Office for Europe) Working Group on the Hazards to Health and Ecological Effects of Pollution of the North Sea held in Bilthoven on 6-8 December 1972, this report will be submitted to the World Health Organization.

experts are at present examining the situation with regard to nutrients, suspended matter, organic material and primary production in the southern North Sea and Skagerak-Kattegat respectively and, depending upon their reports, further work on phosphorus and nitrogen budgets will need to be put in train.

The study of the rates of input of pollutants could be improved by the conduct of more analytical work of sewages and harbour dredgings and by the promotion of multidisciplinary studies designed to assess the flux of pollutants to the North Sea from estuaries, fjords, deltas and river mouths, as well as from the Baltic, under a variety of meteorological and hydrological conditions. There is also a need to acquire much more complete information concerning the nature and quantity of the wastes discharged by industry. Although there have in the past been problems of confidentiality regarding industrial wastes, this does not apply to all countries, and to some extent can be overcome by avoiding reference to single industries; it is probable that most countries would be prepared to publish information provided it could be done on a comparable basis.\* The work to date on the transfer of substances from the atmosphere to the sea has shown this to be a possible major pathway whereby pollutants enter the North Sea and more work is required in order to establish the rates of transfer of organochlorine pesticides, PCBs and metals as accurately as possible.

The Base-Line Survey of fish and shellfish and the work on "dissolved" metals in sea water have both shown the need for more intercalibrations of sampling and analytical methods in these fields, and for basic investigations into the nature and quantification of the partition of substances between different compartments, not only in the fish itself and in the water column, but throughout the ecosystem.

There are obvious gaps in the study to date. For example, the state of the plankton and the seabed sediments has not been included, although a number of national studies are under way in different areas. Some coordination of these is required. Again, a number of chemical compounds, such as low molecular weight organochlorine solvents, polynuclear aromatic hydrocarbons resulting, for example, from the use of Soderberg electrodes, organic wastes from the petrochemical industry and from petroleum cracking

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\* In the future such information could probably best be obtained through various Intergovernmental Commissions such as that established by the Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft.

processes, and polychlorinated terphenyls leak into the environment and are discharged to the sea. Base-line surveys to assess the distribution of these substances are required.

Attention should be paid to the use of indicator species in different types of marine ecosystem as warning signs of pollution, e.g. the use of coliforms as indicators of the presence of pathogenic bacteria and viruses of sewage origin in the North Sea, although again there are some national research programmes in this field.

Continued monitoring of toxic substances in fish and shellfish and in some parts of the marine ecosystem will be required, but it is important to keep the efforts and resources deployed on this activity in balance with those required for programmes of fundamental research. Some basic work is still needed in order to establish what influence such factors as age and spawning may have on residue levels and also to determine the mode of uptake and the main storage organs. Appropriate national monitoring programmes should be coordinated by the Council, and an attempt at rationalization should be made in order to close any gaps which exist and to avoid unnecessary overlapping.

Further hydrographic work is required. The Council's Hydrography Committee, as stated in the Introduction, has already undertaken a number of large-scale studies relevant to North Sea pollution problems and it is at present considering how to tackle the study of river inputs to the North Sea. There is, however, a need for a more detailed knowledge of the current systems of the North Sea and of the rates of exchange across its northern and southern boundaries and through the transition zone between the North Sea and the Baltic. An up-to-date and accurate water budget for the North Sea is also essential in order that flushing rates can be established.

Certain activities, e.g. incineration of wastes, have gained importance over the last three years and may now introduce significant quantities of pollutants to the North Sea; future studies will have to take these sources into account. In particular, since the ICES Study of the Pollution of the North Sea started there have been remarkable discoveries of oil and gas reserves which will give rise to a major production industry and may increase the risk of oil pollution of the North Sea. The effects of this on the living resources and their exploitation will have to be studied. Initial steps in this direction have been taken in Norway and the United Kingdom within the framework of the present ICES study, and it is to be hoped that other countries will strengthen their research facilities in this direction and participate.

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Tables 1 and 2 Key to area codes for each country

Country	Code	Full description
NORWAY	N1	West coast
	N2	South coast
	N3	Oslofjord
SWEDEN	S1	Mouth of the River Earningsälven-mouth of the River Örekilsälven
	S2	Mouth of the River Örekilsälven-Nordre Älv
	S3	Nordre Älv-mouth of the River Göta Älv
	S4	Mouth of the River Göta Älv-north of the River Ätran
	S5	North of the River Ätran-west of Halmstad
	S6	West of Halmstad-Kullen
DENMARK	D1	From Skagen to the Limfjord
	D2	From the Limfjord to Blavandshuk
	D3	From Blavandshuk to the German border
GERMANY	G1	Niedersachsen (coast west of the River Elbe)
	G2	Schleswig-Holstein (coast north of the River Elbe)
	G3	Hamburg
	G4	Bremen
	G5	Bremerhaven
NETHERLANDS	NL1	North coast of the Netherlands, Texel to German border
	NL2	Netherlands coast excluding NL1, including Rotterdam and the Hague
	NL3	Netherlands coast bordering Schelde Estuary
	R. Rhine	Discharges from R. Rhine
BELGIUM	B1	From Dunkirk to the Netherlands border
FRANCE	F1	From Boulogne to the Belgian border
ENGLAND	E1	Scotland/England border - River Tyne
	E2	River Tyne
	E3	River Wear
	E4	River Wear to River Tees
	E5	River Tees
	E6	River Tees to Flamborough Head
	E7	Flamborough Head to Humber (including North Bank)
	E8	Humber (including South Bank) to the Wash (Gibraltar Point)
	E9	The Wash (Gibraltar Point to Hunstanton)
	E10	Hunstanton to River Colne
	E11	River Colne to River Thames
	E12	River Thames
	E13	Kent coast to Hastings
SCOTLAND	Sc1	Scottish east coast from Wick to the border with England

Footnotes to Table 1

NOTE: \* Indicates estimates made by the Questionnaire Coordinator, with the approval of the Working Group (see text), based on extrapolations from other data provided in the replies to the Inputs Questionnaire.

Under Question 6, no information was received for "chlorinated aliphatics" or "others", and these are therefore omitted from this table.

**BELGIUM**

It is assumed that indirect discharges are excluded from the totals. Indirect discharges take place at:

Nieuwpoort: Yser, canal Duinkerke-Nieuwpoort, canal Plassendaal-Nieuwpoort;

Oostende: canal Brugge-Oostende, canal Noordhede;

Blankenberge: Blankenberge canal;

Zeebrugge: canal Brugge-Zeebrugge (industrial waste water of Zeebrugge);

Heyst: canal derivation Lys, canal Leopold.

The area from which these discharges originate is approximately limited by the following places: Lille, Armentières, Menen, Kortrijk, Deinze, Assenede, part of Gent and includes the basin of the River Yser as well as part of Duinkerke.

There is a difference between summer and winter seasons. During the former a larger proportion of the waters of the Deule-Lys are directed to the sea than to the River Scheldt.

No estimates of the amount of pollutants which are transported can be made at present.

In the following comments the number at the left refers to the column marked with that number

(1) NORWAY (N3) Estimated releases to rivers, estuaries and fjords. No information on what amounts reach open waters.

\*SWEDEN (all areas) Estimated on the assumption that water use per person is the same as for Norway.

\*GERMANY (G2) Estimated on the basis of discharge for remaining areas of Germany.

GERMANY (G3) Municipal sewage system only.

GERMANY (G4) Domestic sewage from municipal system only.

GERMANY Ems, Weber and Elbe are river systems (estimated).

\*NETHERLANDS (all areas) Estimated on the basis of figures given for population and discharge for the Hague.

\*BELGIUM (B1) Average calculated from an estimated DWF of 60 000 m<sup>3</sup>/day for June-August and an estimated 20 000 m<sup>3</sup>/day for the remaining months.

ENGLAND Totals include all flows to estuaries by direct discharge.

- (2) BELGIUM (B1) In June-August the population is 1.1 million.  
ENGLAND Includes population around estuaries, e.g. Greater London area.
- (3) NORWAY (N3) Estimated proportion.
- (4) NORWAY (N3) Estimated proportion.
- (5) GERMANY (G2) This percentage is not directly comparable with those quoted for the other areas. However, it refers to the relative proportion after treatment. (This footnote applies to the other percentages given under Question 5 for area G2.)  
\*BELGIUM (B1) Average calculated from 80% for June-August and 95% for each other month.
- (6) \*BELGIUM (B1) Average calculated from 20% for June-August and 5% for each other month.
- (7) NORWAY (N3) Estimated at 60 g/person/day for raw sewage.  
SWEDEN (all areas) BOD is 7-day (70 g/person/day) for raw sewage.  
DENMARK (all areas) Estimated, no base given.  
GERMANY (G2) Estimated for domestic waste water which reaches the North Sea from the coastal area of Schleswig-Holstein. No base given.  
NETHERLANDS (all areas) Based on 54 g/person/day.  
BELGIUM (B1) Estimated, no base given.  
FRANCE (F1) Estimated, no base given.  
ENGLAND (all areas) Based on 70 g/person/day, reducing with treatment.  
SCOTLAND (Sc1) Estimate of domestic component only, no base given.
- (8) NETHERLANDS (all areas) Ratio COD = 2.5 x BOD.  
BELGIUM (B1) Estimated Ratio COD = 2.0 x BOD.  
FRANCE (F1) Estimated Ratio COD = 1.5 x BOD.

\*Figures for all countries except Belgium and the Netherlands have been calculated using the ratio of COD to BOD in the figures for France.

- (9) NORWAY (N3) Estimated at 12 gN/person/day.  
SWEDEN. Estimated from direct measurements of total N concentration in river mouths and by assuming that discharge is 13 g/person/day in areas lying between the rivers.  
NETHERLANDS (all areas) 10g/person/day.  
BELGIUM (B1) Estimated, no base given.  
\*Figures for Denmark, Germany (G2 only), France and Scotland were not given in replies to the questionnaire and were calculated as for England, using the following:

N<sub>2</sub> based on 56 mg/l raw,  
30 mg/l settled,  
20 mg/l biological treatment.

- (10) NORWAY (N3) Estimated at 2.5 gP/person/day.

SWEDEN. Estimated from direct measurements of total P concentration in river mouths and by assuming that discharge is 4 g/person/day in areas lying between the rivers.

NETHERLANDS (all areas) 3 g/person/day.

BELGIUM (B1) Estimated, no base given.

\*Figures for Denmark, Germany (G2 only), France and Scotland were not given in replies to the questionnaire and were calculated as for England, using the following:

P based on 8.9 mg/l raw,  
5.8 mg/l settled,  
4.5 mg/l biological treatment.

- (11) \*All figures were calculated as for England, using the figure of 245 ng/l DWF derived from several analyses of sewage in England.
- (12) \*All figures were calculated using the English ratio of PCB content to organochlorine, i.e. PCB = 10 x organochlorine.
- (13) \*Swedish figures were used to average tonnes/year/1 000 head of population for Zn (0.857), Mn (1.990) and Cu (0.130). Estimates for Norway (N1 and N2), Denmark, Germany (except Niedersachsen), the Netherlands, Belgium, France, England and Scotland were made using these figures.



Table 1 ICES Working Group on Pollution of the North Sea

Answers to Section A of questionnaire to determine sources of input of sewage to the North Sea: NI = no information

Question 1	Question 2	Question 3	Question 4		Question 5			
Country and area	DWF ('000 m <sup>3</sup> /day)	Population ('000)	Proportion		Treatment			
			Domestic sewage (%)	Industrial waste (%)	Untreated (%)	Settled only (%)	Settled and biological (%)	Additional (%)
	(1)	(2)	(3)	(4)	(5)		(6)	
<b>NORWAY</b>								
N1	184	738	100	0	100	0	0	0
N2	68	271	100	0	100	0	0	0
N3	650	1 300	50	50	64	14	18	4
Total	902	2 309	64	36	74	10	13	3
<b>SWEDEN</b>								
S1	11	28			29	50	21	0
S2	3	8			18	24	58	0
S3	263	675			70	6	13	11
S4	63	161			6	3	89	1
S5	12	31			6	47	44	3
S6	89	227			5	34	54	5
Total	441	1 130	65	35	45	14	33	8
<b>DENMARK</b>								
D1	24	80	80	20	45	40	15	0
D2	70	220	60	40	45	25	30	0
D3	74	300	65	35	40	40	20	0
Total	168	600	65	35	43	34	23	0

Table 1 continued

Question 1	Question 2	Question 3	Question 4		Question 5			
Country and area	DWF ('000 m <sup>3</sup> /day)	Population ('000)	Proportion		Treatment			
			Domestic sewage (%)	Industrial waste (%)	Untreated (%)	Settled only (%)	Settled and biological (%)	Additional (%)
	(1)	(2)	(3)	(4)	(5)		(6)	
GERMANY								
G1	NI	NI	NI	NI	NI	NI	NI	NI
G2	113	300	95	5	0	43	54	3
G3	362	1 850	-	-	25	60	15	0
G4	575	600	17	83	10	90	0	0
G5	36	142	80	20	100	0	0	0
Total (excl. G1)	1 086	2 892						
NETHERLANDS								
NL1	69	315	95	5	100	0	0	0
NL2	381	1 750	62	38	67	33	0	0
NL3	28	130	60	40	100	0	0	0
Total	478	2 195	65	35	75	25	0	0
BELGIUM								
B1	30	250	90	10	90	0	10	0
FRANCE								
F1	180	600	70	30	40	0	60	0

Table 1 continued

Question 1	Question 2	Question 3	Question 4		Question 5			
Country and area	DWF ('000 m <sup>3</sup> /day)	Population ('000)	Proportion		Treatment			
			Domestic sewage (%)	Industrial waste (%)	Untreated (%)	Settled only (%)	Settled and biological (%)	Additional (%)
	(1)	(2)	(3)	(4)	(5)		(6)	
<b>ENGLAND</b>								
E1	24	178	80	20	80	10	10	0
E2	195	1 075	60	40	100	0	0	0
E3	32	200	70	30	85	0	15	0
E4	43	272	50	50	90	5	5	0
E5	68	430	70	30	100	0	0	0
E6	32	116	80	20	95	5	0	0
E7	155	850	60	40	99	1	0	0
E8	89	557	70	30	93	5	2	0
E9	36	267	80	20	95	5	0	0
E10	45	333	80	20	90	5	5	0
E11	59	372	70	30	10	10	75	5
E12	2 545	14 000	60	40	10	20	70	0
E13	114	714	70	30	90	5	5	0
Total	3 437	19 364	62	38	31	16	54	0
<b>SCOTLAND</b>								
Sc1	623	1 640	60	40	92	3	5	0
Grand total	7 345	30 979						

Table 1 continued

Question 1	Question 6									
Country and area	Input (tonnes/year) of				Input (kg/year) of		Input (tonnes/year) of			
	BOD	COD	N	P	Organochlorine pesticides	PCBs	Metals			
	(7)	(8)	(9)	(10)	(11)	(12)	(13)			
NORWAY										
N1	16 000	24 000	3 200	670	16.5	165	Zn	633	Mn	1 469
							Cu	96		
N2	6 000	9 000	1 200	250	6.1	61	Zn	232	Mn	539
							Cu	35		
N3	27 000	40 500	5 475	1 180	58.1	581	Zn	50	Mn	2 587
							Cu	50	Cr	25
Total	49 000	73 500	9 875	2 100	80.7	807	Zn	915	Mn	4 595
							Cu	181	Cr	25
SWEDEN										
S1	4 060	6 100	812	128	1.0	10	Zn	26	Mn	100
							Cu	5		
S2	1 000	1 500	312	90	0.3	3	Zn	55	Mn	1
S3	53 453	80 200	9 167	889	23.4	234	Zn	585	Mn	1 024
							Cu	96		
S4	4 518	6 800	1 280	174	5.6	56	Zn	56	Mn	175
							Cu	12		
S5	3 802	5 700	1 100	104	1.1	11	Zn	34	Mn	183
							Cu	5		
S6	20 648	31 000	3 618	379	7.9	79	Zn	101	Mn	502
							Cu	12		
Total	87 481	131 300	16 289	1 764	39.3	393	Zn	856	Mn	1 985
							Cu	130		

Table 1 continued

Question 1	Question 6									
Country and area	Input (tonnes/year) of				Input (kg/year) of		Input (tonnes/year) of			
	BOD	COD	N	P	Organochlorine pesticides	PCBs	Metals			
	(7)	(8)	(9)	(10)	(11)	(12)	(13)			
DENMARK										
D1	2 000	3 000	352	61	2.1	21	Zn	69	Mn	159
							Cu	10		
D2	5 000	7 500	989	174	6.3	63	Zn	188	Mn	438
							Cu	29		
D3	5 500	7 800	1 037	183	6.6	66	Zn	257	Mn	597
							Cu	39		
Total	12 500	18 300	2 378	418	15.0	150	Zn	514	Mn	1 194
							Cu	78		
GERMANY										
G1	NI	NI	NI	NI	NI	NI	NI			
G2	825	1 238	977	202	10.1	101	Zn	257	Mn	597
							Cu	39		
G3	}	See below for estimated river transport			32.3	323	Zn	1 586	Mn	3 681
							Cu	241		
G4					51.4	514	Zn	514	Mn	1 194
							Cu	78		
G5					3.2	32	Zn	121	Mn	283
							Cu	18		
Elms	3 400	5 100	10 000	1 000						
Weser	40 000	60 000	30 000	3 500						
Elbe	22 000	33 000	50 000	9 000						
Total	66 225	99 338	90 977	13 702	97.0	970	Zn	2 478	Mn	5 755
							Cu	376		

Table 1 continued

Question 1	Question 6									
Country and area	Input (tonnes/year) of				Input (kg/year) of		Input (tonnes/year) of			
	BOD	COD	N	P	Organochlorine pesticides	PCBs	Metals			
	(7)	(8)	(9)	(10)	(11)	(12)	(13)			
NETHERLANDS										
NL1	6 200	15 500	1 140	345	6.2	62	Zn	270	Mn	627
							Cu	41		
NL2	65 000	147 500	18 700	7 050	34.0	340	Zn	1 500	Mn	3 483
							Cu	228		
NL3	4 000	10 000	3 000	650	2.5	25	Zn	111	Mn	259
							Cu	17		
Total	75 200	173 000	22 840	8 045	42.7	427	Zn	1 881	Mn	4 369
							Cu	286		
-----										
BELGIUM										
B1	7 500	15 000	1 600	160	2.7	27	Zn	214	Mn	498
							Cu	33		
-----										
FRANCE										
F1	760	1 140	2 260	411	16.1	161	Zn	514	Mn	1 194
							Cu	78		



Table 1 continued

Question 1	Question 6									
Country and area	Input (tonnes/year) of				Input (kg/year) of		Input (tonnes/year) of			
	BOD	COD	N	P	Organochlorine pesticides	PCBs	Metals			
	(7)	(8)	(9)	(10)	(11)	(12)	(13)			
ENGLAND										
E1	3 044	4 566	442	72	2.2	22	Zn	153	Mn	354
							Cu	23		
E2	28 533	42 799	3 995	635	17.5	175	Zn	921	Mn	2 139
							Cu	140		
E3	4 000	6 000	588	96	2.8	28	Zn	171	Mn	398
							Cu	26		
E4	5 854	8 781	834	134	3.9	39	Zn	233	Mn	541
							Cu	35		
E5	9 953	14 929	1 393	221	6.1	61	Zn	369	Mn	856
							Cu	60		
E6	4 529	6 793	635	101	2.8	28	Zn	99	Mn	231
							Cu	15		
E7	22 448	33 672	3 144	500	13.8	138	Zn	728	Mn	1 692
							Cu	111		
E8	12 377	18 565	1 546	280	7.9	79	Zn	477	Mn	1 108
							Cu	72		
E9	5 176	7 764	726	116	3.2	32	Zn	229	Mn	531
							Cu	35		
E10	6 163	9 244	878	141	4.1	41	Zn	285	Mn	663
							Cu	43		
E11	1 779	2 668	509	104	5.3	53	Zn	319	Mn	740
							Cu	49		
E12	93 821	140 731	23 781	4 830	227.6	2 276	Zn	11 998	Mn	27 860
							Cu	1 820	Hg	8
E13	15 407	23 110	2 194	354	10.2	102	Zn	612	Mn	1 421
							Cu	93		
Total	213 074	319 622	40 665	7 584	307.4	3 074	Zn	16 594	Mn	38 534
							Cu	2 512	Hg	8

Table 1 continued

Question 1	Question 6						
Country and area	Input (tonnes/year) of				Input (kg/year) of		Input (tonnes/year) of
	BOD	COD	N	P	Organochlorine pesticides	PCBs	Metals
	(7)	(8)	(9)	(10)	(11)	(12)	(13)
SCOTLAND							
Sc1	34 000	51 000	12 147	1 953	55.7	557	Zn 1 405 Cu 213
Grand total	545 740	882 200	199 031	36 138	656.6	6 566	Zn 25 371 Cu 3 887 Mn 61 388 Cr 25* Hg 8*

\* = very incomplete figure.

Table 1 continued

Question 1	Question 7	Question 8
Country and area	Main industry type	Main industrial waste
<hr/>		
NORWAY		
N1	NI	NI
N2	NI	NI
N3	Food and dairy; galvano industry	Organics; metals
<hr/>		
SWEDEN		
S1	} Paper; car manufacture; fish; dairy and meat; hospitals and scientific institutes; breweries	} NI
S2		
S3		
S4		
S5		
S6		
<hr/>		
DENMARK		
D1	} Dairies; bacon factories; slaughterhouses	} Organic matter
D2		
D3		

Table 1 continued

Question 1	Question 7	Question 8
Country and area	Main industry type	Main industrial waste
<b>GERMANY</b>		
G1	NI	NI
G2	}Grocery and foodstuff; papermill; }oil refinery	}NI
G3	}Mechanical engineering; shipyard; }chemical; hospitals; breweries; }mineral oil refineries	}NI
G4	}Iron smelting; shipyards; }refineries; wool washing; }breweries; hospitals; machine }manufacturing	}NI
G5	Fish processing	NI
<b>NETHERLANDS</b>		
NL1	Very little	NI
NL2	Agriculture and processing	Organics of agricultural origin
NL3	}Fertilizer and sugar beet }processing	Organics of agricultural origin
<b>BELGIUM</b>		
B1	Superphosphates, phthalates	}Phosphates; sulphates; nitrates; }waste from slaughterhouses, }fishing industries, photographic }waste
<b>FRANCE</b>		
F1	Food industries	NI

Table 1 continued

Question 1	Question 7	Question 8
Country and area	Main industry type	Main industrial waste
<b>ENGLAND</b>		
E1	Mixed light industry	NI
E2	Engineering/shipbuilding	Metals
E3	Engineering/chemical	Metals
E4	Mixed light industry	NI
E5	Engineering	Metals
E6	Mixed light industry	NI
E7	}Mixed industry including fish }processing	}High BOD
E8	}Mixed industry including fish }processing	}High BOD
E9	Food processing and chemicals	High BOD
E10	Mixed light industry	NI
E11	Mixed light industry	NI
E12	Mixed industry	NI
E13	}Mixed industry including chemicals }and paper	}NI
<b>SCOTLAND</b>		
Sc1	}Paper and chemical; brewing and }distilling; textile and linoleum; }engineering; dyeing; food }processing and general }manufacturing	}NI

Footnotes to Table 2 (the footnotes refer to Question 4 only)

BOD

SWEDEN (all areas) BOD is a 7-day figure. In addition to total discharge of BOD there were discharges of nitrogen (0.6 tonnes/day) and phosphorus (0.2 tonnes/day).

MINERALS

ENGLAND (E1) Discharges on beach.

ENGLAND (E4) Discharges on beach.

SCOTLAND (Sc1) Calcium sulphate slurry (gypsum).

PESTICIDES

No country provided information.

PCBs

No country provided information.

METALS

SWEDEN (all areas) Metal figures are very incomplete but wherever measurements were available these have been included. Estimates based on usage were not used due to high measure of uncertainty on loss rates.

ENGLAND (E5) Total heavy metals.

CHLORINATED ALIPHATICS

Only Norway provided information.

NORWAY (N2) 0.6 tonnes/day from a PVC factory. (This factory closed on 8 February 1971.)



Table 2 ICES Working Group on Pollution of the North Sea

Answers to Section B of questionnaire to determine sources of input of industrial waste to the North Sea: NI = no information

Question 1	Question 2	Question 3	Question 4				
Country and area	Total flow ('000 m <sup>3</sup> /day)	Main industries producing waste and flow ('000 m <sup>3</sup> /day)	Total discharge of industrial wastes				
			BOD (tonnes/day)	COD	Minerals	Metals (tonnes/year)	Others (tonnes/year)
NORWAY							
N1	500	Aluminium 280 Iron and steel } Chemical industry } 220	4	NI	NI	Fe 8 395 Zn 2 190 Al 1 278 Cu 110 As 33 Pb 1 643 Ni 37 Mn 55 Ag 11 Cd 11 Hg 1 Co 2 Cr 73	Fluoride 1 825
N2	250	Pulp paper 250 Iron and steel plating Chemical industry (fertilizers, Mg, Cl <sub>2</sub> , PVC)	NI	NI	NI	Fe 815 Zn 49 Cu 33 Cr 1 Hg <1	Fluoride 340
N3	1 031	Pulp paper 1 000 Primary iron and steel works 25 Chemical industry Plating industry 6 1 781	214	NI	Negl.	Fe 4 180 Zn 60 Cu 94 Cr 23 Ni 4 Cd <1	NI

Table 2 continued

Question 1	Question 2	Question 3	Question 4				
Country and area	Total flow ('000 m <sup>3</sup> /day)	Main industries producing waste and flow ('000 m <sup>3</sup> /day)	Total discharge of industrial wastes				
			BOD (tonnes/day)	COD (tonnes/day)	Minerals (tonnes/day)	Metals (tonnes/year)	Others (tonnes/year)
SWEDEN							
All areas	265	Fish processing 15	60			Zn 21*	Nitrogen 219
		Pulp paper 200				Cu 2*	Phosphorus 73
		Petrochemical and bulk chemicals 30					
		Metal plating 2					
		Shipbuilding and engineering 15					
		262					
<hr/>							
DENMARK		Most factories discharge to combined sewage systems, but the following industries produce waste:					
D1	NI	Mixed industries					
D2	NI	Pesticides manufacture					
		Lignite mining (ferric waste)					
		Waste pond for the drug and pesticides factory					
		Mixed industries					
D3	NI	Drug and pesticides manufacture (Mercury waste)					
		Mixed industries					

\* = very incomplete figure.

Table 2 continued

Question 1	Question 2	Question 3	Question 4					
Country and area	Total flow ('000 m <sup>3</sup> /day)	Main industries producing waste and flow ('000 m <sup>3</sup> /day)	Total discharge of industrial wastes					
			BOD (tonnes/day)	COD	Minerals	Metals (tonnes/year)	Others (tonnes/year)	
GERMANY All areas	NI	Iron and steel Chemicals Oil refineries Textiles Metal refineries	For Bremen only			1 000 tonnes/year of substances into River Weser of which Fe 500 Cr <1	Cyanides	10
<hr/>								
BELGIUM	No industrial wastes are discharged directly							
<hr/>								
NETHERLANDS								
NL1	NI	Potato starch Food industry Petrochemicals	357	NI	66 Plaster	Hg 2 Zn 115	Brine	20 x 10 <sup>3</sup>
NL2	NI	Iron and steel Bulk chemicals Petrochemicals Paper and pulp Pesticides Oil refineries	NI	NI	NI	Cr 100 Zn 900 Fe 11 000	NI	
NL3	NI	Petrochemicals	NI	NI	NI	NI	NI	
River Rhine	NI	NI	NI	NI	NI	Hg 50- 100 Pb 1 000- 1 500 Cu 1 000- 1 500 Zn 8 000-12 000 Cd 50- 100		

Table 2 continued

Question 1	Question 2	Question 3	Question 4				
Country and area	Total flow ('000 m <sup>3</sup> /day)	Main industries producing waste and flow ('000 m <sup>3</sup> /day)	Total discharge of industrial wastes				
			BOD (tonnes/day)	COD (tonnes/day)	Minerals (tonnes/day)	Metals (tonnes/year)	Others (tonnes/year)
FRANCE	92	Paper pulp 75 Iron and steel 12 Refineries 5 Titanium dioxide manufacture — 92	100	NI	NI		Sulphuric acid 66 x 10 <sup>3</sup> Ferrous sulphate 29 x 10 <sup>3</sup> Organic matter 37 x 10 <sup>3</sup>
-----							
ENGLAND							
E1	2	Pharmaceutical/drug Aluminium smelter	NI	NI	4 100 Coal waste	NI	NI
E2	159	Engineering Shipbuilding Chemicals	NI	NI	3 400 Coal washings	NI	NI
E3	13	Engineering Shipbuilding Chemicals Steel	NI	NI	NI	NI	NI
E4	228	Extraction magnesium from sea water	NI	NI	6 850 Coal waste	NI	Magnesium hydroxide 248 x 10 <sup>3</sup>

Table 2 continued

Question 1	Question 2	Question 3	Question 4					
Country and area	Total flow ('000 m <sup>3</sup> /day)	Main industries producing waste and flow ('000 m <sup>3</sup> /day)	Total discharge of industrial wastes					
			BOD (tonnes/day)	COD	Minerals	Metals (tonnes/year)	Others (tonnes/year)	
ENGLAND (contd)								
E5	911	Plastics manufacture Chlorinated alkalis Fertilizers Oil refineries/ petrochemicals Steel Chemicals	220	254	NI	Total heavy metals 3.3	Acids 62 x 10 <sup>3</sup> Phenols 24 x 10 <sup>2</sup> Cyanides 6 x 10 <sup>2</sup>	
E6	9	Steel Malting Vegetable processing	NI	NI	NI	NI	NI	
E7	9	Chemicals Distillery Fish processing	NI	NI	NI	NI	NI	
E8	154	Chemicals Oil refineries Petrochemicals Titanium dioxide production Fish processing	NI	NI	NI	NI	Acid 365 x 10 <sup>3</sup> Iron 131 x 10 <sup>3</sup> Small quantities of pesticides from upstream	
E9	50	Vegetable processing Chemicals	NI	NI	NI	NI	NI	
E10	68	Chemicals Metal finishing Vegetable processing Sugar beet (seasonal)	NI	NI	NI	NI	NI	

Table 2 continued

Question 1	Question 2	Question 3	Question 4				
Country and area	Total flow ('000 m <sup>3</sup> /day)	Main industries producing waste and flow ('000 m <sup>3</sup> /day)	Total discharge of industrial wastes				
			BOD (tonnes/day)	COD	Minerals	Metals (tonnes/year)	Others (tonnes/year)
ENGLAND (contd)							
E11	36	Brewery and malting Vegetable processing Plastics	NI	NI	NI	NI	NI
E12	910	Oil refineries	NI	NI	NI	NI	NI
E13	91	Paper industries	NI	NI	NI	NI	NI
	<u>2 640</u>						
-----							
SCOTLAND							
Sc1	143	Food and drink	29	100-	NI	500	Cu 104
		Other organic effluents	17	500		Gypsum	Zn 99
		Engineering	14				Pb 13
		Chemical effluents	66				Hg 15
		Miscellaneous	17				Cr 73



Table 3 Preliminary estimates of inputs of metals (tonnes/year)  
to the North Sea via aerial deposition\*

Aluminium	$1.5 \times 10^5$	Manganese	$6 \times 10^3$
Arsenic	$1 \times 10^3$	Nickel	$5 \times 10^3$
Cadmium	$2.3 \times 10^2$	Lead	$1.5 \times 10^4$
Chromium	$2 \times 10^3$	Antimony	$5 \times 10^2$
Cobalt	$2.5 \times 10^2$	Zinc	$1 \times 10^5$
Iron	$1.5 \times 10^5$	Copper	$1.3 \times 10^4$

\* Based on assumed average rainfall of 80 cm/year.

Table 4 Dumping activities by countries bordering the North Sea

NORWAY

Only one dumping authorized during the period 1965-70. This is approved for continuation to 1973. The material dumped is sewage sludge and the dumping zone is outside Oslofjord at 59°10'N 10°40'E.

No other dumping operations are planned and the authorities do not know of any unauthorized dumping.

SWEDEN

Since 1 January 1972 no substances potentially dangerous to the environment can be dumped at sea.

During the period 1965-70 dumping in the North Sea/North Atlantic was reported to be as follows:

North Sea	Acid sodium pyrophosphate	21.5 tonnes
	Magnesium silicate	8.5 tonnes
	Polyol	20.0 tonnes
North Sea 58°20'N 9°40'E	Sodium sulphide	2 100 tonnes
North Sea-Atlantic	Sodium hydroxide	32 tonnes
	Inorganic sulphites	43 tonnes
	Chlorinated aliphatic hydrocarbons	3 850 tonnes
Atlantic 62°N 2°E	Chlorinated aliphatic hydrocarbons	675 tonnes

The authorities do not know of any unauthorized dumping. There were no dumpings in 1971 and none are planned.

DENMARK

No dumping activities have been registered with the authorities and they know of no unregistered ones. There were no reported dumping activities in the period 1965-70, and none are planned for the future.

FEDERAL REPUBLIC OF GERMANY

The dumping operations reported by Germany for the period 1965-70 were as follows:

14 miles NW. Helgoland, 1 800 tonnes/day of 10% sulphuric acid;  
14% ferrous sulphate waste from titanium dioxide production.  
This has been in operation since May 1969.

3 miles NE. of Elbe 1 Lightship 210 000-290 000 tonnes/year  
sewage sludge.

Both these dumpings continue at the present time and no changes are planned for the future. No additional dumpings are planned and the authorities do not know of any unauthorized dumpings.

## NETHERLANDS

During the period 1969-71 the following wastes were dumped into the North Sea by ships operating from Dutch ports. The anticipated 1972 values are shown in parentheses:

	Tonnes/year
<u>Wastes from Dutch industries</u>	
Inorganic acids, organic acids and salts	16 000- 40 000 (40 000)
<u>Wastes from German industries</u>	
Acid from titanium dioxide production	420 000-480 000 (810 000)
Other acids, mainly organic	100 000 (300 000)
Alkaline solutions, mainly organic	27 500- 60 000 (50 000)
<u>Wastes from Belgian industries</u>	
Acid from titanium dioxide production	300 000 (300 000)

During 1972, it is expected that 10 000 tonnes of alkaline wastes will be dumped in deep water in the Atlantic. Since July 1972, all dumping from Dutch ports has been subject to legal control. Before that time, some dumping probably took place without the knowledge of the authorities.

It is expected that the current rate of dumping will continue.

## BELGIUM

Dumping activities during the last 5 years are reported as follows:

- 1 Waste from the manufacture of titanium dioxide (factory 1) dumped 51°50'N 3°10'E at the rate of 675 250 tonnes/year. The waste contains 10% average or 15% maximum sulphuric acid and 2-3% average 9% maximum ferrous sulphate.
- 2 Waste from titanium dioxide (factory 2) dumped 51°30'N 3°E (radius 3 miles): 140 000-150 000 tonnes/year, content 27% sulphuric acid, 6% ferrous sulphate.
- 3 Waste from resin production dumped outside territorial waters: 450 tonnes/month containing 1.5% phenol.
- 4 Waste from enzyme manufacture dumped at 51°28'N 3°09'E at the rate of 340 tonnes/week. The waste contains 66% organic matter and 34% diatomaceous earth.
- 5 An unspecified amount of waste ammunition is dumped by the Belgian Army at 51°54'N 3°15'E.

Present approved dumping activities are reported to be confined to wastes 1, 2, 3 and 4 and the area of disposal for waste 2 is now 51°27'09"N 2°59'10"E to 51°34'24"N to 2°59'E.

## FRANCE

Only one dumping operation was reported as being known to the authorities, that of 1 to  $1.5 \times 10^6$  m<sup>3</sup>/year of dredgings from Dunkirk harbour.

No other dumpings are reported as being under planning consideration and the authorities are not aware of any unapproved operation.

## UNITED KINGDOM

Excluding harbour dredgings for which comprehensive details were not available, dumping over the last 5 years in the North Sea area was reported as follows:

- 1 Clay slurry, 1 730 tonnes/year, outer Thames Estuary (Falls).
- 2 Sewage sludge,  $4.3 \times 10^6$ , outer Thames Estuary (Barrow Deep).
- 3 Colliery waste (stone),  $1.5 \times 10^6$  tonnes/year, off north-east England coast.
- 4 Fuel ash from power stations, 765 000 tonnes/year, off north-east England coast.
- 5 Waste from synthetic fibre manufacture, 56 680 tonnes/year, outer Humber Estuary.

Current dumping activities are as reported above with the addition of waste from aluminium manufacture (not red mud) amounting to 1 800 m<sup>3</sup> slurry or 500 tonnes of solids dumped off the Scottish coast annually.

The only reported planned dumping was of up to 45 000 tonnes (dry solids) sewage sludge to be dumped off the Scottish coast from Edinburgh, Aberdeen and Dundee.

Table 5 Summary of the input data in Tables 1-4

Pollutant (tonnes/year)	Source			Atmosphere (preliminary data)
	Domestic	Industry	Dumping	
BOD	546 $\times 10^3$	459 $\times 10^3$	?	?
COD	882 $\times 10^3$	?	?	?
Nitrogen	199 $\times 10^3$	219*	?	?
PO <sub>4</sub> Phosphorus	36 $\times 10^3$	73*	?	?
Organochlorine pesticides	0.66	?	?	?
PCBs	6.56	?	?	?
Zinc	25.4 $\times 10^3$	15.4 $\times 10^3$ *	?	100 $\times 10^3$ †
Copper	3.9 $\times 10^3$	1.84 $\times 10^3$ *	?	13 $\times 10^3$
Manganese	61.4 $\times 10^3$	?	?	6 $\times 10^3$
Lead	?	3.16 $\times 10^3$ *	?	15 $\times 10^3$
Mercury	22	119*	?	?
Cadmium	?	112*	?	2.3 $\times 10^2$
Iron	?	176 $\times 10^3$ *	75 $\times 10^3$ †	150 $\times 10^3$
Acids	-	493 $\times 10^3$ *	225 $\times 10^3$	?
Volume of discharge/rainfall (m <sup>3</sup> /year)	2 680 $\times 10^6$	1 795 $\times 10^6$ *	?	46 000 $\times 10^7$

\* Data very incomplete.

† Titanium dioxide waste only and assumes 10% acid and 10% FeSO<sub>4</sub>.

‡ There is considerable doubt about the validity of this figure.

Table 6A Addresses of the laboratories listed

Number in Table 6B	Address
<u>(i) Participants in Base-Line Survey</u>	
1	The Official Norwegian Quality Control Institute for Canned Fish Products, Stavanger, Norway
2	Environment Protection Board, Research Laboratory, Drottningholm, Sweden
3	Bundesforschungsanstalt für Fischerei Isotopenlaboratorium, Hamburg, Germany
4	Netherlands Institute for Fishery Investigation, IJmuiden, Netherlands
5	Institute for Sea Research, Texel, Netherlands
6	Institut de Recherches Chimique, Tervuren, Belgium
7	Institut Scientifique et Technique des Pêches Maritimes, Nantes, France
8	Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Burnham-on-Crouch, England
9	Department of Agriculture and Fisheries for Scotland, Freshwater Fisheries Laboratory, Pitlochry, Scotland
10	Department of Agriculture and Fisheries for Scotland, Fisheries Laboratory, Aberdeen, Scotland
<u>(ii) Other analysts</u>	
11	Institute of Marine Biology and Limnology, University of Oslo, Oslo, Norway
12	Central Institute for Industrial Research, Oslo, Norway
13	The Veterinary College of Norway, Oslo, Norway
14	Danish Isotope Centre, Copenhagen, Denmark
15	Chemisches Untersuchungsamt, Speyer, Germany
16	University of Liège, Liège, Belgium
17	Department of Pharmacology, Free University, Brussels, Belgium
18	Eidgenössisches Veterinäramt, Berne, Switzerland



Table 6B Results of intercalibration study of fish flour sample

Lab. number (see Table 6A)	Reported concentrations found in mg/kg of sample												
	Hg	Cu	Zn	Cd	Pb	Cr	Mn	Fe	Ni	Sn	Ag	Ti	Co
(i) <u>Participants in Base-Line Survey</u>													
1	0.17	20	75	1.3	1.0	-	-	-	-	-	-	-	-
2	0.09	-	71	2.4	7.1	2.5	-	-	7.8	-	-	-	15
3	-	19	39*	-	-	-	18	520	-	-	-	-	-
4	1.1*	-	-	-	-	-	-	-	-	-	-	-	-
5†	0.09	20	80	3.3	-	-	-	470	-	-	-	-	-
6	0.11	17	80	-	1.9	-	20	-	-	4.0	-	19	-
7	0.17	11	55*	2.5	9.0	4.0	-	-	-	-	-	-	-
8	0.23	17	75	1.3	8.4	4.6	-	-	-	-	-	-	-
9	0.20	20	135*	1.8	12	-	-	-	-	-	-	-	-
10	-	20	66	1.1	5.7	-	-	-	-	-	-	-	-
(ii) <u>Other analysts</u>													
11	-	17	41*	1.0	12	-	-	-	-	-	-	-	-
12	0.20	22	71	<2.0	22	-	-	440	-	-	-	-	-
13	0.17	-	-	-	-	-	-	-	-	-	-	-	-
14	0.22	-	-	-	-	-	-	-	-	-	-	-	-
15	0.78*	20	88	1.2	1.1	-	-	-	-	-	0.13	-	-
16	0.11	-	-	-	-	-	-	-	-	-	-	-	-
17	-	17	74	-	-	-	-	-	-	-	-	-	-
18	0.15	-	60	5.0	3.8	-	-	-	-	-	-	-	-
<hr/>													
(i) Mean	0.15	18	75	2.0	6.4	3.7	19	495	7.8	4.0	-	19	15
s.d.	0.06	3.1	5.4	0.81	3.9								
(i)+ Mean	0.16	18	74	2.1	7.6	3.7	19	477	7.8	4.0	0.13	19	15
(ii) s.d.	0.05	2.8	7.8	1.2	6.2								

\* Omitted in calculating means and standard deviation.

† New results submitted after analysts' meeting.

Table 7A Addresses of the laboratories listed

Number in Table 7B	Address
<u>(i) Participants in Base-Line Survey</u>	
1	Institute of Marine Research, Bergen, Norway
2	Environment Protection Board, Special Analytical Laboratory, Stockholm, Sweden
3	Institut für Küsten und Binnen Fischerei, Hamburg, Germany
4	Institute for Sea Research, Texel, Netherlands
5	Rijksuivelstation, Leiden, Netherlands
6	Station de Phytopharmacie, Gembloux, Belgium
7	Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Burnham-on-Crouch, England
8	Department of Agriculture and Fisheries for Scotland, Freshwater Fisheries Laboratory, Pitlochry, Scotland
<u>(ii) Other analysts</u>	
9	Agricultural College of Norway, Aas, Norway
10	Institute für Tierphysiologie, Munich, Germany
11	Department of Pharmacology, Free University, Brussels, Belgium
12	Ontario Research Foundation, Ontario, Canada

Table 7B Results of intercalibration study of fish oil sample

Lab. number (see Table 7A)	Reported concentrations found in mg/kg of sample						
	Sample 2A (unspiked)						
	BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	PCB
	(i) <u>Participants in Base-Line Survey</u>						
1	-	-	0.37	0.31	0.37	0.16	2.2 <sup>+</sup>
2	<0.01	<0.1	0.51	0.25	0.52	Present	1.9
3	0.12	0.20	0.34	0.28	0.44	-	3.9
4 <sup>+</sup>	-	0.21	0.78	0.48	0.44	-	2.6
5	-	-	0.38	0.23	0.34	-	1.4
6 <sup>+</sup>	0.06	0.07	0.45	0.25	0.40	-	1.0
7	-	0.09	0.42	0.32	0.41	-	1.4
8	0.13	0.07	0.47	0.27	0.61	0.02	1.4
	(ii) <u>Other analysts</u>						
9	-	-	0.38	0.18	-	0.52	<u>c.</u> 1
10	0.09	0.36	0.80	0.53	0.68	Present	-
11	0.17	-	0.13	0.18	0.10	-	0.20*
12	-	0.09	0.41	0.22	0.36	-	1.5
(i) Mean	0.080	0.12	0.47	0.30	0.44	0.09	1.97
s.d.	0.056	0.064	0.14	0.099	0.087	-	0.93
(i)+ Mean	0.097	0.15	0.45	0.29	0.42	0.09	1.83
(ii) s.d.	0.057	0.10	0.18	0.11	0.15	-	0.89

Lab. number (see Table 7A)	Reported concentrations found in mg/kg of sample						
	Sample 2B (in excess of 2A)						
	BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	PCB
	(i) <u>Participants in Base-Line Survey</u>						
1	-	-	6.3	3.5	5.8	0.70	10.4 <sup>+</sup>
2	0.73	1.5	5.2	2.9	4.7	Present	9.1
3	0.03*	1.5	7.3	2.6	4.5	Present	8.3
4 <sup>+</sup>	0.89	1.4	5.7	2.6	5.0	-	11.8
5	0.72	1.6	4.1	2.7	4.6	-	10.3
6 <sup>+</sup>	0.88	1.4	4.8	3.6	5.9	-	10.5
7	0.70	1.4	4.1	4.0	5.1	-	9.0
8	0.67	1.3	5.1	3.0	4.8	0.3	10.6
	(ii) <u>Other analysts</u>						
9	-	-	4.6	2.3	4.6	-	<u>c.</u> 6
10	0.51	2.4	3.3	2.6	4.8	Present	6.5
11	0.64	-	1.2*	1.0*	0.71*	-	0.70*
12	0.78	1.4	4.4	2.9	4.6	-	8.0
Amount added	0.80	1.5	5.0	3.0	5.0	0.30	10.0
(i) Mean	0.77	1.4	5.3	3.1	5.1	0.40	10.0
s.d.	0.095	0.097	1.0	0.52	0.53	-	1.1
(i)+ Mean	0.74	1.5	5.0	3.0	4.9	0.40	9.1
(ii) s.d.	0.12	0.33	1.1	0.52	0.48	-	1.8

+ New results submitted after analysts' meeting.

\* Omitted in calculating means and standard deviation.

Table 8 Results of Base-Line Survey: metals in fish and shellfish

Table 8a Cod (Gadus morhua). N.B. Underlined values indicate that the fish were of the selected year-class

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
NORWAY													
J22	Jan	<u>1968</u>	3	-	-	-	-	-	-	-	-	-	
				<u>0.23</u>	<u>6.0</u>	<u>1.2</u>	<u>&lt;0.02</u>	<u>&lt;0.1</u>					
K15	Mar	1969	1	-	-	-	-	-	-	-	-	-	
				0.08	6.0	1.0	<0.02	<0.1					
K12	Feb	1971	1	-	-	-	-	-	-	-	-	-	
				0.08	4.0	1.5	<0.02	0.2					
K12	Feb	1970	1	-	-	-	-	-	-	-	-	-	
				0.06	4.0	2.0	<0.02	0.2					

Table 8a continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
SWEDEN												
N13	Jan	<u>1968</u>	15	0.01 0.12 <u>0.04</u> 0.03	2.2 5.2 <u>3.5</u> 0.9	<0.3 0.5 <u>0.4</u> -	0.2 0.6 <u>0.3</u> 0.1	<1.0 5.9 <u>3.0</u> 1.8	<0.3 - <u>&lt;0.3</u> -	0.4 2.0 <u>1.3</u> 0.6		
Q14	Jan	<u>1968</u>	15	0.02 0.09 <u>0.05</u> 0.02	2.3 4.2 <u>3.1</u> 0.8	<0.3 0.6 <u>0.3</u> -	0.2 0.7 <u>0.4</u> 0.2	<1.0 5.6 <u>2.6</u> 1.7	<0.3 - <u>&lt;0.3</u> -	0.5 1.9 <u>1.1</u> 0.5		
R14	Jan	<u>1968</u>	15	0.03 0.19 <u>0.09</u> 0.05	2.5 4.3 <u>3.4</u> 0.8	<0.3 0.8 <u>0.5</u> -	0.2 0.6 <u>0.4</u> 0.2	<1.0 4.5 <u>2.4</u> 1.6	<0.3 - <u>&lt;0.3</u> -	<0.3 2.7 <u>1.3</u> 0.7		
Q16	Jan	<u>1968</u>	13	0.05 0.14 <u>0.09</u> 0.04	2.2 4.0 <u>3.2</u> 0.7	<0.3 0.6 <u>0.3</u> -	0.2 0.8 <u>0.5</u> 0.2	<1.0 4.9 <u>2.7</u> 1.5	<0.3 - <u>&lt;0.3</u> -	<0.3 2.2 <u>1.1</u> 0.5		
<hr/>												
GERMANY												
N9	May	<u>1968</u>	10		2.2 2.6 <u>2.4</u> 0.2	0.6 0.9 <u>0.8</u> 0.1					0.3 0.5 <u>0.4</u> 0.1	<0.1 0.1 <u>0.10</u> 0.02
<hr/>												

Table 8a continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
NETHERLANDS												
J5	Feb	1969	10	0.04*	2.7	-	-	-	-	-	-	-
				0.20*	6.3	-	-	-	-	-	-	-
				0.13*	3.9	-	-	-	-	-	-	-
				0.06*	1.3	-	-	-	-	-	-	-
H3-4: J3-4	Jan	1967	10	-								
				-								
				0.23								
				-								
<hr/>												
BELGIUM												
G1		1969	4	0.08								
				0.20								
				0.15								
				-								
G1		1970	52†	0.04	3.3	0.30	-	0.21				
				0.27	5.1	1.2	-	0.83				
				0.13	4.2	0.67	-	0.30				
				0.05	0.51	0.29	-	0.16				
G1		1971	8	0.04								
				0.21								
				0.11								
				0.06								

\* Probably low by factor of 2.

† Smaller numbers were used for Zn, Cu and Pb.

Table 8a continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
FRANCE												
G1	Feb	<u>1968</u>	5	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				<u>0.10</u>	<u>2.6</u>	<u>1.1</u>	<u>0.08</u>	<u>0.5</u>	<u>&lt;0.4</u>			
				-	-	-	-	-	-	-	-	-
G6	Apr		3	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				0.03	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
<hr/>												
ENGLAND												
L8	Feb	<u>1968</u>	10	0.32	4.0	0.30	0.15	<0.5	<0.5			
				0.65	7.1	1.3	0.25	<0.5	<0.5			
				<u>0.48</u>	<u>5.0</u>	<u>0.58</u>	<u>0.21</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.13	0.87	0.34	0.04	-	-			
D7: E7	Feb	<u>1968</u>	8	0.08	3.4	0.30	0.05	<0.5	<0.5			
				0.29	4.7	0.50	0.15	<0.5	<0.5			
				<u>0.18</u>	<u>4.0</u>	<u>0.35</u>	<u>0.08</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.06	0.50	0.09	0.04	-	-			
J9	Feb	<u>1968</u>	12	0.09	3.3	0.30	<0.05	<0.5	<0.5			
				0.30	4.1	0.50	0.10	<0.5	<0.5			
				<u>0.19</u>	<u>3.6</u>	<u>0.30</u>	<u>&lt;0.07</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.07	0.20	0.08	0.03	-	-			
<hr/>												



Table 8a continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
SCOTLAND												
B13: C13	Jan/Feb	1967	9	0.05	2.9	0.25	-	<0.2	-			
				0.19	4.2	0.63	-	0.4	-			
				0.11	3.3	0.43	<0.03	<0.2	-			
				0.05	0.40	0.14	-	-	-			
G15	Jan/Feb	1967	10	0.03	2.5	0.18	-	<0.2	-			
				0.14	3.7	0.63	-	0.4	-			
				0.08	3.3	0.39	<0.03	<0.2	-			
				0.03	0.40	0.15	-	-	-			
G19	Jan/Feb	1967	10	0.03	2.5	0.08	-	<0.2				
				0.14	3.7	0.45	-	0.4				
				0.06	2.9	0.26	<0.03	<0.2				
				0.03	0.35	0.12	-	-				
B-D18-20: E19-20	Jan/Feb	1967	10	0.06	3.1	0.13	-	<0.2				
				0.13	4.1	0.55	-	0.3				
				0.10	3.5	0.33	<0.03	<0.2				
				0.03	0.30	0.12	-	-				
A11: B11	Jan/Feb	1967	10	0.06	2.8	0.18	-	<0.2				
				0.38	4.1	0.53	-	0.2				
				0.14	3.4	0.34	<0.03	<0.2				
				0.09	0.40	0.10	-	-				

Table 8b Plaice (Pleuronectes platessa). N.B. Underlined values indicate that the fish were of the selected year-class

Source	Date of collection	Year-class or size	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
NORWAY													
K22	Feb	35 cm	1	-	-	-	-	-	-	-	-	-	
				0.06	7.0	1.0	<0.02	<0.1					
				-	-	-	-	-					
K22	May	33 cm	1	-	-	-	-	-	-	-	-	-	
				0.12	5.0	1.0	<0.02	<0.1					
				-	-	-	-	-					
K15	Mar	36 cm	1	-	-	-	-	-	-	-	-	-	
				0.08	8.0	1.5	<0.02	<0.1					
				-	-	-	-	-					
J11	Feb	33 cm	5	-	-	-	-	-	-	-	-	-	
				0.06	6.0	1.5	<0.02	0.2					
				-	-	-	-	-					
J8	Feb	30 cm	12	-	-	-	-	-	-	-	-	-	
				0.06	5.0	1.8	<0.02	<0.2					
				-	-	-	-	-					

Table 8b continued

Source	Date of collection	Year-class or size	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
SWEDEN												
N13	Jan	<u>1968</u>	6	0.04	3.0	<0.3	0.4	0.7	<0.3	0.9		
				0.06	6.0	0.7	0.7	1.7	<0.3	2.0		
				<u>0.05</u>	<u>4.3</u>	<u>0.5</u>	<u>0.6</u>	<u>1.1</u>	<u>&lt;0.3</u>	<u>1.6</u>		
				0.01	1.3	-	0.2	0.5	-	0.4		
N13		1966	2	-	-	-	-	-	-	-		
				-	-	-	-	-	-	-		
				0.04	3.6	0.5	0.7	1.0	<0.3	1.6		
				-	-	-	-	-	-	-		
Q14	Jan	<u>1968</u>	15	0.01	2.7	<0.3	0.2	<0.5	<0.3	0.4		
				0.12	7.5	0.8	0.8	4.4	<0.3	2.8		
				<u>0.05</u>	<u>4.3</u>	<u>0.5</u>	<u>0.5</u>	<u>2.6</u>	<u>&lt;0.3</u>	<u>1.5</u>		
				0.03	1.6	-	0.2	3.4	-	0.8		
R14	Jan	<u>1968</u>	12	<0.01	2.7	<0.3	0.2	<0.5	<0.3	0.4		
				0.07	7.8	0.6	0.8	3.6	<0.3	1.8		
				<u>0.04</u>	<u>4.5</u>	<u>0.4</u>	<u>0.5</u>	<u>2.1</u>	<u>&lt;0.3</u>	<u>1.1</u>		
				0.03	1.9	-	0.2	1.4	-	0.5		
Q16	Jan	<u>1968</u>	4	0.02	3.7	0.4	0.5	0.9	<0.3	0.9		
				0.04	5.0	0.5	0.7	1.8	<0.3	1.5		
				<u>0.03</u>	<u>4.2</u>	<u>0.4</u>	<u>0.5</u>	<u>1.4</u>	<u>&lt;0.3</u>	<u>1.2</u>		
				0.01	0.7	-	0.3	0.7	-	0.5		

Table 8b continued

Source	Date of collection	Year-class or size	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
SWEDEN (contd)												
Q16		1967	2	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				0.04	4.6	0.5	0.5	1.2	<0.3	1.6		
				-	-	-	-	-	-	-	-	-
		1966	3	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				0.04	4.0	0.8	0.6	1.5	<0.3	1.9		
				-	-	-	-	-	-	-	-	-
<hr/>												
GERMANY												
M9	May	1968	10	-	4.9	0.4	-	-	-	-	0.3	0.1
				-	5.5	0.6	-	-	-	-	0.5	0.2
				-	<u>5.2</u>	<u>0.5</u>	-	-	-	-	<u>0.4</u>	<u>0.1</u>
				-	0.3	0.1	-	-	-	-	0.1	0.02
<hr/>												
NETHERLANDS												
G4: H4	Feb	1968	10	0.01*	5.4						4.3	-
				0.03*	9.0						<u>9.6</u>	-
				<u>0.02*</u>	<u>6.9</u>						<u>5.9</u>	-
				<0.01*	1.3						1.7	-

\* Probably low by factor of 2.

Table 8b continued

Source	Date of collection	Year-class or size	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
				min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.				
<hr/>												
NETHERLANDS (contd)												
H8	Jan/Feb	1967	10	-								
				-								
				0.13								
				-								
H4	Jan/Feb	1967	10	-								
				-								
				0.11								
				-								
H4	Jan/Feb	1967	10	-								
				-								
				0.12								
				-								
H4	Jan/Feb	<u>1968</u>	10	-								
				-								
				<u>0.16</u>								
				-								
H4	Jan/Feb	<u>1968</u>	10	-								
				-								
				<u>0.08</u>								
				-								
H4	Jan/Feb	1969	2 x 10	-								
				-								
				0.12								
				-								

Table 8b continued

Source	Date of collection  1972	Year- class or size	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
				min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
BELGIUM												
G1		1967	5 <sup>+</sup>	0.13	3.1	0.56	-	0.21				
				0.36	6.4	1.3	-	0.27				
				0.24	4.7	0.74	-	0.24				
				0.09	-	0.33	-	-				
G1		<u>1968</u>	23 <sup>+</sup>	0.06	5.0	0.51	-	0.25				
				0.39	11	1.3	-	0.36				
				<u>0.17</u>	<u>7.3</u>	<u>0.74</u>	-	<u>0.31</u>				
				0.08	1.9	0.25	-	0.03				
G1		1969	76 <sup>+</sup>	0.04	3.6	0.26	-	0.18				
				0.32	8.0	1.7	-	0.50				
				0.16	6.0	0.63	-	0.29				
				0.06	1.3	0.24	-	0.07				
G1		1970	60 <sup>+</sup>	0.04	3.3	0.42	-	0.20				
				0.39	9.3	1.6	-	0.62				
				0.18	6.6	0.66	-	0.35				
				0.08	1.6	0.29	-	0.15				
G1		1971	37 <sup>+</sup>	0.03	-	0.41						
				0.39	-	1.2						
				0.22	-	0.77						
				0.09	-	0.32						

+ Smaller numbers were used for Zn, Cu and Pb.

Table 8b continued

Source	Date of collection	Year-class or size	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
BELGIUM (contd)												
G3-4		<u>1968</u>	5	0.13	-	0.34						
				0.37	-	0.81						
				<u>0.26</u>	-	<u>0.55</u>						
				0.10	-	0.20						
<hr/>												
FRANCE												
G1	Feb	<u>1968</u>	5	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				<u>0.12</u>	<u>5.8</u>	<u>3.6</u>	<u>0.10</u>	<u>0.7</u>	<u>&lt;0.5</u>			
				-	-	-	-	-	-	-	-	-
H4	Mar	-	4	-								
				-								
				0.13								
				-								
G4	Mar	-	2	-								
				-								
				0.08								
				-								
G6	Apr	-	2	-								
				-								
				0.08								
				-								
<hr/>												



Table 8b continued

Source	Date of collection	Year-class or size	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
ENGLAND												
L8	Feb	<u>1968</u>	12	0.05	5.5	0.3	0.05	<0.5	<0.5			
				0.12	7.9	0.8	0.25	<0.5	<0.5			
				<u>0.09</u>	<u>6.4</u>	<u>0.4</u>	<u>0.18</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.02	0.7	0.2	0.10	-	-			
J6	Mar	<u>1968</u>	13	0.08	4.2	<0.3	0.05	<0.5	<0.5			
				0.17	6.4	0.3	0.10	<0.5	<0.5			
				<u>0.11</u>	<u>5.1</u>	<u>&lt;0.3</u>	<u>0.07</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.03	0.6	-	0.03	-	-			
K8	Feb	<u>1968</u>	10	0.05	3.9	<0.3	0.05	<0.5	<0.5			
				0.14	7.7	0.5	0.10	<0.5	<0.5			
				<u>0.09</u>	<u>5.4</u>	<u>&lt;0.4</u>	<u>0.08</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.03	1.0	0.1	0.03	-	-			
K8	Feb	<u>1968</u>	5	0.06	4.2	1.0	0.10	<0.5	<0.5			
				0.11	5.8	1.8	0.20	<0.5	<0.5			
				<u>0.10</u>	<u>4.7</u>	<u>1.4</u>	<u>0.13</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.05	0.6	0.4	0.05	-	-			
H7	Mar	<u>1968</u>	5	0.05	4.1	0.3	0.10	<0.5	<0.5			
				0.08	5.4	0.5	0.10	<0.5	<0.5			
				<u>0.07</u>	<u>4.7</u>	<u>0.5</u>	<u>0.10</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.01	0.6	0.09	-	-	-			
<hr/>												

Table 8b continued

Source	Date of collection	Year-class or size	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
<hr/>													
SCOTLAND													
B-D18-20: E19-20	Jan/Feb	1967	10	0.02	2.9	0.13	-	<0.2					
				0.17	5.0	0.50	-	0.4					
				0.05	4.0	0.22	<0.03	<0.2					
				0.05	0.6	0.13	-	-					
A14	Jan/Feb	1967	10	0.06	2.5	0.25	-	<0.2					
				0.21	4.9	0.55	-	0.2					
				0.10	3.7	0.38	<0.03	<0.2					
				0.04	0.8	0.12	-	-					
A11	Jan/Feb	-	5	0.09	2.6	0.13	-	-					
				0.09	4.2	0.25	-	-					
				0.09	3.1	0.21	<0.03	<0.2					
				-	0.6	0.06	-	-					
B13: C13	Jan/Feb	-	5	0.06	3.2	0.25	-	<0.2					
				0.06	4.3	0.55	-	0.2					
				0.06	3.7	0.38	<0.03	<0.2					
				-	0.4	0.15	-	-					
G19	Jan/Feb	1967	4	0.08	3.9	0.25	-	-					
				0.08	4.2	0.55	-	-					
				0.08	4.0	0.42	<0.03	<0.2					
				-	0.2	0.15	-	-					

Table 8b continued

Source	Date of collection	Year- class or size	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
				min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
SCOTLAND (contd)												
A14	Dec	<u>1968</u>	6	-	3.7	0.25	-	<0.2				
				-	4.8	0.38	-	0.6				
				-	<u>4.5</u>	<u>0.36</u>	<u>&lt;0.03</u>	<u>0.3</u>				
				-	0.7	0.05	-	0.2				

Table 8c Herring (Clupea harengus). N.B. Underlined values indicate that the fish were of the selected year-class

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
NORWAY												
F17	Feb	1971	10	-	-	-	-	-	-	-	-	-
				0.04	8	3.0	<0.02	<0.2				
				-	-	-	-	-	-	-	-	-
E16	Feb	1971	10	-	-	-	-	-	-	-	-	-
				0.04	10	1.5	<0.02	<0.1				
				-	-	-	-	-	-	-	-	-
D22	Feb	1971	10	-	-	-	-	-	-	-	-	-
				0.04	11	2.0	<0.02	<0.2				
				-	-	-	-	-	-	-	-	-
F22	Feb	1971	11	-	-	-	-	-	-	-	-	-
				0.04	10	2.5	<0.02	<0.2				
				-	-	-	-	-	-	-	-	-
A18	Feb	1971	5	-	-	-	-	-	-	-	-	-
				0.05	8	2.0	<0.02	0.3				
				-	-	-	-	-	-	-	-	-

Table 8c continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
<hr/>													
NORWAY (contd)													
D15	Feb	1971	7	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.08	14	3.5	<0.02	0.1					
				-	-	-	-	-	-	-	-	-	
D15	Feb	1970	4	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.06	14	3.5	<0.02	0.1					
				-	-	-	-	-	-	-	-	-	
F15	Feb	1971	10	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.06	9	3.0	<0.02	0.2					
				-	-	-	-	-	-	-	-	-	
G14	Feb	1971	9	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.06	7	1.0	<0.02	<0.2					
				-	-	-	-	-	-	-	-	-	
<hr/>													
SWEDEN													
N13		1969	10	0.02	2.6	0.4	<0.3	2.5	<0.3	0.8			
				0.05	5.7	1.4	0.9	6.6	-	2.3			
				<u>0.04</u>	<u>4.5</u>	<u>0.9</u>	<u>0.6</u>	<u>4.8</u>	<u>&lt;0.3</u>	<u>1.6</u>			
				0.01	1.9	0.6	0.2	1.4	-	0.6			

Table 8c continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
<hr/>													
SWEDEN (contd)													
N13		1970	3	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.04	5.9	0.8	0.6	2.9	<0.3	1.6			
				-	-	-	-	-	-	-	-	-	
Q14		1969	15	0.01	2.4	0.2	0.3	1.6	<0.3	0.8			
				0.07	13	1.2	1.2	7.7	-	2.5			
				0.04	5.7	0.6	0.7	3.5	<0.3	1.6			
				0.02	4.7	0.3	0.3	2.1	-	0.7			
R14		1969	12	0.04	2.3	0.4	0.3	2.2	<0.3	0.3			
				0.09	3.9	1.7	1.0	13	-	2.4			
				0.05	3.0	0.8	0.6	5.1	<0.3	1.4			
				0.02	0.6	0.5	0.2	3.6	-	0.6			
Q16		1969	15	0.02	4.7	0.7	<0.2	0.4	<0.3	1.1			
				0.06	11	2.3	0.8	2.1	-	2.1			
				0.04	7.3	1.3	0.4	1.1	<0.3	1.5			
				0.01	2.0	0.6	0.2	0.5	-	0.3			
Q16		1970	5	-	-	-	-	-	-	-			
				-	-	-	-	-	-	-			
				0.03	5.0	1.2	0.5	1.2	<0.3	1.5			
				-	-	-	-	-	-	-			

Table 8c continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
NETHERLANDS												
H2-5: J3-5	Jan	1968	10	-								
				-								
				0.17								
				-								
<hr/>												
FRANCE												
J9	Mar		1	-								
				-								
				0.14								
				-								
H3	Apr		2	-								
				-								
				0.13								
				-								
<hr/>												
ENGLAND												
F2	Apr	<u>1969</u>	8	0.14	4.6	0.75	0.10	<0.5	<0.5			
				0.44	8.9	1.3	0.20	<0.5	<0.5			
				<u>0.24</u>	<u>6.4</u>	<u>0.94</u>	<u>0.19</u>	<u>&lt;0.5</u>	<u>&lt;0.5</u>			
				0.09	1.6	0.23	0.05	-	-			
E8	Feb	<u>1969</u>	12	0.01	9.5	1.1	<0.10	0.69	3.3			
				0.14	19	2.4	0.23	1.4	3.7			
				<u>0.05</u>	<u>14</u>	<u>1.5</u>	<u>0.16</u>	<u>0.97</u>	<u>3.5</u>			
				0.04	2.7	0.39	0.04	0.23	0.12			



Table 8c continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
<hr/>													
ENGLAND (contd)													
F10	Feb	1969	10	0.03	13	1.3	<0.10	<0.5	0.80				
				0.06	21	1.9	<0.10	1.9	1.7				
				0.04	17	1.5	<0.10	1.3	1.4				
				0.01	3.7	0.17	-	0.35	0.20				
F6	Feb	1969	10	0.04	16	0.10	<0.10	0.80	1.4				
				0.26	35	1.7	<0.10	3.2	2.8				
				0.08	22	0.9	<0.10	1.4	1.8				
				0.05	5.4	0.50	-	0.80	0.40				
<hr/>													
SCOTLAND													
B-D18-20: E19-20	Jan/Feb	1968/ 69	10	-	7.7	0.83	-	<0.2					
				-	15	1.3	-	0.2					
				0.02	11	0.98	<0.03	<0.2					
				0.01	2.6	0.21	-	-					
A14	Jan/Feb	1969	10	-	5.3	0.83	-	<0.2					
				-	16	1.8	-	0.6					
				0.02	7.1	1.2	<0.03	0.2					
				0.01	3.3	0.29	-	-					
A14	Apr	1969/ 70	10	-	8.8	1.3	-	0.8					
				-	14	2.0	-	1.6					
				-	11	1.6	<0.03	1.0					
				-	1.8	0.27	-	0.3					

Table 8c continued

Source	Date of collection	Year-class	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
SCOTLAND (contd)												
A14	Apr	1969	10	-	3.0	0.53	-	0.5				
				-	8.5	1.6	-	1.1				
				-	6.4	0.96	<0.03	0.8				
				-	1.6	0.31	-	0.2				
A14	Apr	1968	10	-	4.1	0.52	-	<0.2				
				-	9.6	1.0	-	0.9				
				-	6.3	0.70	<0.03	0.4				
				-	1.9	0.16	-	0.3				

Table 8d Mussel (Mytilus edulis). N.B. Underlined values indicate that the fish were of the selected size range

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
NORWAY												
J22	Jan	45-60	43	-	-	-	-	-	-	-	-	-
				0.06	26	7.0	0.15	1.0	-	-	-	-
				-	-	-	-	-	-	-	-	-
K15	Dec <sup>+</sup>	<u>55-60</u>	-	-	-	-	-	-	-	-	-	-
				<u>0.06</u>	<u>32</u>	<u>3.8</u>	<u>0.50</u>	<u>7.2</u>	-	-	-	-
				-	-	-	-	-	-	-	-	-
<hr/>												
SWEDEN												
Seläter Idefjord		45-50	25	-	-	-	-	-	-	-	-	-
				0.08	22	2.4	0.2	1.2	<0.1	-	-	-
				-	-	-	-	-	-	-	-	-
Kattholmen		45-50	25	-	-	-	-	-	-	-	-	-
Singlefjord				0.10	21	1.7	0.3	<0.7	<0.1	-	-	-
				-	-	-	-	-	-	-	-	-
Korsholmen,		50-55	24	-	-	-	-	-	-	-	-	-
N. Koster				0.03	14	0.7	0.1	<0.7	<0.2	-	-	-
				-	-	-	-	-	-	-	-	-

+ 1971.

Table 8d continued

Source	Date of collection  1972	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
				min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
SWEDEN (contd)												
Korsholmen, N. Koster		<u>55-60</u>	25	-	-	-	-	-	-	-	-	-
				<u>0.03</u>	<u>13</u>	<u>0.7</u>	<u>0.2</u>	<u>&lt;0.7</u>	<u>&lt;0.1</u>			
				-	-	-	-	-	-	-	-	-
Harbour of Fjällbacka		50-55	19	-	-	-	-	-	-	-	-	-
				0.03	16	1.5	0.1	<1.1	<0.2			
				-	-	-	-	-	-	-	-	-
Dyngö (Fjällbacka archipelago)		50-55	25	-	-	-	-	-	-	-	-	-
				0.02	15	1.1	0.1	<0.9	<0.2			
				-	-	-	-	-	-	-	-	-
Dyngö (Fjällbacka archipelago)		<u>55-60</u>	25	-	-	-	-	-	-	-	-	-
				<u>0.02</u>	<u>14</u>	<u>1.1</u>	<u>0.1</u>	<u>&lt;0.9</u>	<u>&lt;0.2</u>			
				-	-	-	-	-	-	-	-	-
Måsekär		50-55	25	-	-	-	-	-	-	-	-	-
				0.04	20	1.1	0.2	<0.5	<0.3			
				-	-	-	-	-	-	-	-	-

Table 8d continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
SWEDEN (contd)												
Lerskiten		50-55	25	-	-	-	-	-	-			
Askeröfjord				-	-	-	-	-	-			
				0.08	20	1.6	0.1	<0.4	<0.4			
				-	-	-	-	-	-			
Lerskiten		<u>55-60</u>	25	-	-	-	-	-	-			
Askeröfjord				-	-	-	-	-	-			
				<u>0.08</u>	<u>25</u>	<u>1.7</u>	<u>0.2</u>	<u>0.6</u>	<u>&lt;0.4</u>			
				-	-	-	-	-	-			
St Dyrön,		50-55	25	-	-	-	-	-	-			
Algöfjord				-	-	-	-	-	-			
				0.05	26	1.5	0.2	0.7	<0.3			
				-	-	-	-	-	-			
St Dyrön,		<u>55-60</u>	25	-	-	-	-	-	-			
Algöfjord				-	-	-	-	-	-			
				<u>0.04</u>	<u>18</u>	<u>1.3</u>	<u>0.2</u>	<u>0.8</u>	<u>&lt;0.3</u>			
				-	-	-	-	-	-			
Pater Noster		50-55	25	-	-	-	-	-	-			
				-	-	-	-	-	-			
				0.04	25	1.1	0.2	0.6	<0.3			
				-	-	-	-	-	-			

Table 8d continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
<hr/>													
SWEDEN (contd)													
Pater Noster		<u>55-60</u>	25	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				<u>0.04</u>	<u>17</u>	<u>0.9</u>	<u>0.3</u>	<u>1.2</u>	<u>&lt;0.3</u>				
				-	-	-	-	-	-	-	-	-	
KA4 Älvsborgsfjord		50-55	25	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.22	27	2.1	0.3	0.7	<0.3				
				-	-	-	-	-	-	-	-	-	
KA4 Älvsborgsfjord		<u>55-60</u>	25	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				<u>0.10</u>	<u>33</u>	<u>2.5</u>	<u>0.2</u>	<u>1.8</u>	<u>&lt;0.3</u>				
				-	-	-	-	-	-	-	-	-	
Skalkorgarna		45-50	22	-	-	-	-	-	-	-	-	-	
Hakefjord				-	-	-	-	-	-	-	-	-	
				0.15	29	1.5	0.2	0.8	<0.3				
				-	-	-	-	-	-	-	-	-	
Skalkorgarna		50-55	25	-	-	-	-	-	-	-	-	-	
Hakefjord				-	-	-	-	-	-	-	-	-	
				0.29	28	1.2	0.3	2.2	<0.3				
				-	-	-	-	-	-	-	-	-	

Table 8d continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<b>SWEDEN (contd)</b>												
Skalkorgarna Hakefjord		<u>55-60</u>	23	-	-	-	-	-	-	-	-	-
				<u>0.18</u>	<u>29</u>	<u>1.4</u>	<u>0.2</u>	<u>0.7</u>	<u>&lt;0.4</u>			
Skalkorgarna Hakefjord		60-65	19	-	-	-	-	-	-	-	-	-
				0.25	34	1.1	0.2	0.9	<0.4			
Kalvön Kungsbackafjord		<u>55-60</u>	25	-	-	-	-	-	-	-	-	-
				<u>0.04</u>	<u>22</u>	<u>1.2</u>	<u>0.4</u>	<u>0.5</u>	<u>&lt;0.3</u>			
Onsala Peninsula, southern end		<u>55-60</u>	20	-	-	-	-	-	-	-	-	-
				<u>0.03</u>	<u>17</u>	<u>1.1</u>	<u>0.3</u>	<u>0.7</u>	<u>&lt;0.3</u>			
<b>GERMANY</b>												
M6: N6	Oct	<u>55-60</u>	100	-	-	-	-	-	-	-	-	-
				-	<u>21</u>	<u>13</u>	-	-	-	-	<u>128</u>	<u>2.9</u>
				-	-	-	-	-	-	-	-	-



Table 8d continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
NETHERLANDS												
K5	Oct	60-65	100	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				0.08*	18	3.9	0.3	-	-	-	20	-
				-	-	-	-	-	-	-	-	-
J4: K4	Jan	<u>55-60</u>	100	-								
				-								
				<u>0.50</u>								
				-								
H2	Jan	<u>55-60</u>	100	-								
				-								
				<u>0.68</u>								
				-								
<hr/>												
FRANCE												
G1	Nov <sup>†</sup>	35-55	98	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				0.04	19	7.5	0.32	0.4	<0.7			
				-	-	-	-	-	-			

\* Probably low by factor of 2.

† 1971.

Table 8d continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
FRANCE (contd)												
G1	Feb	35-55	64	-	-	-	-	-	-			
				-	-	-	-	-	-			
				0.04	-	-	-	-	-			
				-	-	-	-	-	-			
G1	Oct	25-52	157	-	-	-	-	-	-			
				-	-	-	-	-	-			
				0.06	14	2.5	0.17	0.8	<0.4			
				-	-	-	-	-	-			
<hr/>												
ENGLAND												
E4	Dec <sup>+</sup>	51-64	60	-	-	-	-	-	-			
				-	-	-	-	-	-			
				0.04	30	3.3	0.39	4.0	2.2			
				-	-	-	-	-	-			
E2	Nov <sup>+</sup>	54-62	72	-	-	-	-	-	-			
				-	-	-	-	-	-			
				0.31	60	4.6	1.32	3.5	2.3			
				-	-	-	-	-	-			
E4	Oct <sup>+</sup>	51-65	60	-	-	-	-	-	-			
				-	-	-	-	-	-			
				0.04	28	4.4	0.33	2.1	1.5			
				-	-	-	-	-	-			

+ 1971.

Table 8d continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								Fe	Mn
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe		
	1971			min	min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
ENGLAND (contd)													
D7	Nov	<u>55-60</u>	82	-	-	-	-	-	-	-	-	-	-
				<u>0.10</u>	<u>28</u>	<u>4.1</u>	<u>0.36</u>	<u>3.7</u>	<u>2.0</u>				
				-	-	-	-	-	-	-	-	-	-
D7	Nov	<u>55-60</u>	60	-	-	-	-	-	-	-	-	-	-
				<u>0.10</u>	<u>39</u>	<u>2.6</u>	<u>0.29</u>	<u>4.1</u>	<u>1.8</u>				
				-	-	-	-	-	-	-	-	-	-
E2	Oct	<u>55-60</u>	80	-	-	-	-	-	-	-	-	-	-
				<u>0.26</u>	<u>33</u>	<u>2.6</u>	<u>0.45</u>	<u>3.2</u>	<u>1.8</u>				
				-	-	-	-	-	-	-	-	-	-
F4	Nov	58-68	50	-	-	-	-	-	-	-	-	-	-
				0.05	29	1.7	0.33	2.7	1.8				
				-	-	-	-	-	-	-	-	-	-
G10	Nov	55-63	50	-	-	-	-	-	-	-	-	-	-
				0.07	29	2.8	0.33	2.5	1.6				
				-	-	-	-	-	-	-	-	-	-

Table 8d continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1971			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>				<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
ENGLAND (contd)												
E4	Nov	50-58	50	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				0.06	23	2.2	0.29	2.5	1.8			
				-	-	-	-	-	-	-	-	-
C8	Nov	55-64	50	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				0.11	40	3.3	0.39	4.5	5.4			
				-	-	-	-	-	-	-	-	-

Table 8e Brown shrimp (Crangon crangon). N.B. Underlined values indicate that the fish were of the selected size range

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1972			min	min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
NORWAY ‡													
J22	Jan	70-120	-	-	-	-	-	-	-	-	-	-	-
				0.07	24	23	0.10	0.10					
				-	-	-	-	-					
K15	Dec†	85-130	-	-	-	-	-	-	-	-	-	-	-
				0.17	21	31	0.30	0.10					
				-	-	-	-	-					
Q17	Dec†	70-95	-	-	-	-	-	-	-	-	-	-	-
				0.06	21	24	0.18	0.10					
<hr/>													
GERMANY													
M6: N6	Oct†	55	100	-	-	-	-	-	-	-	-	-	-
				-	6.3	7.2	-	-	-	-	28	3.2	-
				-	-	-	-	-	-	-	-	-	-
<hr/>													

‡ The shrimps analysed were probably Pandalid species, not Crangon.

† 1971.

Table 8e continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>												
NETHERLANDS												
J5	Oct	55-60	100	-	-	-	-	-	-	-	-	-
				-	-	-	-	-	-	-	-	-
				<u>0.04*</u>	<u>24</u>	<u>19</u>	<u>0.74</u>	-	-	-	<u>46</u>	-
				-	-	-	-	-	-	-	-	-
J4-5	Jan	55	100	-								
				-								
				0.09								
				-								
<hr/>												
BELGIUM												
G1			99	-	-	-		-				
				-	-	-		-				
				0.11	26	13		4.3				
				-	-	-		-				
<hr/>												
FRANCE												
G1	Apr	40-70	153	-	-	-	-	-	-			
				-	-	-	-	-	-			
				0.05	21	13	<0.5	3.4	<0.1			
				-	-	-	-	-	-			

\* Probably low by factor of 2.

Table 8e continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1971			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
ENGLAND												
E4	Oct	60-70	80	-	-	-	-	-	-	-	-	-
				0.23	36	22	0.72	6.8	2.3			
				-	-	-	-	-	-	-	-	-
D6	Nov	60-70	78	-	-	-	-	-	-	-	-	-
				0.07	40	21	1.0	4.5	2.6			
				-	-	-	-	-	-	-	-	-
F4	Oct	55-70	85	-	-	-	-	-	-	-	-	-
				0.13	38	22	0.52	4.4	2.1			
				-	-	-	-	-	-	-	-	-
E2	Oct	50-60	100	-	-	-	-	-	-	-	-	-
				0.13	29	19	0.55	4.4	2.2			
				-	-	-	-	-	-	-	-	-

Table 8f Shore crab (Garcinus maenas)

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1972			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
NORWAY												
J22	Jan	>60	15	-	-	-	-	-				
				-	-	-	-	-				
				0.05	31	26	0.12	0.4				
				-	-	-	-	-				
J22	Jan	<60	11	-	-	-	-	-				
				-	-	-	-	-				
				0.05	32	30	0.14	0.4				
				-	-	-	-	-				
J22	Jan	≥52	15	-	-	-	-	-				
				-	-	-	-	-				
				0.06	30	25	0.06	0.6				
				-	-	-	-	-				
J22	Jan	<52	14	-	-	-	-	-				
				-	-	-	-	-				
				0.05	25	11	0.05	0.3				
				-	-	-	-	-				
Q17	Dec <sup>†</sup>	53 <sup>‡</sup>	9	-	-	-	-	-				
				-	-	-	-	-				
				0.14	27	21	0.07	0.5				
				-	-	-	-	-				

† 1971.

‡ Mean value.



Table 8f continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1971			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
NORWAY (contd)												
Q17	Dec	≥53	12	-	-	-	-	-	-	-	-	-
				0.17	30	21	0.06	0.5				
				-	-	-	-	-				
Q17	Dec	<53	17	-	-	-	-	-	-	-	-	-
				0.18	26	23	0.06	0.5				
				-	-	-	-	-				
Q17	Dec	<53	12	-	-	-	-	-	-	-	-	-
				0.12	26	17	0.02	0.3				
				-	-	-	-	-				
Q17	Dec	<52	10	-	-	-	-	-	-	-	-	-
				0.21	26	14	0.06	0.4				
				-	-	-	-	-				
Q17	Dec	>53	13	-	-	-	-	-	-	-	-	-
				0.16	27	20	0.05	0.4				
				-	-	-	-	-				

Table 8f continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1971			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
<hr/>													
NORWAY (contd)													
Q17	Dec	>52	16	-	-	-	-	-	-	-	-	-	
				0.21	27	14	0.06	0.3					
				-	-	-	-	-					
Q17	Dec	≥57	15	-	-	-	-	-	-	-	-	-	
				0.20	28	12	0.05	0.3					
				-	-	-	-	-					
Q17	Dec	<57	10	-	-	-	-	-	-	-	-	-	
				0.16	25	11	0.03	0.3					
				-	-	-	-	-					
K15	Dec	≥62	17	-	-	-	-	-	-	-	-	-	
				0.07	31	22	0.08	0.4					
				-	-	-	-	-					
K15	Dec	<62	8	-	-	-	-	-	-	-	-	-	
				0.06	29	18	0.05	0.5					
				-	-	-	-	-					

Table 8f continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)									
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn	
	1971			min	min	min	min	min	min	min	min	min	
				max	max	max	max	max	max	max	max	max	
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	
<hr/>													
NORWAY (contd)													
K15	Dec	≥58	11	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.10	29	14	0.06	0.4					
				-	-	-	-	-	-	-	-	-	
K15	Dec	<58	15	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.08	25	11	0.06	0.5					
				-	-	-	-	-	-	-	-	-	
K15	Dec	≥61	17	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.08	23	11	0.08	0.5					
				-	-	-	-	-	-	-	-	-	
K15	Dec	<61	9	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.08	25	11	0.05	0.5					
				-	-	-	-	-	-	-	-	-	
K15	Dec	61.5 <sup>‡</sup>	8	-	-	-	-	-	-	-	-	-	
				-	-	-	-	-	-	-	-	-	
				0.09	30	24	0.05	0.5					
				-	-	-	-	-	-	-	-	-	

‡ Mean value.

Table 8f continued

Source	Date of collection	Size range (mm)	Number in sample	Concentration (in mg/kg, wet weight)								
				Hg	Zn	Cu	Cd	Pb	Cr	Co	Fe	Mn
	1971			min	min	min	min	min	min	min	min	min
				max	max	max	max	max	max	max	max	max
				MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
NORWAY (contd)												
K15	Dec	≥59	13	-	-	-	-	-	-	-	-	-
				0.08	27	12	0.07	0.4				
				-	-	-	-	-				
K15	Dec	<59	13	-	-	-	-	-	-	-	-	-
				0.07	30	11	0.06	0.4				
				-	-	-	-	-				

Table 9 Results of Base-Line Survey: organochlorine pesticide residues and PCBs in fish and shellfish

Table 9a Cod (Gadus morhua). N.B. Underlined values indicate that the fish were of the selected year-class

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
NORWAY													
J22	Jan	<u>1968</u>	3	0.03	-	-	-	-	-	0.005	-	-	-
					-	-	-	-	-	0.040	-	-	-
					-	-	-	<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>0.017</u>	<u>&lt;0.001</u>	<u>&lt;0.020</u>	-
					-	-	-	-	-	-	-	-	-
K17	Mar	1966	1	0.02	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	<0.001	<0.001	<0.001	<0.003	<0.001
					-	-	-	-	-	-	-	-	-
K12	Feb	1971	1	0.04	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	<0.001	<0.001	0.001	<0.001	<0.004	-
					-	-	-	-	-	-	-	-	-
K12	Feb	1970	1	0.06	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	<0.001	<0.001	0.002	<0.001	<0.005	-
					-	-	-	-	-	-	-	-	-
<hr/>													
SWEDEN													
N13	Jan	<u>1968</u>	15	0.45	-	-	-	0.007	0.002	0.003	-	0.004	0.015
					-	-	-	0.009	0.004	0.011	-	0.019	0.059
					-	-	-	<u>0.004</u>	<u>0.001</u>	<u>0.006</u>	-	<u>0.011</u>	<u>0.035</u>
					-	-	-	0.002	<0.001	0.002	-	0.004	0.012

Table 9a continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					α BHC	γ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	ΣDDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
SWEDEN (contd)													
Q14	Jan	<u>1968</u>	15	0.57	-	-	-	0.001	<0.001	0.002	-	0.003	0.011
					-	-	-	0.022	0.002	0.010	-	0.23	0.079
					-	-	-	<u>0.017</u>	<u>0.001</u>	<u>0.003</u>	-	<u>0.021</u>	<u>0.023</u>
					-	-	-	0.056	0.001	0.002	-	0.056	0.016
R14	Jan	<u>1968</u>	15	0.55	-	-	-	0.001	<0.001	0.003	-	0.005	0.018
					-	-	-	0.010	0.002	0.015	-	0.027	0.11
					-	-	-	<u>0.004</u>	<u>0.001</u>	<u>0.006</u>	-	<u>0.011</u>	<u>0.045</u>
					-	-	-	0.002	0.001	0.003	-	0.006	0.025
Q16	Jan	<u>1968</u>	13	0.46	-	-	-	0.001	<0.001	0.002	-	0.003	0.021
					-	-	-	0.007	<0.001	0.011	-	0.018	0.079
					-	-	-	<u>0.003</u>	<u>&lt;0.001</u>	<u>0.005</u>	-	<u>&lt;0.009</u>	<u>0.038</u>
					-	-	-	0.002	-	0.003	-	0.004	0.017
<hr/>													
GERMANY <sup>†</sup>													
N9	May		10	0.26	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	0.001	0.023	0.004	0.019	0.003	-	0.026	0.046
					-	-	-	-	-	-	-	-	-
K10: L10	Feb		5	0.21	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	0.006	0.004	0.009	0.005	0.005	-	0.019	0.051
					-	-	-	-	-	-	-	-	-

<sup>†</sup> Analyses carried out in duplicate on composite of all specimens in sample.

Table 9a continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
					min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
	1972				s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
GERMANY <sup>‡</sup> (contd)													
K10: L10	Feb		5	0.20	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	0.004	0.004	0.014	0.022	0.002	-	0.038	0.062
					-	-	-	-	-	-	-	-	-
<hr/>													
NETHERLANDS													
J5	Feb	1969	6	0.26	-	-	0.001	0.001	<0.001	0.001	-	-	0.038
					-	-	0.002	0.005	0.002	0.003	-	-	0.071
					<0.001	<0.001	0.001	0.003	0.001	0.002	-	0.006	0.052
					-	-	<0.001	0.001	<0.001	<0.001	-	-	0.011
H3-4: J3-4	Jan	1967	10	0.6	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					0.002	<0.001	0.002	0.006	0.004	<0.008	-	<0.018	0.099
					-	-	-	-	-	-	-	-	-
<hr/>													
BELGIUM													
G1	+	1970	11		-	0.003	<0.001	0.001	<0.001	0.007	-	-	0.044
					-	0.008	0.015	0.017	0.011	0.051	-	-	0.25
					-	0.006	0.007	0.006	0.003	0.026	-	0.035	0.10
					-	0.002	0.005	0.005	0.003	0.014	-	-	0.061
G1	+	1971	2		-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	0.006	0.009	0.008	0.004	0.040	-	0.052	0.18
					-	-	-	-	-	-	-	-	-

<sup>‡</sup> Analyses carried out in duplicate on composite of all specimens in sample.

+ 1971.

Table 9a continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC min max MEAN s.d.	$\gamma$ BHC min max MEAN s.d.	Dieldrin min max MEAN s.d.	ppDDE min max MEAN s.d.	ppTDE min max MEAN s.d.	ppDDT min max MEAN s.d.	opDDT min max MEAN s.d.	$\Sigma$ DDT min max MEAN s.d.	PCB min max MEAN s.d.
	1972												
ENGLAND L8	Feb	1968	10	0.07	<0.001 <0.001 <0.001 -	<0.001 0.001 <0.001 -	<0.001 0.003 <0.001 -	<0.001 0.004 0.001 -	<0.001 0.005 <0.001 -	<0.002 0.002 <0.002 -	- - - -	- - <0.004 -	<0.01 0.84 0.099 -
D7: E7	Feb	1968	8	0.2	<0.001 0.001 <0.001 -	<0.001 <0.001 <0.001 -	<0.001 <0.001 <0.001 -	<0.001 0.003 <0.001 -	<0.002 <0.002 <0.002 -	<0.002 0.003 <0.002 -	- - - -	- - <0.005 -	<0.016 0.030 0.017 0.014
J9	Feb	1968	12	0.2	<0.001 <0.001 <0.001 -	<0.001 <0.001 <0.001 -	<0.001 <0.001 <0.001 -	<0.001 <0.001 <0.001 -	<0.002 <0.002 <0.002 -	<0.002 <0.002 <0.002 -	- - - -	- - <0.005 -	<0.016 0.020 <0.016 -
-----													
SCOTLAND B13: G13	Jan/Feb	1967	9	0.1- 0.03	- - - -	- - - -	- - <0.001 -	- - 0.002 -	- - <0.001 -	- - 0.004 -	- - - -	- - <0.007 -	- - 0.018 -
G15	Jan/Feb	1967	10	0.1- 0.2	- - - -	- - - -	- - <0.001 -	- - 0.001 -	- - <0.001 -	- - 0.001 -	- - - -	- - <0.003 -	- - <0.01 -



Table 9a continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
SCOTLAND (contd)													
G19	Jan/Feb	1967	10	0.01-0.2	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	<0.001	<0.001	<0.001	0.002	-	<0.004	<0.01
					-	-	-	-	-	-	-	-	-
B-D18-20: E19-20	Jan/Feb	1967	10	0.04-0.1	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	<0.001	<0.001	<0.001	<0.002	-	<0.004	<0.01
					-	-	-	-	-	-	-	-	-
A11: B11	Jan/Feb	1967	10	0.04-0.2	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	<0.001	0.001	<0.001	0.003	-	<0.005	0.011
					-	-	-	-	-	-	-	-	-

Table 9b Plaice (Pleuronectes platessa). N.B. Underlined values indicate that the fish were of the selected year-class

Source	Date of collection	Year-class or size	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
NORWAY													
K22	Feb	35 cm	1	0.21	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	0.013	0.013	<0.001	<0.027	0.02
					-	-	-	-	-	-	-	-	-
K22	May	33 cm	1	1.14	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	0.006	0.008	<0.001	<0.015	0.10
					-	-	-	-	-	-	-	-	-
K17	Mar	39 cm	1	0.15	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	0.006	0.009	<0.001	<0.016	0.01
					-	-	-	-	-	-	-	-	-
J11	Feb	33 cm	5	0.34	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.001	<0.001	0.020	0.001	<0.023	-
					-	-	-	-	-	-	-	-	-
J8	Feb	30 cm	12	0.45	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.001	<0.001	0.008	0.003	<0.013	-
					-	-	-	-	-	-	-	-	-

Table 9b continued

Source	Date of collection	Year-class or size	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
SWEDEN													
Q14	Jan	<u>1968</u>	10	0.98	-	-	-	<0.001	<0.001	0.003	-	0.004	0.04
					-	-	-	0.009	0.010	0.052	-	0.071	0.39
					-	-	-	<u>0.003</u>	<u>0.003</u>	<u>0.013</u>	-	<u>0.019</u>	<u>0.12</u>
					-	-	-	0.003	0.003	0.016	-	0.020	0.10
R14	Jan	<u>1968</u>	8	0.93	-	-	-	0.002	<0.001	<0.001	-	0.002	0.015
					-	-	-	0.116	0.008	0.026	-	0.15	0.15
					-	-	-	<u>0.017</u>	<u>0.002</u>	<u>0.005</u>	-	<u>0.024</u>	<u>0.042</u>
					-	-	-	0.040	0.003	0.009	-	0.049	0.040
Q16	Jan	<u>1968</u>	2	0.89	-	-	-	0.001	<0.001	0.002	-	0.003	0.009
					-	-	-	0.001	0.001	0.002	-	0.004	0.011
					-	-	-	<u>0.001</u>	<u>&lt;0.001</u>	<u>0.002</u>	-	<u>&lt;0.004</u>	<u>0.010</u>
					-	-	-	-	-	-	-	-	-
<hr/>													
GERMANY													
M9	Jan	<u>1968</u>	10	0.25	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	<u>0.021</u>	<u>0.010</u>	<u>0.019</u>	<u>0.004</u>	-	<u>0.033</u>	<u>0.077</u>
					-	-	-	-	-	-	-	-	-
M7	Jun	1965/ 68	10	2.00	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	0.006	0.027	0.039	0.006	-	0.072	0.15
					-	-	-	-	-	-	-	-	-
<hr/>													

Table 9b continued

Source	Date of collection	Year-class or size	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
NETHERLANDS													
G4: H4	Feb	1968/ 69	6	2.2	0.001	0.001	0.004	0.011	0.005	0.009	-	-	0.17
					0.006	0.005	0.023	0.025	0.034	0.019	-	-	0.56
					0.003	0.002	0.011	0.015	0.014	0.014	-	0.043	0.33
					0.002	0.002	0.008	0.006	0.012	0.005	-	-	0.17
H7	Jan/Feb	1967	10	2.8	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					0.004	0.001	0.006	0.012	0.006	<0.008	-	<0.024	0.15
					-	-	-	-	-	-	-	-	-
H3	Jan/Feb	1967	10	1.0	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					0.004	0.001	0.006	0.011	0.003	<0.008	-	<0.022	0.16
					-	-	-	-	-	-	-	-	-
H3	Jan/Feb	1967	10	2.3	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					0.005	0.001	0.006	0.009	0.004	<0.008	-	<0.021	0.14
					-	-	-	-	-	-	-	-	-
H8	Jan/Feb	<u>1968</u>	10	<u>3.0</u>	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					<u>0.004</u>	<u>0.002</u>	<u>0.007</u>	<u>0.007</u>	<u>0.010</u>	<u>&lt;0.008</u>	-	<u>&lt;0.025</u>	<u>0.056</u>
					-	-	-	-	-	-	-	-	-

Table 9b continued

Source	Date of collection	Year-class or size	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
NETHERLANDS (contd)													
H4	Jan/Feb	1968	10	3.7	-	-	-	-	-	-	-	-	-
					0.002	0.001	0.005	0.007	0.006	<0.008	-	<0.021	0.070
					-	-	-	-	-	-	-	-	-
H4	Jan/Feb	1968	10	6.8	-	-	-	-	-	-	-	-	-
					0.002	0.002	0.005	0.006	0.004	<0.020	-	<0.030	0.050
					-	-	-	-	-	-	-	-	-
H8	Jan/Feb	1969	10	1.6	-	-	-	-	-	-	-	-	-
					0.004	0.002	0.008	0.012	0.010	<0.008	-	<0.030	0.12
					-	-	-	-	-	-	-	-	-
H4	Jan/Feb	1969	10	4.0	-	-	-	-	-	-	-	-	-
					0.003	0.002	0.008	0.009	0.010	<0.008	-	<0.027	0.099
					-	-	-	-	-	-	-	-	-
H4	Jan/Feb	1969	10	6.3	-	-	-	-	-	-	-	-	-
					0.003	0.002	0.005	0.009	0.005	<0.020	-	<0.034	0.087
					-	-	-	-	-	-	-	-	-

Table 9b continued

Source	Date of collection	Year-class or size	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					α BHC	γ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	ΣDDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
BELGIUM													
G1	+	<u>1968</u>	3		-	0.003	0.008	0.003	<0.001	0.021	-	-	0.10
					-	0.009	0.011	0.019	0.016	0.022	-	-	0.22
					-	<u>0.007</u>	<u>0.009</u>	<u>0.009</u>	<u>0.006</u>	<u>0.022</u>	-	<u>0.037</u>	<u>0.16</u>
					-	-	-	-	-	-	-	-	-
G1	+	1969	14		-	0.003	0.007	<0.001	<0.001	0.004	-	-	0.08
					-	0.010	0.014	0.011	0.009	0.055	-	-	0.47
					-	0.007	0.010	0.006	0.003	0.025	-	0.034	0.22
					-	0.002	0.002	0.004	0.002	0.014	-	-	0.12
G1	+	1970	2		-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	0.006	0.010	0.004	0.015	0.026	-	0.045	0.20
					-	-	-	-	-	-	-	-	-
F1	+	1964	2		-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	0.007	0.005	0.011	0.003	0.028	-	0.042	0.15
					-	-	-	-	-	-	-	-	-
<hr/>													
ENGLAND													
L8	Feb	<u>1968</u>	12	1.1	<0.001	<0.001	0.001	0.001	0.002	0.002	-	-	<0.010
					0.003	0.002	0.006	0.007	0.008	0.015	-	-	0.180
					<u>0.002</u>	<u>0.001</u>	<u>0.004</u>	<u>0.005</u>	<u>0.005</u>	<u>0.007</u>	-	<u>0.017</u>	<u>0.081</u>
					0.001	0.001	0.001	0.002	0.002	0.004	-	-	0.054

+ 1971.

Table 9b continued

Source	Date of collection	Year-class or size	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
ENGLAND (contd)													
J6	Mar	<u>1968</u>	13	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	-	-	<0.010
					0.001	0.001	0.005	0.007	0.005	0.007	-	-	0.160
					<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>0.002</u>	<u>0.003</u>	<u>0.003</u>	<u>0.002</u>	-	<u>0.008</u>	<u>0.060</u>
					-	-	0.001	0.002	-	-	-	-	0.040
K8	Feb	<u>1968</u>	10	0.8	<0.001	<0.001	<0.001	0.001	<0.001	<0.002	-	-	0.020
					<0.001	<0.001	0.002	0.003	0.002	0.004	-	-	0.040
					<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>0.002</u>	<u>&lt;0.001</u>	<u>&lt;0.002</u>	-	<u>&lt;0.005</u>	<u>0.026</u>
					-	-	-	<0.001	-	-	-	-	0.008
K8	Feb	<u>1968</u>	5	0.6	<0.001	<0.001	<0.001	0.001	<0.001	<0.002	-	-	0.020
					<0.001	<0.001	<0.001	0.004	0.005	0.003	-	-	0.100
					<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>0.002</u>	<u>0.003</u>	<u>0.002</u>	-	<u>0.007</u>	<u>0.040</u>
					-	-	-	0.001	0.002	0.001	-	-	0.030
H7	Mar	<u>1968</u>	5	0.7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	-	-	0.016
					<0.001	<0.001	0.002	0.003	0.010	0.003	-	-	0.060
					<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>&lt;0.001</u>	<u>0.002</u>	<u>0.004</u>	<u>&lt;0.002</u>	-	<u>&lt;0.008</u>	<u>0.035</u>
					-	-	-	0.001	-	-	-	-	0.015
<hr/>													
SCOTLAND													
B-D18-20:	Jan/Feb	1967	10	0.2-	-	-	-	-	-	-	-	-	-
E19-20				0.6	-	-	-	-	-	-	-	-	-
					-	-	<0.002	0.002	<0.001	0.007	-	<0.010	0.017
					-	-	-	-	-	-	-	-	-

Table 9b continued

Source	Date of collection	Year-class or size	Number in sample	% fat	Concentration (in mg/kg, wet weight)								
					$\alpha$ BHC min max MEAN s.d.	$\gamma$ BHC min max MEAN s.d.	Dieldrin min max MEAN s.d.	ppDDE min max MEAN s.d.	ppTDE min max MEAN s.d.	ppDDT min max MEAN s.d.	opDDT min max MEAN s.d.	$\Sigma$ DDT min max MEAN s.d.	PCB min max MEAN s.d.
SCOTLAND (contd)													
A11: B11	Jan/Feb	1967	10	0.1-0.40	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	<0.002	0.002	0.002	0.007	-	0.011	0.025
					-	-	-	-	-	-	-	-	-



Table 9o(i) Herring (Clupea harengus). N.B. Underlined values indicate that the fish were of the selected year-class

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fresh weight basis)								
					$\alpha$ BHC min max MEAN s.d.	$\gamma$ BHC min max MEAN s.d.	Dieldrin min max MEAN s.d.	ppDDE min max MEAN s.d.	ppTDE min max MEAN s.d.	ppDDT min max MEAN s.d.	opDDT min max MEAN s.d.	$\Sigma$ DDT min max MEAN s.d.	PCB min max MEAN s.d.
	1972												
NORWAY													
F17	Feb	1971	10	6.4	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.010	<0.001	0.060	0.003	<0.074	-
					-	-	-	-	-	-	-	-	-
E16	Feb	1971	10	2.2	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.010	<0.001	0.030	0.003	<0.044	-
					-	-	-	-	-	-	-	-	-
E13	Feb	1971	10	3.4	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.009	<0.001	0.030	0.003	<0.043	-
					-	-	-	-	-	-	-	-	-
G13	Feb	1971	11	3.0	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.005	<0.001	0.030	0.004	<0.040	-
					-	-	-	-	-	-	-	-	-
F10	Feb	1971	5	3.2	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.010	<0.001	0.040	0.007	<0.058	-
					-	-	-	-	-	-	-	-	-

Table 9c(i) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fresh weight basis)								
					$\alpha$ BHC min max MEAN s.d.	$\gamma$ BHC min max MEAN s.d.	Dieldrin min max MEAN s.d.	ppDDE min max MEAN s.d.	ppTDE min max MEAN s.d.	ppDDT min max MEAN s.d.	opDDT min max MEAN s.d.	$\Sigma$ DDT min max MEAN s.d.	PCB min max MEAN s.d.
NORWAY (contd)													
G7	Feb	1971	7	2.7	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	0.035	0.041	0.002	0.078	<0.001
					-	-	-	-	-	-	-	-	-
G7	Feb	1972	4	8.0	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	0.025	0.038	0.002	0.065	0.19
					-	-	-	-	-	-	-	-	-
J7	Feb	1971	10	5.1	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.010	0.010	0.060	0.020	0.10	-
					-	-	-	-	-	-	-	-	-
H16	Mar	<u>1969</u>	2	4.6	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	<u>0.033</u>	<u>0.076</u>	<u>0.002</u>	<u>0.11</u>	<u>0.16</u>
					-	-	-	-	-	-	-	-	-
SWEDEN													
N13	Jan	<u>1969</u>	11	5.1	-	-	-	0.006	0.004	0.021	-	0.033	0.11
					-	-	-	0.059	0.041	0.10	-	0.20	0.36
					-	-	-	<u>0.023</u>	<u>0.017</u>	<u>0.052</u>	-	<u>0.092</u>	<u>0.23</u>
					-	-	-	0.018	0.012	0.031	-	0.060	0.10

Table 9c(i) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fresh weight basis)								
					$\alpha$ BHC min max MEAN s.d.	$\gamma$ BHC min max MEAN s.d.	Dieldrin min max MEAN s.d.	ppDDE min max MEAN s.d.	ppTDE min max MEAN s.d.	ppDDT min max MEAN s.d.	opDDT min max MEAN s.d.	$\Sigma$ DDT min max MEAN s.d.	PCB min max MEAN s.d.
1972													
SWEDEN (contd)													
Q14	Jan	1969	12	6.9	-	-	-	0.018	0.012	0.026	-	0.056	0.17
					-	-	-	0.074	0.096	0.10	-	0.23	0.65
					-	-	-	0.049	0.037	0.081	-	0.17	0.41
					-	-	-	0.019	0.022	0.034	-	0.061	0.15
R14	Jan	1969	12	3.3	-	-	-	0.008	0.004	0.018	-	0.030	0.08
					-	-	-	0.26	0.042	0.079	-	0.33	0.38
					-	-	-	0.055	0.015	0.039	-	0.11	0.18
					-	-	-	0.073	0.012	0.023	-	0.091	0.11
Q16	Jan	1970	1	9.8	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.032	0.020	0.058	-	0.11	0.27
					-	-	-	-	-	-	-	-	-
-----													
GERMANY													
J7	†		10	3.9	-	0.004	0.014	0.010	0.009	0.013	-	0.038	0.16
					-	0.005	0.024	0.014	0.016	0.020	-	0.049	0.18
					-	0.005	0.019	0.012	0.014	0.017	-	0.042	0.18
					-	<0.001	0.004	0.002	0.003	0.004	-	0.005	0.01
-----													
NETHERLANDS													
J5-6	Feb	1969	6	6.5	0.009	0.004	0.023	0.021	0.015	0.020	-	-	0.22
					0.014	0.009	0.045	0.032	0.029	0.038	-	-	0.58
					0.011	0.006	0.034	0.026	0.022	0.029	-	0.077	0.41
					0.001	0.002	0.008	0.003	0.005	0.007	-	-	0.13

† 1973.

Table 9c(i) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fresh weight basis)								
					$\alpha$ BHC min max MEAN s.d.	$\gamma$ BHC min max MEAN s.d.	Dieldrin min max MEAN s.d.	ppDDE min max MEAN s.d.	ppTDE min max MEAN s.d.	ppDDT min max MEAN s.d.	opDDT min max MEAN s.d.	$\Sigma$ DDT min max MEAN s.d.	PCB min max MEAN s.d.
1972													
<hr/>													
NETHERLANDS (contd)													
H2-5: J3-5	Jan	1968	10	7.9	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					0.043	0.024	0.040	0.078	0.043	0.025	-	0.15	0.48
					-	-	-	-	-	-	-	-	-
<hr/>													
ENGLAND													
F2	Apr	1969	8	10.4	<0.001 0.011 <0.005 -	<0.001 0.015 <0.006 -	<0.002 0.042 <0.017 0.016	0.004 0.080 0.040 0.021	0.010 0.062 0.026 0.017	<0.005 0.060 <0.031 0.018	- - - -	- - <0.097 -	0.090 1.50 0.48 0.424
E8	Feb	1969	10	3.3	<0.001 0.058 0.003 0.001	<0.001 0.024 0.002 <0.001	0.001 0.027 0.011 0.007	0.008 0.037 0.013 0.008	0.005 0.053 0.020 0.011	0.009 0.053 0.020 0.010	- - - -	- - 0.053 -	0.040 0.33 0.13 0.079
F10	Feb	1969	10	2.9	<0.001 0.008 0.004 <0.002	<0.001 0.004 0.002 0.001	<0.001 0.008 0.005 -	0.007 0.020 0.014 0.004	0.002 0.033 0.012 0.009	0.002 0.040 0.014 0.012	- - - -	- - 0.040 -	0.040 0.21 0.12 0.043
F6	Feb	1969	10	2.9	0.001 0.005 0.004 0.002	0.001 0.003 0.002 0.001	<0.001 <0.001 <0.001 -	0.007 0.020 0.014 0.005	0.005 0.036 0.017 0.010	0.003 0.008 0.005 0.002	- - - -	- - 0.036 -	0.07 0.24 0.15 0.053

Table 9c(i) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fresh weight basis)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
SCOTLAND													
B-D18-20:	Jan/Feb	1968/ 69	10	4.9	-	-	0.002	0.007	0.003	0.007	-	-	0.040
E19-20					-	-	0.007	0.021	0.020	0.032	-	-	0.13
					-	-	0.004	0.013	0.006	0.016	-	0.035	0.078
					-	-	0.002	0.005	0.005	0.009	-	-	0.040
A14	Apr	1969/ 70	10	6.1	-	-	0.003	0.006	<0.005	0.033	-	-	0.020
					-	-	0.015	0.024	0.010	0.10	-	-	0.16
					-	-	0.007	0.014	<0.006	0.056	-	<0.076	0.078
					-	-	0.003	0.006	-	0.024	-	-	0.041

Table 9c(ii) Herring (Clupea harengus). N.B. Underlined values indicate that the fish were of the selected year-class

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fat weight basis)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
NORWAY													
F17	Feb	1971	10	6.4	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.10	<0.001	0.90	0.040	1.0	-
					-	-	-	-	-	-	-	-	-
E16	Feb	1971	10	2.2	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.40	<0.001	1.2	0.20	1.8	-
					-	-	-	-	-	-	-	-	-
E13	Feb	1971	10	3.4	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.30	0.010	0.80	0.10	1.2	-
					-	-	-	-	-	-	-	-	-
G13	Feb	1971	11	3.0	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.20	<0.001	0.90	0.10	1.2	-
					-	-	-	-	-	-	-	-	-
F10	Feb	1971	5	3.2	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.40	<0.004	1.3	0.20	1.9	-
					-	-	-	-	-	-	-	-	-

Table 9c(ii) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fat weight basis)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
NORWAY (contd)													
G7	Feb	1971	7	2.7	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	1.33	1.6	0.072	2.9	0.04
					-	-	-	-	-	-	-	-	-
G7	Feb	1970	4	8.0	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	0.35	0.48	0.026	0.86	2.3
					-	-	-	-	-	-	-	-	-
J7	Feb	1971	10	5.1	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.20	0.10	1.2	0.30	1.8	-
					-	-	-	-	-	-	-	-	-
H16	Mar	<u>1969</u>	2	4.6	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	-	<u>0.73</u>	<u>1.7</u>	<u>0.044</u>	<u>2.4</u>	<u>3.5</u>
					-	-	-	-	-	-	-	-	-
<hr/>													
SWEDEN													
N13	Jan	<u>1969</u>	11	5.1	-	-	-	0.15	0.18	0.51	-	0.9	2.6
					-	-	-	1.7	1.2	3.0	-	6.0	11
					-	-	-	<u>0.54</u>	<u>0.46</u>	<u>1.2</u>	-	<u>2.1</u>	<u>5.4</u>
					-	-	-	0.52	0.37	1.0	-	1.9	3.1

Table 9c(ii) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fat weight basis)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
SWEDEN (contd)													
Q14	Jan	<u>1969</u>	12	6.9	-	-	-	0.34	0.23	0.52	-	1.1	3.3
					-	-	-	2.4	1.5	2.6	-	7.2	18
					-	-	-	<u>0.84</u>	<u>0.58</u>	<u>1.3</u>	-	<u>2.7</u>	<u>6.9</u>
					-	-	-	0.58	0.35	0.81	-	1.7	4.1
R14	Jan	<u>1969</u>	12	3.3	-	-	-	0.23	0.19	0.45	-	0.9	2.0
					-	-	-	11	0.73	2.5	-	13	15
					-	-	-	<u>2.2</u>	<u>0.46</u>	<u>1.3</u>	-	<u>4.0</u>	<u>6.4</u>
					-	-	-	3.3	0.25	0.69	-	3.8	4.0
Q16	Jan	1970	1	9.8	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	-	-	0.29	0.19	0.54	-	1.1	2.7
					-	-	-	-	-	-	-	-	-
<hr/>													
GERMANY													
J7	†		10	3.9	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					-	0.13	0.49	0.31	0.36	0.44	-	1.08	4.6
					-	-	-	-	-	-	-	-	-
<hr/>													
NETHERLANDS													
J5-6	Feb	<u>1969</u>	6	6.5	0.14	0.08	0.38	0.35	0.25	0.32	-	-	3.6
					0.20	0.13	0.61	0.54	0.38	0.58	-	-	9.6
					<u>0.18</u>	<u>0.10</u>	<u>0.52</u>	<u>0.41</u>	<u>0.34</u>	<u>0.45</u>	-	<u>0.12</u>	<u>6.6</u>
					0.02	0.02	0.09	0.07	0.05	0.09	-	-	2.5

† 1973.



Table 9c(ii) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fat weight basis)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
	1972				min	min	min	min	min	min	min	min	min
					max	max	max	max	max	max	max	max	max
					MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	MEAN
					s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
<hr/>													
NETHERLANDS (contd)													
H2-5: J3-5	Jan	1968	10	7.9	-	-	-	-	-	-	-	-	-
					-	-	-	-	-	-	-	-	-
					0.54	0.31	0.51	0.98	0.54	<0.32	-	<1.8	7.3
					-	-	-	-	-	-	-	-	-
<hr/>													
ENGLAND													
F2	Apr	1969	8	10.4	<0.009	<0.009	<0.023	0.036	0.091	<0.073	-	-	0.80
					0.081	0.10	0.36	0.82	0.43	0.61	-	-	6.4
					<0.087	<0.054	<0.18	0.41	0.26	<0.29	-	<0.96	3.2
					-	-	0.16	0.23	0.14	0.20	-	-	0.17
E8	Feb	1969	10	3.3	0.029	0.021	0.086	0.18	0.11	0.21	-	-	1.2
					0.17	0.11	0.62	0.71	0.95	1.1	-	-	5.9
					0.089	0.054	0.31	0.45	0.44	0.67	-	1.6	4.0
					0.049	0.025	0.15	0.19	0.26	0.29	-	-	1.8
F10	Feb	1969	10	2.9	0.064	0.040	<0.042	0.16	0.11	0.18	-	-	1.6
					0.24	0.13	0.28	1.9	0.64	0.70	-	-	17
					0.11	0.062	<0.13	0.70	0.42	0.41	-	1.5	6.0
					0.049	0.026	-	0.58	0.17	0.15	-	-	4.3
F6	Feb	1969	10	2.9	0.071	0.036	0.017	0.19	0.13	0.064	-	-	2.1
					0.27	0.31	0.25	4.5	3.7	0.78	-	-	37
					0.15	0.11	<0.062	0.91	0.92	0.27	-	2.1	8.6
					0.073	0.092	0.087	1.3	1.0	0.25	-	-	10
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Table 9c(ii) continued

Source	Date of collection	Year-class	Number in sample	% fat	Concentration (in mg/kg, fat weight basis)								
					$\alpha$ BHC min max MEAN s.d.	$\gamma$ BHC min max MEAN s.d.	Dieldrin min max MEAN s.d.	ppDDE min max MEAN s.d.	ppTDE min max MEAN s.d.	ppDDT min max MEAN s.d.	opDDT min max MEAN s.d.	$\Sigma$ DDT min max MEAN s.d.	PCB min max MEAN s.d.
	1972												
SCOTLAND													
B-D18-20:	Jan/Feb	1968/	10	4.9	-	-	0.03	0.08	0.04	0.1	-	-	0.6
E19-20		69			-	-	0.15	0.80	0.35	1.0	-	-	4.9
					-	-	0.074	0.30	0.12	0.36	-	0.78	1.7
					-	-	-	-	-	-	-	-	-
A14	Apr	1969/	10	6.1	-	-	0.06	0.09	<0.05	0.5	-	-	0.4
		70			-	-	0.30	0.45	0.17	1.8	-	-	2.8
					-	-	0.12	0.23	<0.10	0.94	-	<1.3	1.3
					-	-	-	-	-	-	-	-	-

Table 9d Mussel (Mytilus edulis). N.B. Underlined values indicate that the fish were of the selected size range

Source	Date of collection 1972	Size range (mm)	Number in sample	% fat	Mean concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
NORWAY													
K17	Dec <sup>†</sup>	50-60	59	0.8	-	-	-	-	<0.001	0.024	0.002	<0.027	0.04
K15	Dec <sup>†</sup>	50-60	157	1.2	-	-	-	-	0.008	0.015	0.002	0.025	0.02
<hr/>													
SWEDEN													
Seläter Idefjord		45-50	12	0.8				0.088		-		0.088	0.094
Katteholmen, Singlefjord		45-50	12	1.0				0.020		-		0.020	0.057
Korsholmen, N. Koster		51-55 56-60	12 12	0.7 0.9				0.041 0.003		- -		0.041 0.003	0.050 0.029
Fjällbacka Harbour		51-55	12	2.3				0.019	0.008	-		0.027	0.039
Dyngö Fjällbacka archipelago		51-55 56-60	12 12	1.6 1.5				0.011 0.003	0.002 0.001	- -		0.013 0.004	0.015 0.013
Måsekär		51-55	12	1.0				0.004		-		0.004	0.044
Lerskiten, Askeröfjord		51-55 56-60	12 12	1.6 1.4				0.004 0.002	0.003 0.003	- -		0.007 0.005	0.13 0.12
St Dyrön, Älgöfjord		51-55 56-60	12 12	1.4 1.4				0.003 0.006	0.001 0.001	- -		0.004 0.007	0.11 0.10
Pater Noster		51-55 56-60	12 12	1.0 1.1				0.004 0.003	- -	- -		0.004 0.003	0.040 0.038
KA4 Älvsborgsfjord		51-55 56-60	12 12	1.3 1.2				0.006 0.004	0.006 0.005	- -		0.012 0.009	0.22 0.19
Skalkongarna		45-50	12	1.7				0.004	0.004	-		0.008	0.17
Hakefjord		51-55 56-60 61-65	12 12 12	1.6 1.6 1.5				0.005 0.008 0.004	0.005 0.004 0.005	- - -		0.010 0.012 0.009	0.19 0.17 0.18

+ 1971.

Table 9d continued

Source	Date of collection 1972	Size range (mm)	Number in sample	% fat	Mean concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
SWEDEN (contd)													
Kalvön Kungsbfjord		56-60	12	1.1				0.003	0.001	-		0.004	0.049
Onsala Peninsula, southern end		56-60	12	1.0				0.003	0.001	-		0.004	0.047
GERMANY													
M6	May	55-65	100	1.37	-	0.011	0.003	0.012	0.013	0.008	-	0.033	0.121
M6	May	55-65	100	1.23	-	0.006	0.003	0.009	0.010	0.007	-	0.025	0.092
M6	May	55-65	100	1.34	-	0.010	0.003	0.008	0.010	0.005	-	0.023	0.096
N7-8	May	55-65	100	0.60	-	0.001	0.007	0.008	0.007	0.002	-	0.017	0.072
N7-8	May	55-65	100	0.86	-	0.002	0.013	0.007	0.012	0.004	-	0.023	0.075
N7-8	May	55-65	100	1.13	-	0.002	0.019	0.008	0.015	0.005	-	0.028	0.066
N7	Nov <sup>†</sup>	55-65	100	0.81	-	-	0.001	0.014	0.007	0.006	-	0.027	0.112
NETHERLANDS													
K5	Oct	60-70	100	1.6	0.005	0.003	0.009	0.002	0.006	0.002	-	0.010	0.237
H2	Jan	<u>55-60</u>	100	4.5	<u>0.011</u>	<u>0.006</u>	<u>0.010</u>	<u>0.024</u>	<u>0.008</u>	<u>&lt;0.008</u>	-	<u>&lt;0.040</u>	<u>0.390</u>
J4	Jan	<u>55-60</u>	100	4.6	<u>0.013</u>	<u>0.004</u>	<u>0.006</u>	<u>0.016</u>	<u>0.003</u>	<u>&lt;0.008</u>	-	<u>&lt;0.027</u>	<u>0.298</u>
ENGLAND													
E4	Dec <sup>†</sup>	51-64	60	1.0	0.001	0.002	<0.001	0.007	0.010	<0.002	-	<0.019	0.06
E2	Nov <sup>†</sup>	54-62	72	1.0	<0.001	0.002	0.001	0.012	0.018	<0.002	-	<0.032	0.21
E4	Oct <sup>†</sup>	51-65	60	1.6	0.001	0.001	0.001	0.007	0.012	<0.002	-	<0.021	0.08
D7	Nov <sup>†</sup>	<u>55-60</u>	82	1.4	<u>0.001</u>	<u>0.001</u>	<u>&lt;0.001</u>	<u>0.008</u>	<u>0.017</u>	<u>0.005</u>	-	<u>0.030</u>	<u>0.08</u>

† 1971.

Table 9d continued

Source	Date of collection 1971	Size range (mm)	Number in sample	% fat	Mean concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
ENGLAND (contd)													
D7	Nov	55-60	60	1.4	<0.001	<0.001	<0.001	0.004	0.016	0.006	-	0.026	0.08
E2	Oct	55-60	80	1.0	0.001	0.002	<0.001	0.009	0.011	0.003	-	0.023	0.15
F4	Nov	58-68	50	1.2	0.002	0.002	<0.001	0.005	0.007	<0.002	-	<0.014	0.06
C10	Nov	55-63	50	1.2	<0.001	0.001	<0.001	0.003	0.003	<0.002	-	<0.008	0.04
E4	Nov	50-58	50	1.6	0.002	0.003	<0.001	0.005	0.007	<0.002	-	<0.014	0.02
C8	Nov	55-64	50	2.0	0.001	0.003	<0.001	0.005	0.012	<0.002	-	<0.019	0.12

Table 9e Brown shrimp (Crangon crangon). N.B. Underlined values indicate that the fish were of the selected size range

Source	Date of collection 1972	Size range (mm)	Number in sample	% fat	Mean concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
NORWAY <sup>†</sup>													
J22	Jan	70-120		1.02	-	-	-	<0.001	<0.001	0.016	0.001	<0.019	-
Q17	Dec	70-95		1.05	-	-	-	-	0.008	0.009	<0.001	<0.018	0.05
J16	Dec	80-140		0.96	-	-	-	-	0.009	0.011	<0.001	<0.021	0.06
GERMANY													
M6	Apr	55	100	1.3	-	-	0.003	0.004	0.009	0.002	-	0.015	0.078
M6	Apr	55	100	0.92	-	-	0.002	0.003	0.008	0.002	-	0.013	0.038
M6	Apr	55	100	0.67	-	0.001	0.002	0.003	0.007	0.002	-	0.012	0.042
N6	May	55	100	0.49	-	-	0.001	0.003	0.007	0.001	-	0.011	0.033
M6	Apr	55	100	0.72	-	0.001	0.001	0.002	0.007	0.001	-	0.010	0.034
M6	May	55	100	1.11	-	0.001	0.001	0.002	0.008	0.003	-	0.013	0.042
N6	May	55	100	0.82	-	-	0.001	0.001	0.007	0.004	-	0.012	0.034
N6	May	55	100	0.75	-	-	-	0.001	0.010	0.004	-	0.015	0.039
N6	May	55	100	0.63	-	0.01	0.001	0.001	0.014	0.004	-	0.019	0.024
N6	Oct	55	100	0.48	-	0.006	0.006	0.006	0.003	0.007	-	0.016	0.081
NETHERLANDS													
J5	Oct	55-65	100	1.2	0.005	0.001	0.002	0.002	0.001	-	-	0.003	0.083
J5	Jan	55- ?	100	1.2	0.006	0.002	0.002	0.003	<0.003	<0.008	-	<0.014	0.091
L5	Oct	<u>55-60</u>	100	<u>1.5</u>	<u>0.005</u>	<u>0.002</u>	<u>0.008</u>	<u>&lt;0.005</u>	<u>&lt;0.003</u>	<u>&lt;0.008</u>	-	<u>&lt;0.016</u>	<u>0.11</u>
J3	Oct	<u>55-60</u>	100	<u>0.9</u>	<u>0.005</u>	<u>0.001</u>	<u>0.004</u>	<u>&lt;0.005</u>	<u>&lt;0.003</u>	<u>&lt;0.008</u>	-	<u>&lt;0.016</u>	<u>0.20</u>
H2	Oct	<u>55-60</u>	100	<u>1.0</u>	<u>0.005</u>	<u>0.001</u>	<u>0.002</u>	<u>&lt;0.005</u>	<u>&lt;0.003</u>	<u>&lt;0.008</u>	-	<u>&lt;0.016</u>	<u>0.13</u>

‡ The shrimps analysed were probably Pandalid species, not Crangon.

Table 9e continued

Source	Date of collection 1971	Size range (mm)	Number in sample	% fat	Mean concentration (in mg/kg, wet weight)								
					$\alpha$ BHC	$\gamma$ BHC	Dieldrin	ppDDE	ppTDE	ppDDT	opDDT	$\Sigma$ DDT	PCB
BELGIUM													
G1		55	10		-	0.006	0.007	0.003	0.001	0.019	-	0.023	0.080
ENGLAND													
E4	Oct	60-70	80	0.8	0.001	<0.001	<0.001	0.001	<0.001	<0.002	-	<0.004	0.02
D6	Nov	60-70	78	1.2	<0.001	0.001	<0.001	0.001	0.015	0.003	-	0.019	0.06
F4	Oct	55-70	85	1.4	0.002	<0.001	<0.001	0.006	<0.001	0.003	-	<0.010	0.04
E2	Oct	50-60	100	1.0	0.001	<0.001	<0.001	<0.001	<0.001	<0.002	-	<0.004	<0.01

Table 10 Methods for heavy metals analysis used in Base-Line Survey

Metals	Weight	Ash	Other treatment	Volume used	Atomic absorption		Standards	
					Type	Background correction	Compound	Frequency of preparation
NORWAY: The Official Norwegian Quality Control Institute for Canned Fish Products								
Hg*	2 g wet wt	WET, H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> KMnO <sub>4</sub>	Dilute to 100 ml; reduce to 50 ml with SnCl <sub>2</sub>	50 ml	Flameless	No		Not stated
Zn, Cu <sup>+</sup>	2 g wet wt	WET, H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> KMnO <sub>4</sub>	Dilute to 100 ml; reduce to 50 ml with SnCl <sub>2</sub>	50 ml	Flame, air/C <sub>2</sub> H <sub>2</sub>	No		Not stated, but by addition to sample solutions
Cd, Pb <sup>+</sup>	10 g	DRY, 450-500°C	Dissolve in HCl; dilute	Varies according to sample	Flame, air/C <sub>2</sub> H <sub>2</sub>			Not stated, but by addition to sample solutions
-----								
SWEDEN: Environment Protection Board Research Laboratory, Drottningholm								
Hg	1 g wet wt in duplicate	WET, Cold Na OH NaCl + 10:2 HClO <sub>4</sub> /HNO <sub>3</sub> at 70°C	Dilute to 50 ml	25 ml			BDH standard for AAS	Daily
Cr, Pb, Zn Cu, Co, Cd	1 g wet wt in duplicate	WET, Cold Na OH NaCl + 10:2 HClO <sub>4</sub> /HNO <sub>3</sub> at 70°C		25 ml	Flame, air/C <sub>2</sub> H <sub>2</sub>	Reference sample only	BDH standards in 2N HNO <sub>3</sub>	

\* Blank subtracted.

+ Metals extracted from dry ash sample with APDC; residue used as blank.



Table 10 continued

Metals	Weight	Ash	Other treatment	Volume used	Atomic absorption		Standards	
					Type	Background correction	Compound	Frequency of preparation
GERMANY: Bundesforschungsanstalt für Fisherei, Hamburg Isotopenlaboratorium								
Cu, Zn Fe, Mn	100 g wet wt fish; 5 g wet wt shellfish	DRY, 450°C	Add 10 ml 5N HCl; dry on sand bath; repeat with 5 ml 5N HNO <sub>3</sub> ; dissolve in 20 ml 2N HNO <sub>3</sub> ; filter	Dilute to appropriate volume	Flame, air/H <sub>2</sub>	No	Merck standard solutions	
NETHERLANDS: Rijksinstituut voor Visserijonderzoek (RIVO) ITAL, Keyenkagseweg 6, Wageningen								
Σ Hg	0.5-2.0 g wet wt	WET, H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> 1:3, 30 min	10 ml K <sub>2</sub> S <sub>2</sub> O <sub>8</sub> ; aerate 2 min; reduce with NaCl/ hydroxylamine hydrochloride/ SnCl <sub>2</sub>	Whole	Flameless	D <sub>2</sub>		
NETHERLANDS: Institute for Sea Research								
Hg	1 g wet wt	WET, H <sub>2</sub> SO <sub>4</sub> , 2 hours, 55°C (shellfish overnight)	Permanganate, reductant in 100 ml	Whole	Flameless	No		
Zn, Fe	4 g wet wt	WET, HNO <sub>3</sub> HClO <sub>4</sub> , 4 hours, 90°C	Dilute to 100 ml			No		

Table 10 continued

Metals	Weight	Ash	Other treatment	Volume used	Atomic absorption		Standards	
					Type	Background correction	Compound	Frequency of preparation
BELGIUM: Institut de Recherches Chimiques, Tervuren								
Hg	3 g wet wt	WET, H <sub>2</sub> SO <sub>4</sub> H <sub>2</sub> O <sub>2</sub>	Dilute to 100 ml; 95 ml → 150 ml with H <sub>2</sub> O; add 10 d; KMnO <sub>4</sub> 2 ml NaBH <sub>4</sub>	Whole	Flameless		HgCl <sub>2</sub> in H <sub>2</sub> SO <sub>4</sub>	Calibrations checked daily, replaced weekly
Cu	3 g wet wt	WET, H <sub>2</sub> SO <sub>4</sub> H <sub>2</sub> O <sub>2</sub>	5 ml of Hg solution used	10 or 20 µl	Carbon furnace		Cu from electrolysis in H <sub>2</sub> SO <sub>4</sub>	
Pb	3 g	DRY, 450°C, 5 hours	Add 5 ml HNO <sub>3</sub> , 2.5 ml H <sub>2</sub> O <sub>2</sub> ; make up to 100 ml, 20 or 50 µl		Carbon furnace		PbO specpure in HNO <sub>3</sub> /H <sub>2</sub> O <sub>2</sub>	
Zn	3 g	DRY, 450°C, 5 hours	Add 5 ml HNO <sub>3</sub> , 2.5 ml H <sub>2</sub> O <sub>2</sub> ; make up to 100 ml, 20 or 50 µl		Flame, air/C <sub>2</sub> H <sub>2</sub>		ZnO specpure in HNO <sub>3</sub> /H <sub>2</sub> O <sub>2</sub>	
FRANCE: Institut Scientifique et Technique des Pêches Maritimes, Nantes								
Hg	0.4-0.7 g wet wt	WET, HNO <sub>3</sub> H <sub>2</sub> SO <sub>4</sub> 2 hours, 50-60°C	KMnO <sub>4</sub> , 3 hours; add 50 ml H <sub>2</sub> SO <sub>4</sub> / hydroxylamine hydrochloride/ SnCl <sub>2</sub>		Flameless		HgCl <sub>2</sub> in HNO <sub>3</sub>	Daily

Table 10 continued

Metals	Weight	Ash	Other treatment	Volume used	Atomic absorption		Standards	
					Type	Background correction	Compound	Frequency of preparation
FRANCE (contd)								
Cd, Zn Cu, Pb Cr	2-5 g wet wt	WET, HNO <sub>3</sub> HClO <sub>4</sub>	Dilute to 25 ml with 5N HCl		Flame, air/C <sub>2</sub> H <sub>2</sub>		Fisher standard solutions in 5N HCl	2-3 months
-----								
ENGLAND: Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Burnham-on-Crouch								
Hg	0.4-0.6 g wet wt	WET, HNO <sub>3</sub> H <sub>2</sub> SO <sub>4</sub> 12 hours, 60°C	KMnO <sub>4</sub> , 40% SnCl <sub>2</sub> in 5N HCl	Whole	Flameless	Sometimes	HgCl <sub>2</sub>	Weekly
Cu, Zn Cr, Cd	5 g wet wt	WET, HNO <sub>3</sub> 12 hours, 60°C	Dilute to 50 ml		Flame, air/C <sub>2</sub> H <sub>2</sub>	No	CuSO <sub>4</sub> 5H <sub>2</sub> O ZnSO <sub>4</sub> 7H <sub>2</sub> O K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> CdCl <sub>2</sub> 2½H <sub>2</sub> O	Weekly
Pb	5 g wet wt	WET, HNO <sub>3</sub> 12 hours, 60°C	Dilute to 50 ml; 25 ml extracted in APDC/MiBK		Flame, air/C <sub>2</sub> H <sub>2</sub>	No	Pb(NO <sub>3</sub> ) <sub>2</sub> ; extracted in APDC/MiBK	Daily
-----								
SCOTLAND: Department of Agriculture and Fisheries for Scotland, Freshwater Fisheries Laboratory, Pitlochry								
Hg		WET, HNO <sub>3</sub> H <sub>2</sub> SO <sub>4</sub>	SnCl <sub>2</sub> reductant	5 ml		No	HgCl <sub>2</sub> in H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub>	Daily

Table 10 continued

Metals	Weight	Ash	Other treatment	Volume used	Atomic absorption		Standards	
					Type	Background correction	Compound	Frequency of preparation
SCOTLAND: Department of Agriculture and Fisheries for Scotland, Fisheries Laboratory, Aberdeen								
Pb, Zn Cd, Cu	10 g	WET HNO <sub>3</sub> HClO <sub>4</sub> 12 hours, 140-150°C	Reduce volume by heat to 5 ml; dilute to 25 ml		Flame, air/C <sub>2</sub> H <sub>2</sub>	Pb and Cd only	BDH standards	Daily

Table 11 Methods for organochlorine pesticide and PCB analysis used in Base-Line Survey

NORWAY: Institute of Marine Research, Bergen

Extractions

Solvent: homogenize with 125 ml petroleum-ether + 2 x 50 ml leachings

Extraction: -

Time: -

Clean-up

Partition: celite  $H_2SO_4$

Column: -

Pre-gas liquid chromatography separation

Column: -

Solvent: n-pentane and acetone

TLC: Merck 60F<sub>254</sub>

Gas liquid chromatography (GLC)

Column 1

Gas: Argon + 5%  $CH_4$

Packing: 11% QF1 + OV.17 on Gaschrom Q

Length and ID: 200 cm, 4 mm

Temperature: 190°C

Detector:  $H^3$

Column 2

Gas:  $N_2$

Packing: 1.5% SP2250 + 1.95% SP2401 on Superclo AW DMCS

Length and ID: 200 cm, 4 mm

Temperature: 200°C

Detector:  $H^3$

Confirmation

GLC: 2 cols

Chem.: -

TLC: -

PCB

Formulation: Clophen A50

No. of peaks: 5

DDE corrected for PCB: -

As reference method?: Yes

-----  
SWEDEN: Environment Protection Board, Special Analytical Laboratory,  
Stockholm

Extractions

Solvent: 25 ml acetone, 10 ml  $C_6H_{14}$  + 2 x 25 ml  $C_6H_{14}$ /ether 90:10

Extraction: -

Time: -

Clean-up

Partition:  $H_2SO_4$  destruction of fat

Column: -

Pre-gas liquid chromatography separation

Column: -

Solvent: -

TLC: -

Table 11 continued

SWEDEN (contd)

Gas liquid chromatography (GLC)

Column 1

Gas: 10% CH<sub>4</sub> in Argon

Packing: 8% QF1 + 4% SF 96 on 100/120 mesh, silanized, acid-washed  
Chromosorb W

Length and ID: 160 cm

Temperature: 180°C

Detector: Ni<sup>63</sup>

Confirmation

GLC: -

Chem.: -

TLC: -

PCB

Formulation: Clophen A50

No. of peaks: 14

DDE corrected for PCB: not usually

As reference method?: Yes

-----  
GERMANY: Bundesforschungsanstalt für Küsten und Binnen Fischerei,  
Hamburg

Extractions

Solvent: C<sub>6</sub>H<sub>14</sub>

Extraction: Soxhlet

Time: -

Clean-up

Partition: C<sub>6</sub>H<sub>14</sub>

Column: alumina

Pre-gas liquid chromatography separation

Column: silica

Solvent: 1.n-C<sub>6</sub>H<sub>14</sub>:C<sub>4</sub>H<sub>10</sub>O

TLC: -

Gas liquid chromatography (GLC)

Column 1

Gas: -

Packing: 5% DCF-S 1265 + 4% DC 200 on Chromosorb W, AW-DMCS 80/100

Length and ID: 1.4 m

Temperature: -

Detector: -

Column 2

Gas: -

Packing: 10% silicon DC 200 Chromosorb W, AW-DMCS 80/100

Length and ID: 2 mm

Temperature: 200 C

Detector: H<sup>3</sup>

Confirmation

GLC: 3 cols

Chem.: -

TLC: -

Table 11 continued

---

GERMANY (contd)

PCB

Formulation: Aroclor 1254

No. of peaks: 4

DDE corrected for PCB: No

As reference method?: Yes

Notes: PCB on column 1 only

---

NETHERLANDS: Institute for Sea Research, Texel

Extractions

Solvent: Pentane

Extraction: Soxhlet

Time: 5 hours

Clean-up

Partition: n-C<sub>6</sub>H<sub>14</sub>

Column: alumina

Pre-gas liquid chromatography separation

Column: silica

Solvent: 1.n-C<sub>6</sub>H<sub>14</sub>, 2.n-C<sub>6</sub>H<sub>14</sub>:C<sub>4</sub>H<sub>10</sub>O

TLC: -

Gas liquid chromatography (GLC)

Column 1

Gas: -

Packing: 2% OV 1/3% OV 210 on supercoport 100-120 mesh

Length and ID: 6 ft, 2.8 mm

Temperature: 200°C

Detector: Ni<sup>63</sup>

Column 2

Gas: -

Packing: 1% OV 17/4% OV 210 on Gaschrom Q 80-100 mesh

Length and ID: 6 ft, 2.8 mm

Temperature: 200°C

Detector: Ni<sup>63</sup>

Confirmation

GLC: 2 cols

Chem.: -

TLC: -

PCB

Formulation: Aroclor 1254

No. of peaks: 1

DDE corrected for PCB: No

As reference method?: Yes

Notes: Fraction 1 on column 1; fraction 2 on column 2

Table 11 continued

NETHERLANDS: Rijksuivelstation, Leiden

Extractions

Solvent: Pentane  
Extraction: Soxhlet  
Time: 8 hours

Clean-up

Partition: Pentane  
Column: Alumina

Pre-gas liquid chromatography separation

Column: Silica  
Solvent: 1.n-C<sub>6</sub>H<sub>14</sub>:C<sub>6</sub>H<sub>6</sub>, 2.n-C<sub>6</sub>H<sub>14</sub> ether  
TLC: -

Gas liquid chromatography (GLC)

Column 1

Gas: N<sub>2</sub>  
Packing: 3% OV 210/OV 17 on Gaschrom Q 100-120 mesh  
Length and ID: 1.8 m, 2 mm  
Temperature: 195°C  
Detector: H<sub>3</sub>

Column 2

Gas: N<sub>2</sub>  
Packing: 3% DEGS-1% phosphoric acid on Gaschrom Q 100-120 mesh  
Length and ID: 1.8 m, 2 mm  
Temperature: 195°C  
Detector: H<sub>3</sub>

Confirmation

GLC: 2 cols  
Chem.: -  
TLC: -

PCB

Formulation: Aroclor 1254  
No. of peaks: 2

DDE corrected for PCB: No

As reference method?: -

Notes: -

-----  
BELGIUM: Station de Phytopharmacie, Gembloux

Extractions

Solvent: petroleum-ether  
Extraction: non-siphoning  
Time: 6 hours

Clean-up

Partition: petroleum-ether  
Column: alumina

or

Partition: DMF  
Column: liquid liquid

or

Partition: petroleum-ether:diethyl-ether  
Column: Florisil



Table 11 continued

BELGIUM (contd)

Pre-gas liquid chromatography separation

Column: silica acid celite

Solvent: 1. petroleum-ether; 2. petroleum-ether acetonitrile  
dichloroethane

Eluate 2

Column: alumina

Solvent: 1. 2 ml petroleum-ether; 2. 5 ml petroleum-ether

TLC: -

Gas liquid chromatography (GLC)

Column 1

Gas: N<sub>2</sub>

Packing: 4% OV 1/6% QF Chromosorb W 80/100 mesh

Length and ID: 1.8 m, 3 mm

Temperature: 170°C

Detector: H<sub>3</sub>

Confirmation

GLC: -

Chem.: alcoholic NaOH hydrolysis

TLC: -

PCB

Formulation: Aroclor 1254

No. of peaks: 5

DDE corrected for PCB: -

As reference method?: Yes

-----  
ENGLAND: Ministry of Agriculture, Fisheries and Food, Fisheries  
Laboratory, Burnham-on-Crouch

Extractions

Solvent: hexane

Extraction: soxhlet

Time: 2 hours

Clean-up

Partition: hexane

Column: alumina

Pre-gas liquid chromatography separation

Column: silica

Solvent: 1. hexane; 2. hexane:diethyl-ether

TLC: -

Gas liquid chromatography (GLC)

Column 1

Gas: N<sub>2</sub>

Packing: 4% DC 200 + 6% QF1 on 80/100 mesh Chromosorb W, AW DMCS

Length and ID: 6 ft

Temperature: -

Detector: H<sub>3</sub>

Table 11 continued

---

ENGLAND (contd)

Gas liquid chromatography (GLC)

Column 2

Gas: N<sub>2</sub>

Packing: 8% DC 200 on 80/100 mesh Chromosorb W, AW DMCS

Length and ID: 6 ft

Temperature: -

Detector: H<sub>3</sub>

Confirmation

GLC: 2 cols

Chem.: -

TLC: -

PCB

Formulation: Aroclor 1254

No. of peaks: 3

DDE corrected for PCB: No

As reference method?: Yes

-----  
SCOTLAND: Department of Agriculture and Fisheries for Scotland,  
Freshwater Fisheries Laboratory, Pitlochry

Extractions

Solvent: hexane

Extraction: soxhlet

Time: 1 hour

Clean-up

Partition: hexane

Column: alumina

Pre-gas liquid chromatography separation

Column: silica

Solvent: 1. hexane; 2. hexane:petroleum ether

TLC: -

Gas liquid chromatography (GLC)

Column 1

Gas: N<sub>2</sub>

Packing: 6% DC 200 on Chromosorb W-HP

Length and ID: 6 ft

Temperature: -

Detector: H<sub>3</sub>

Column 2

Gas: N<sub>2</sub>

Packing: 4% DC 200 + 6% QF1 on Chromosorb W-HP

Length and ID: 6 ft

Temperature: -

Detector: H<sub>3</sub>

Confirmation

GLC: 2 cols

Chem.: -

TLC: -

Table 11 continued

---

SCOTLAND (contd)

PCB

Formulation: Usually Aroclor 1254

No. of peaks: 4

DDE corrected for PCB: Yes, on reference sample only

As reference method?: Yes

Notes: PCB on 1 column only

---

#### NOTES ON FIGURES

Figures 2-11 give the concentrations of certain metals, organochlorine pesticide residues and PCBs in fish muscle and shellfish. These concentrations are calculated on a wet weight basis, except in the case of herring where the concentrations of dieldrin,  $\Sigma$ DDT and PCBs are given both on a fresh weight and a fat weight basis.

In cases where the sample was reported as coming from a group of statistical rectangles rather than from one particular rectangle, the group has been indicated by diagonal shading and the concentration value placed in the middle of the shading.

Values for samples from the selected year-class or size range are underlined.

The mean value for each statistical rectangle is usually given but in some cases, where more than one sample was taken in a particular rectangle and one sample was much larger than the other, the value of the larger sample is given instead of the mean.

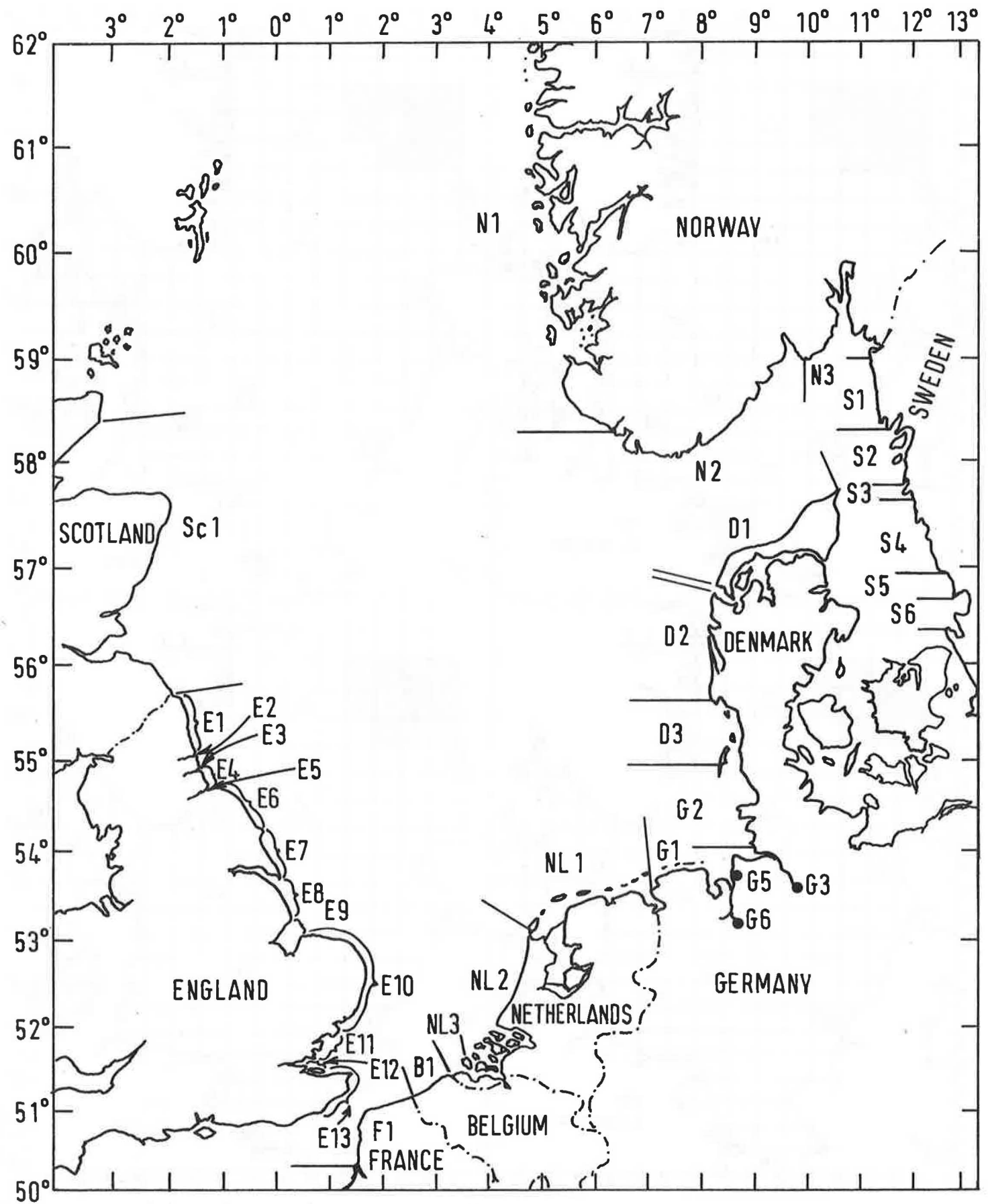


Figure 1 Inputs Questionnaire: Coastal zones used as basis of Tables 1-4.

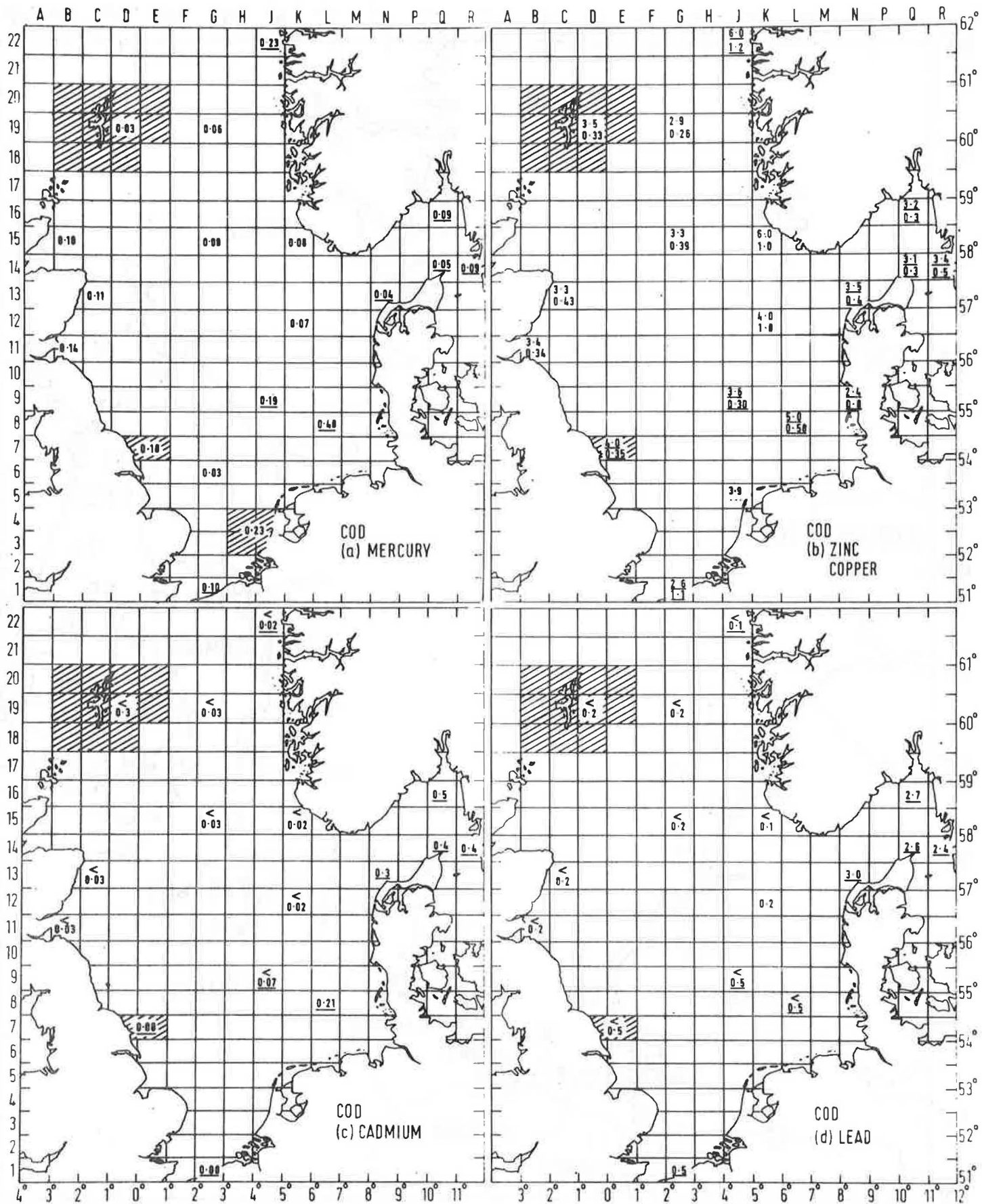


Figure 2 Mean concentrations (mg/kg) of certain metals in cod muscle.

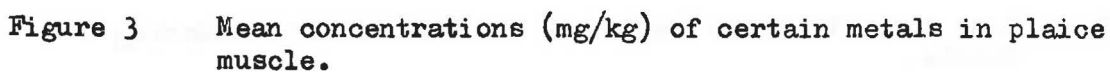


Figure 3 Mean concentrations (mg/kg) of certain metals in plaice muscle.



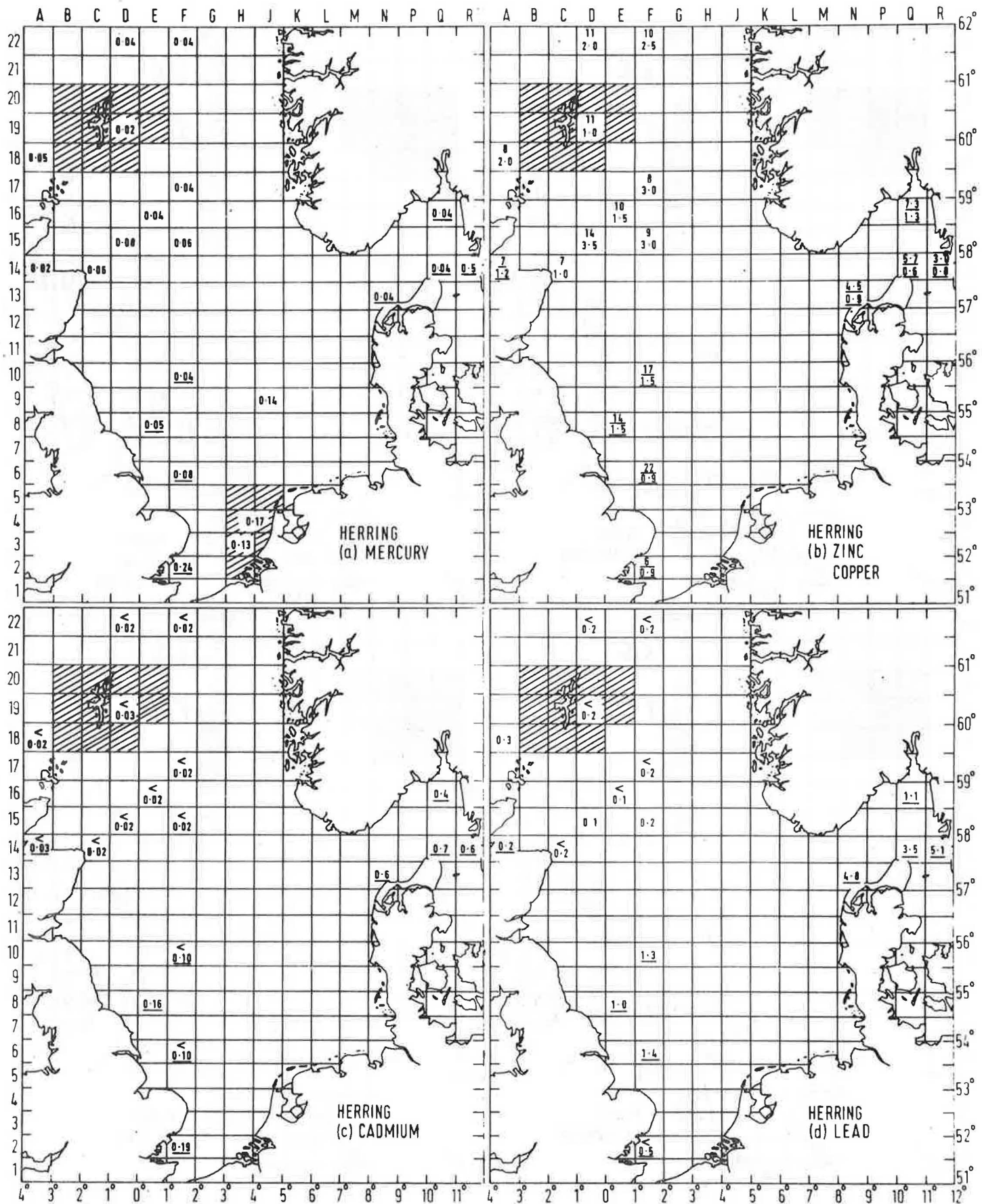


Figure 4 Mean concentrations (mg/kg) of certain metals in herring muscle.



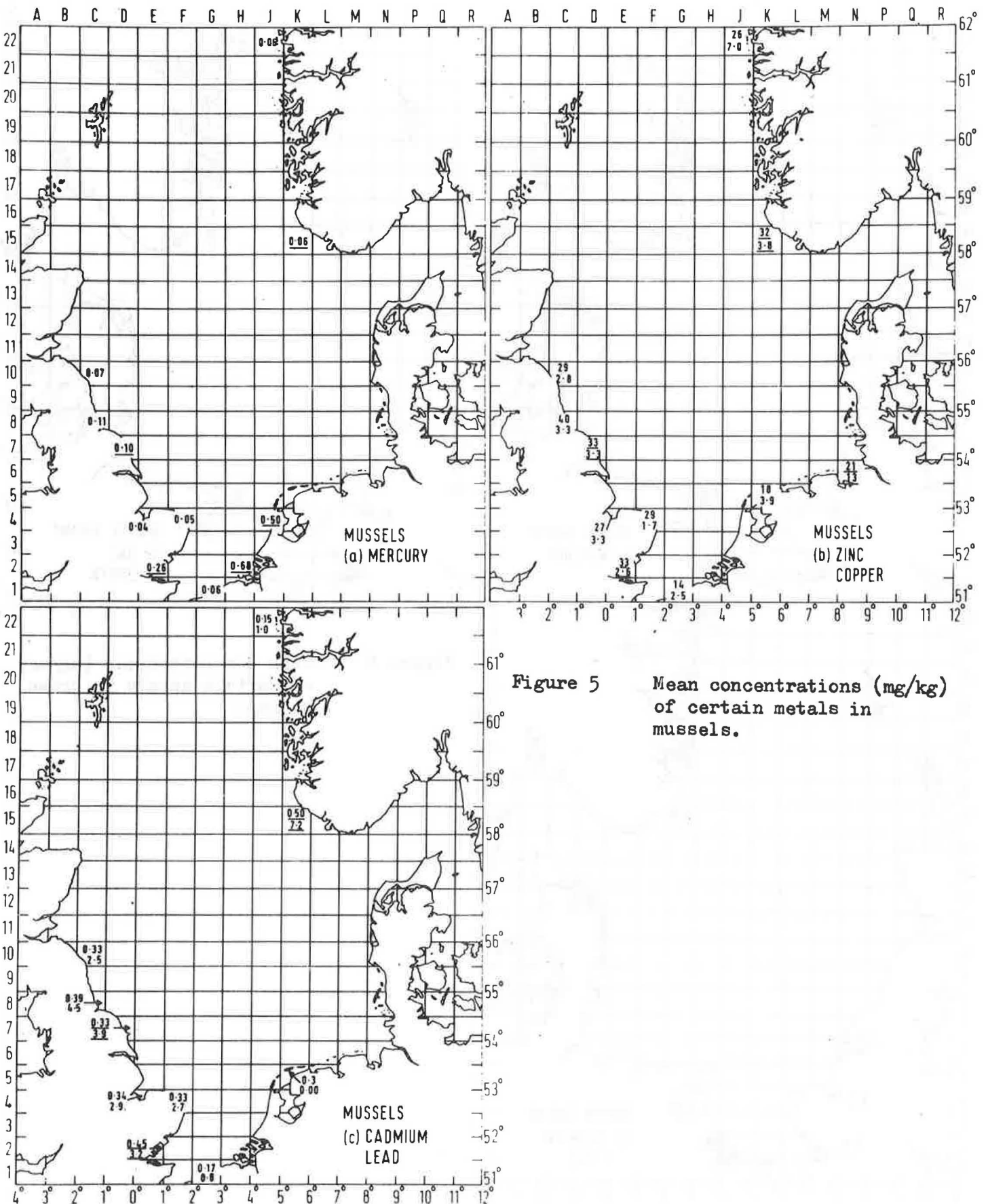


Figure 5 Mean concentrations (mg/kg) of certain metals in mussels.

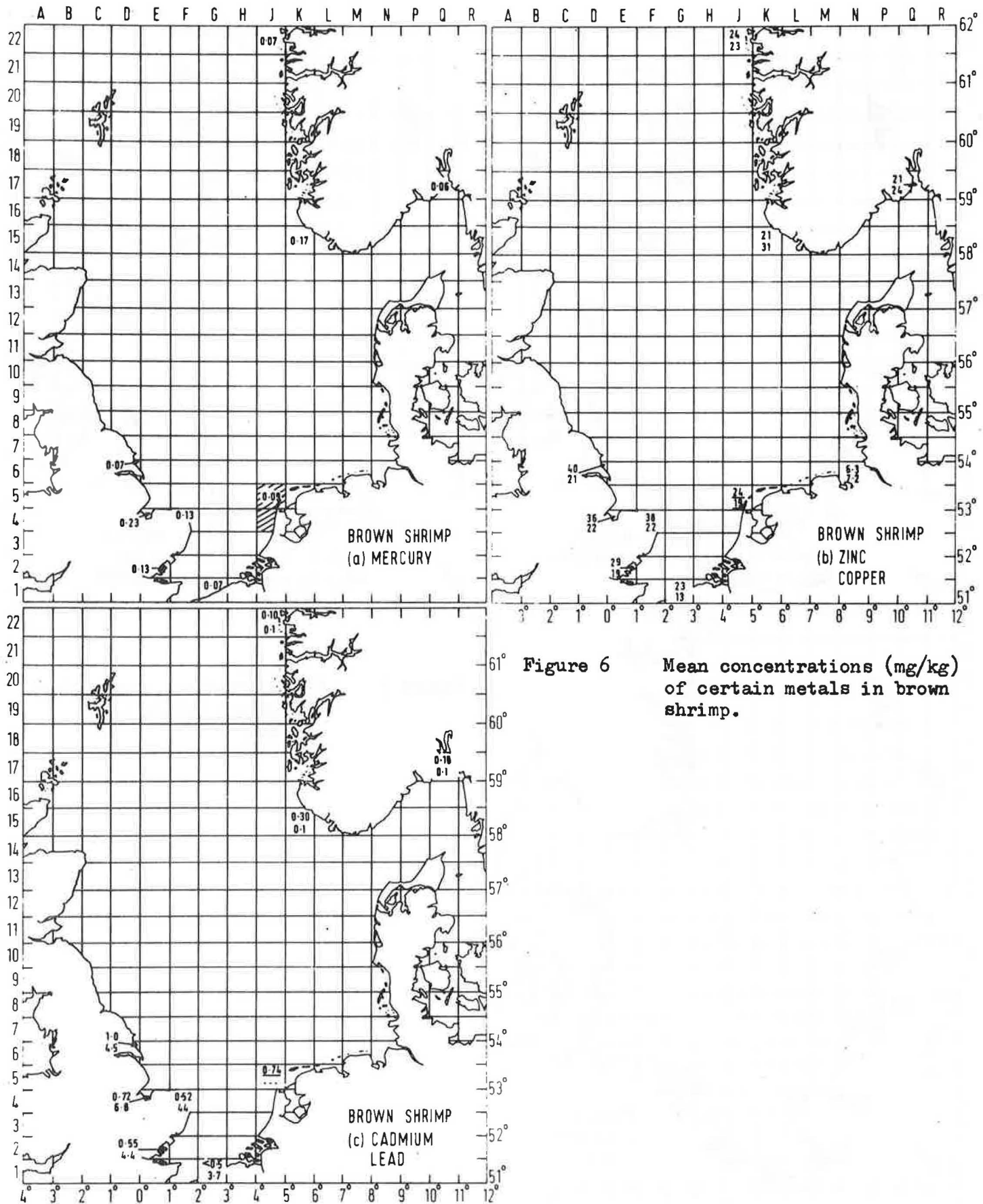
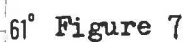
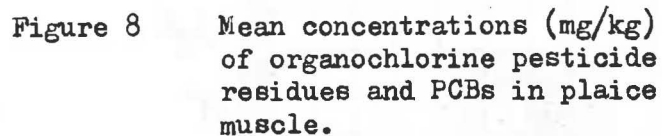


Figure 6 Mean concentrations (mg/kg) of certain metals in brown shrimp.



Mean concentrations (mg/kg)  
of organochlorine pesticide  
residues and PCBs in cod  
muscle.



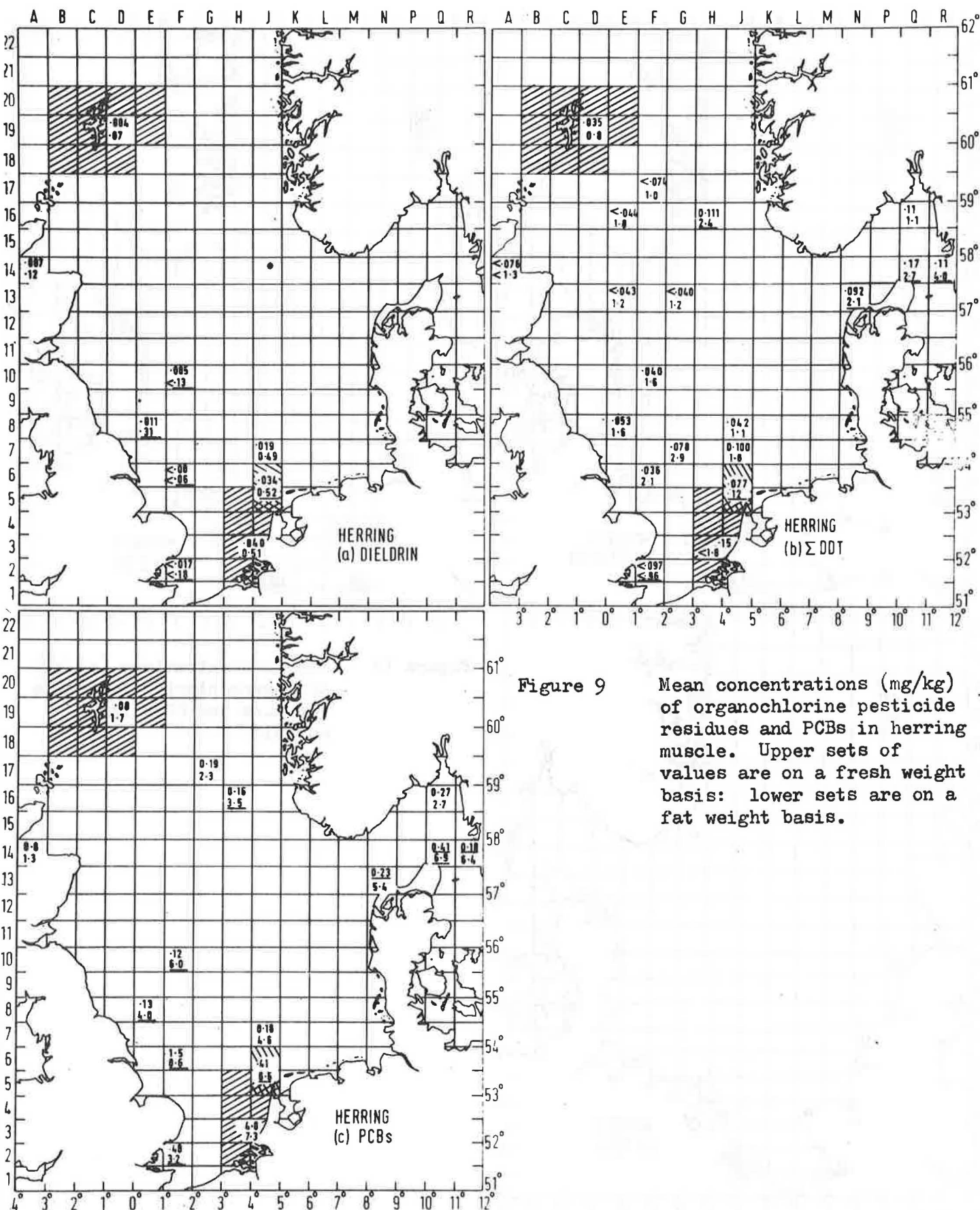


Figure 9

Mean concentrations (mg/kg) of organochlorine pesticide residues and PCBs in herring muscle. Upper sets of values are on a fresh weight basis: lower sets are on a fat weight basis.



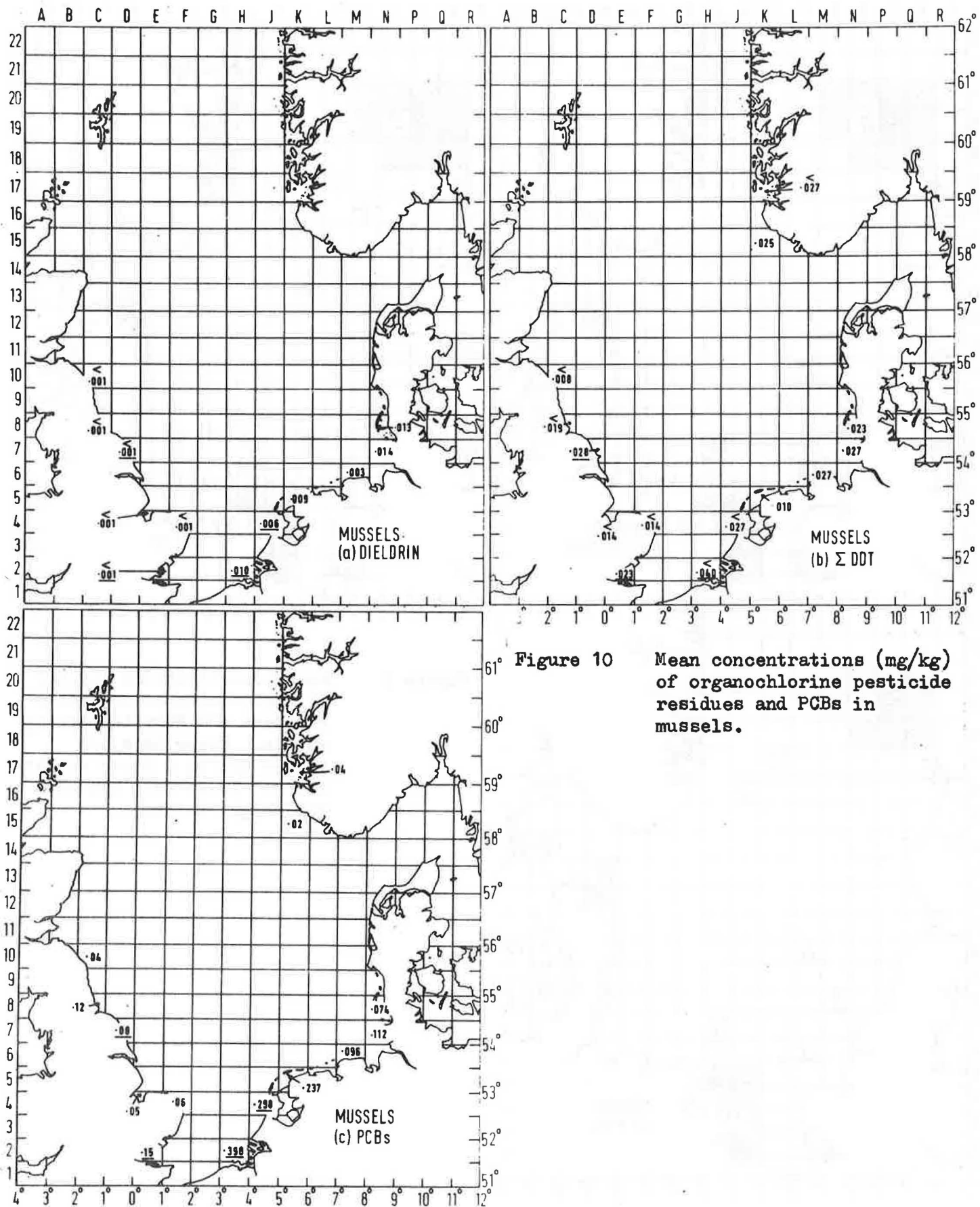


Figure 10 Mean concentrations (mg/kg) of organochlorine pesticide residues and PCBs in mussels.

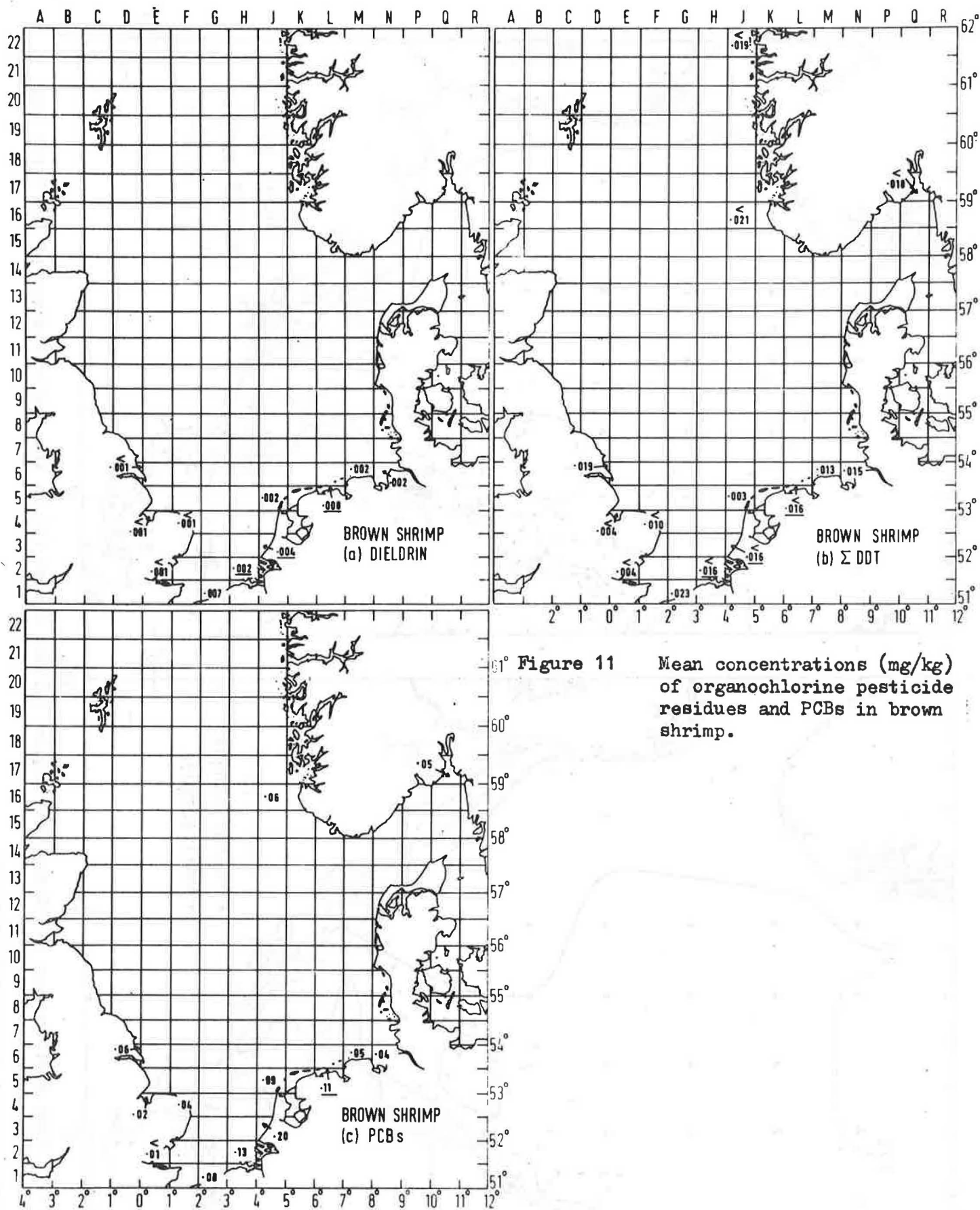


Figure 11 Mean concentrations (mg/kg) of organochlorine pesticide residues and PCBs in brown shrimp.

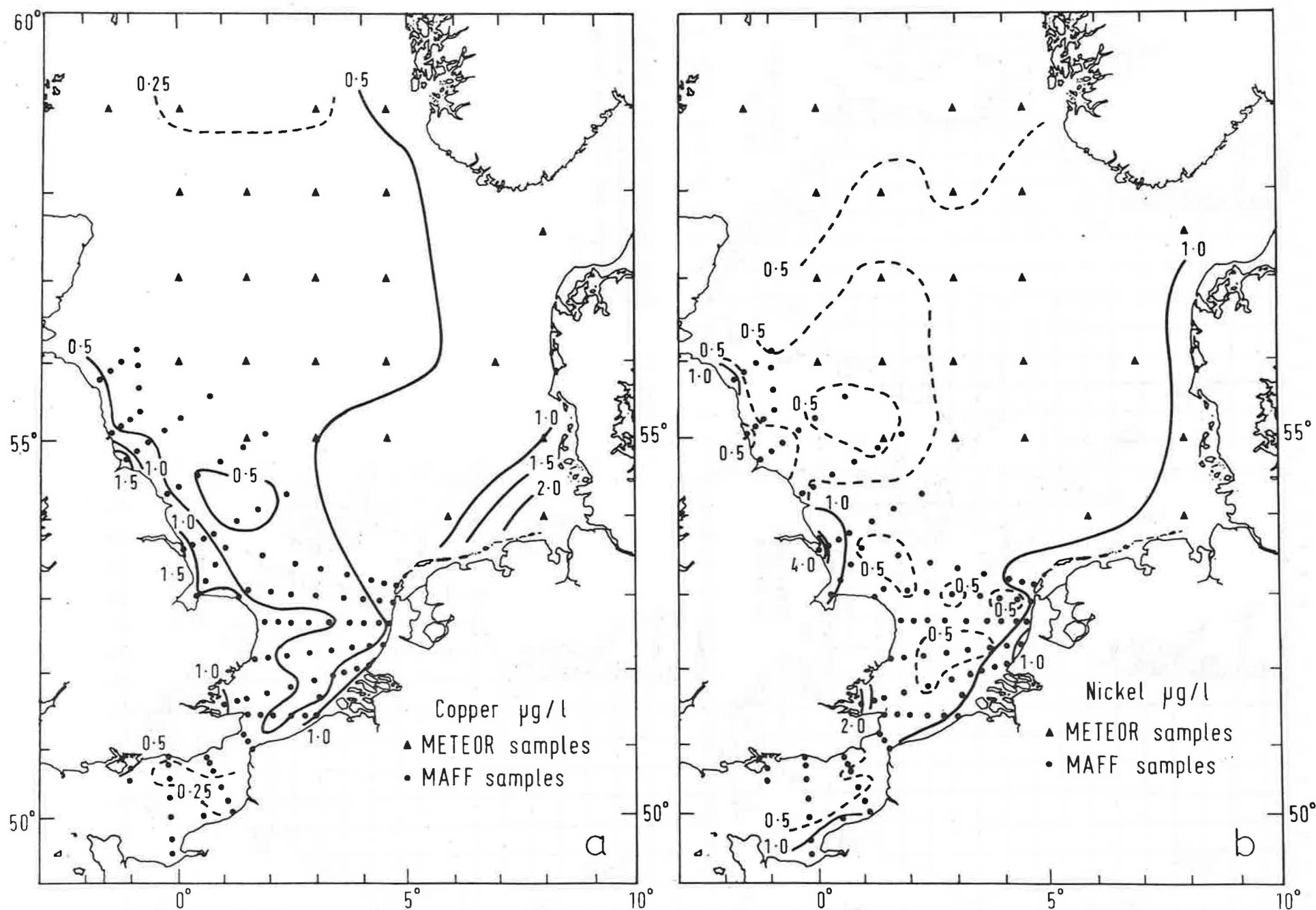


Figure 12 Mean distribution of "dissolved" copper (a) and nickel (b) in the surface waters of the North Sea: UK surveys 1971-1973.



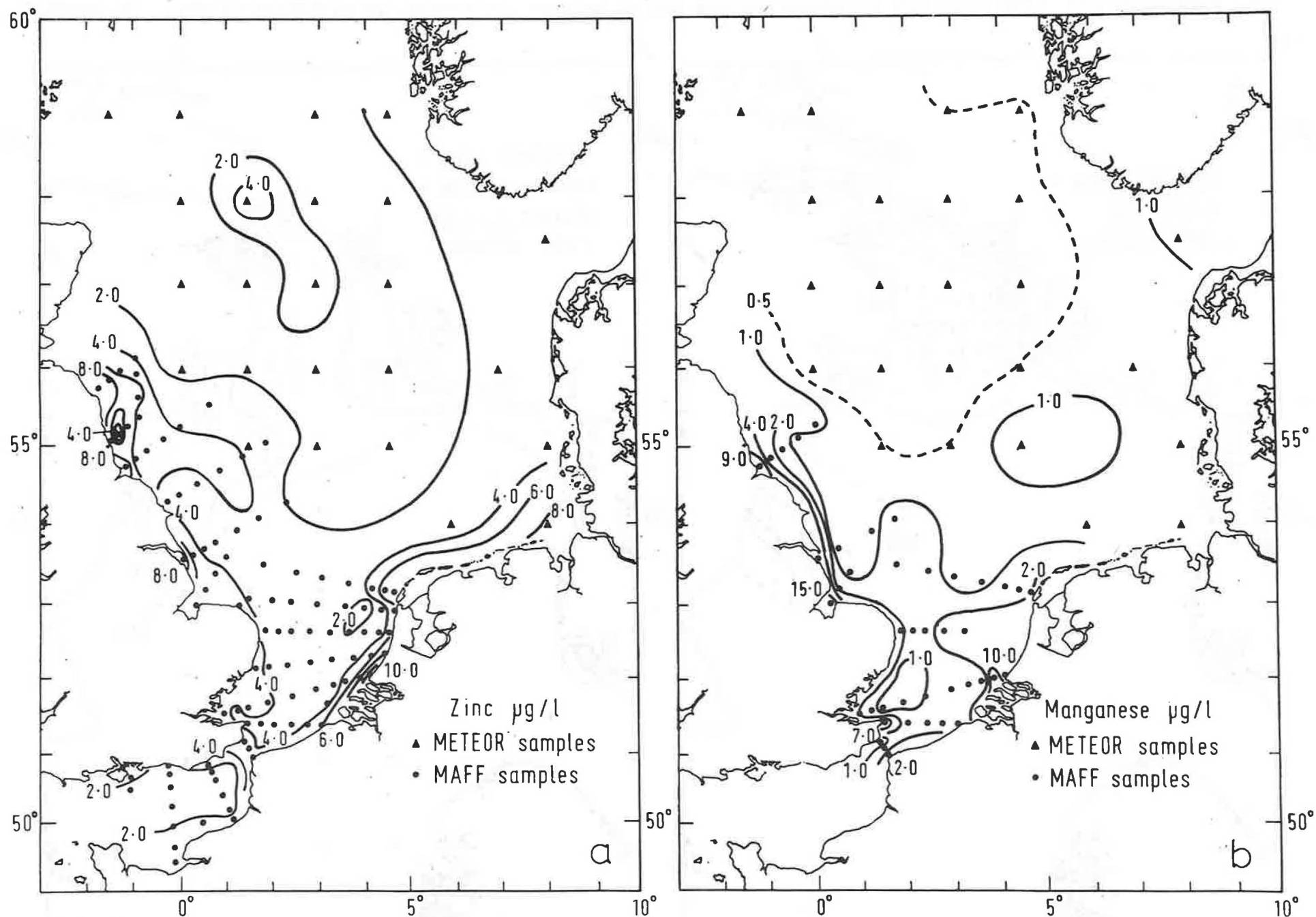


Figure 13 (a) Mean distribution of "dissolved" zinc in the surface waters of the North Sea: UK surveys 1971-1973.  
 (b) Distribution of "dissolved" manganese in the surface waters of the North Sea: UK surveys 1971 and 1972.

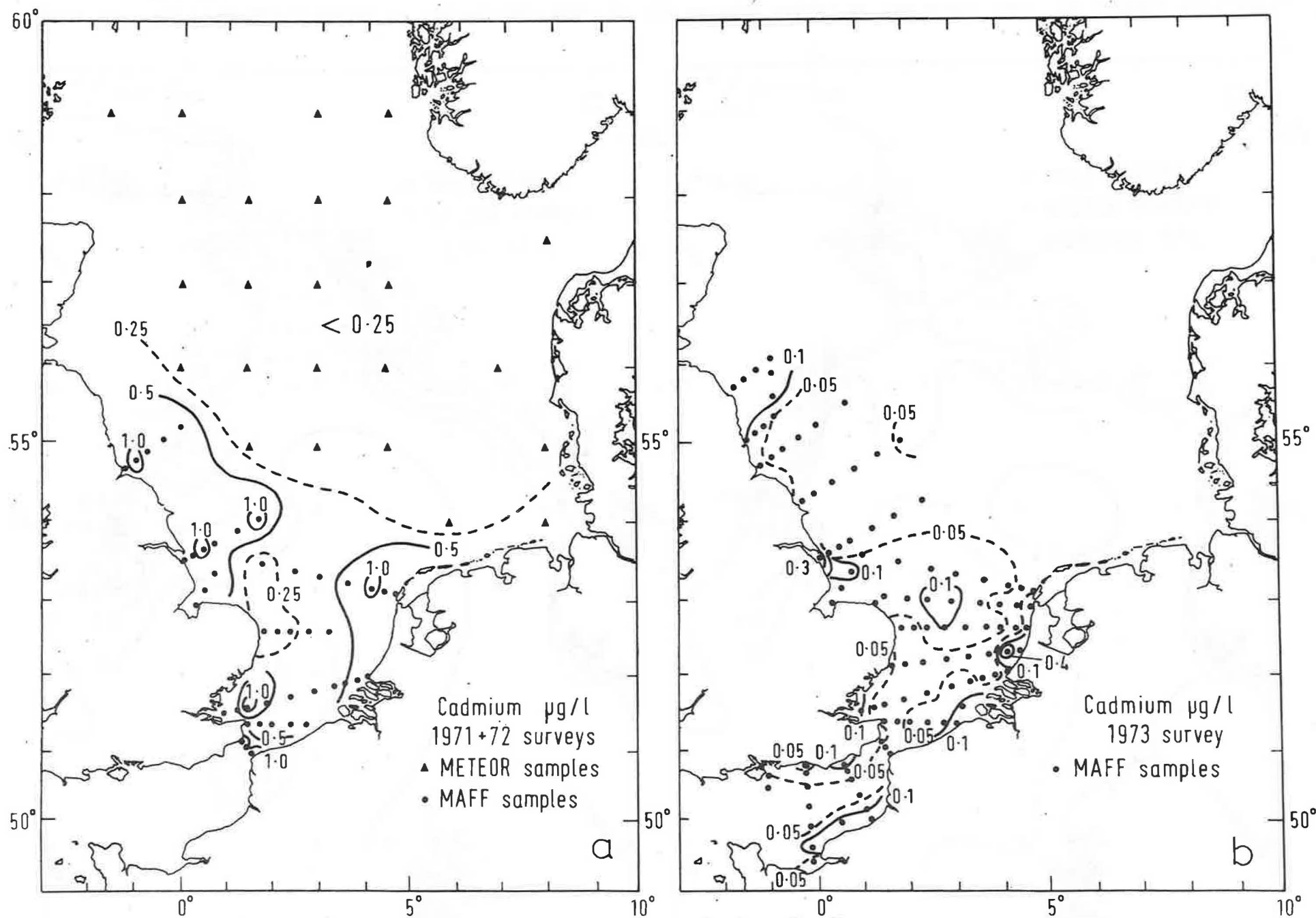


Figure 14 Mean distribution of "dissolved" cadmium in the surface waters of the North Sea. (a) UK surveys 1971 and 1972. (b) UK surveys 1973.

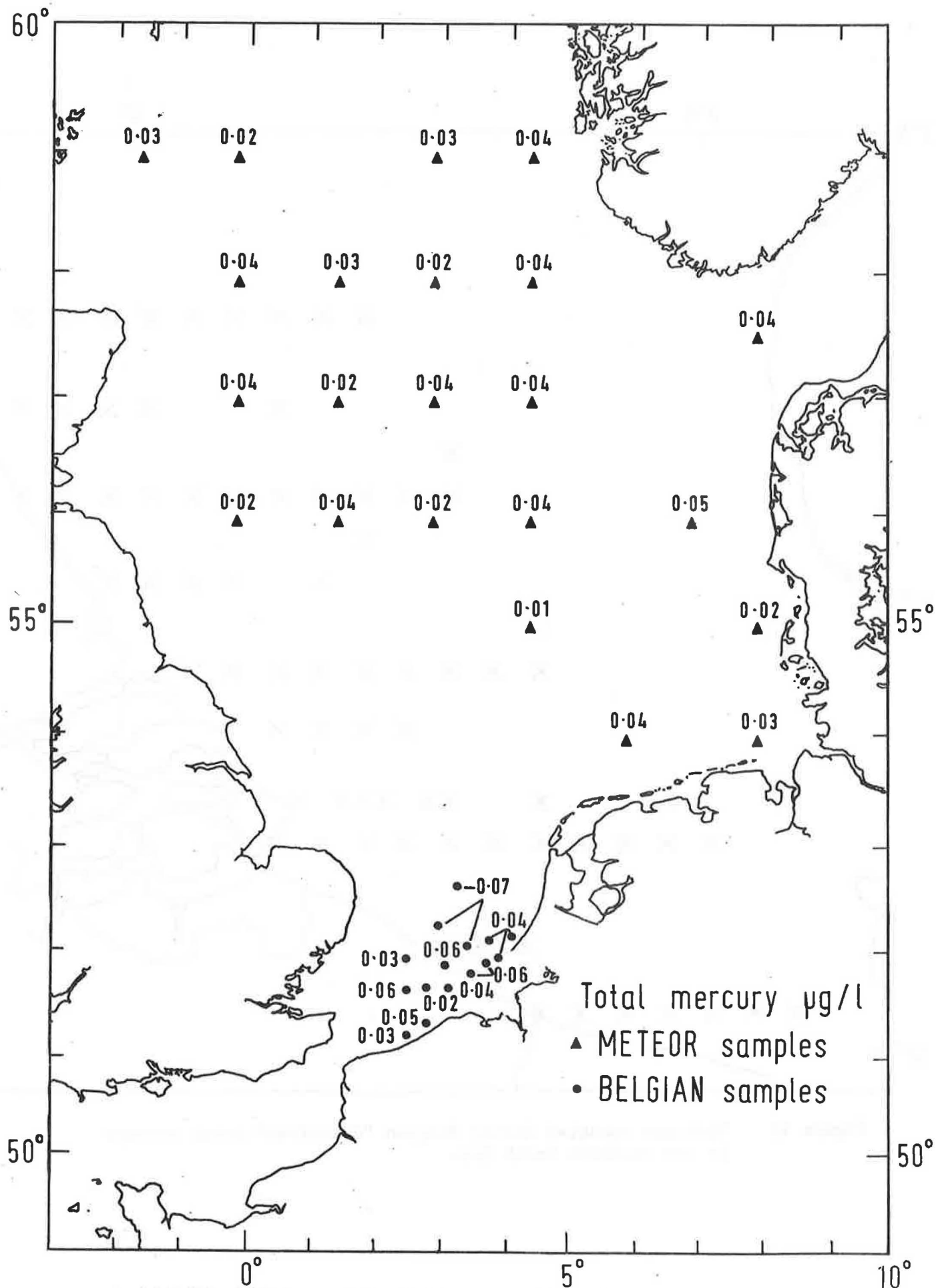


Figure 15 Distribution of "dissolved" total mercury in the surface waters of the North Sea: METEOR and Belgian surveys 1972.

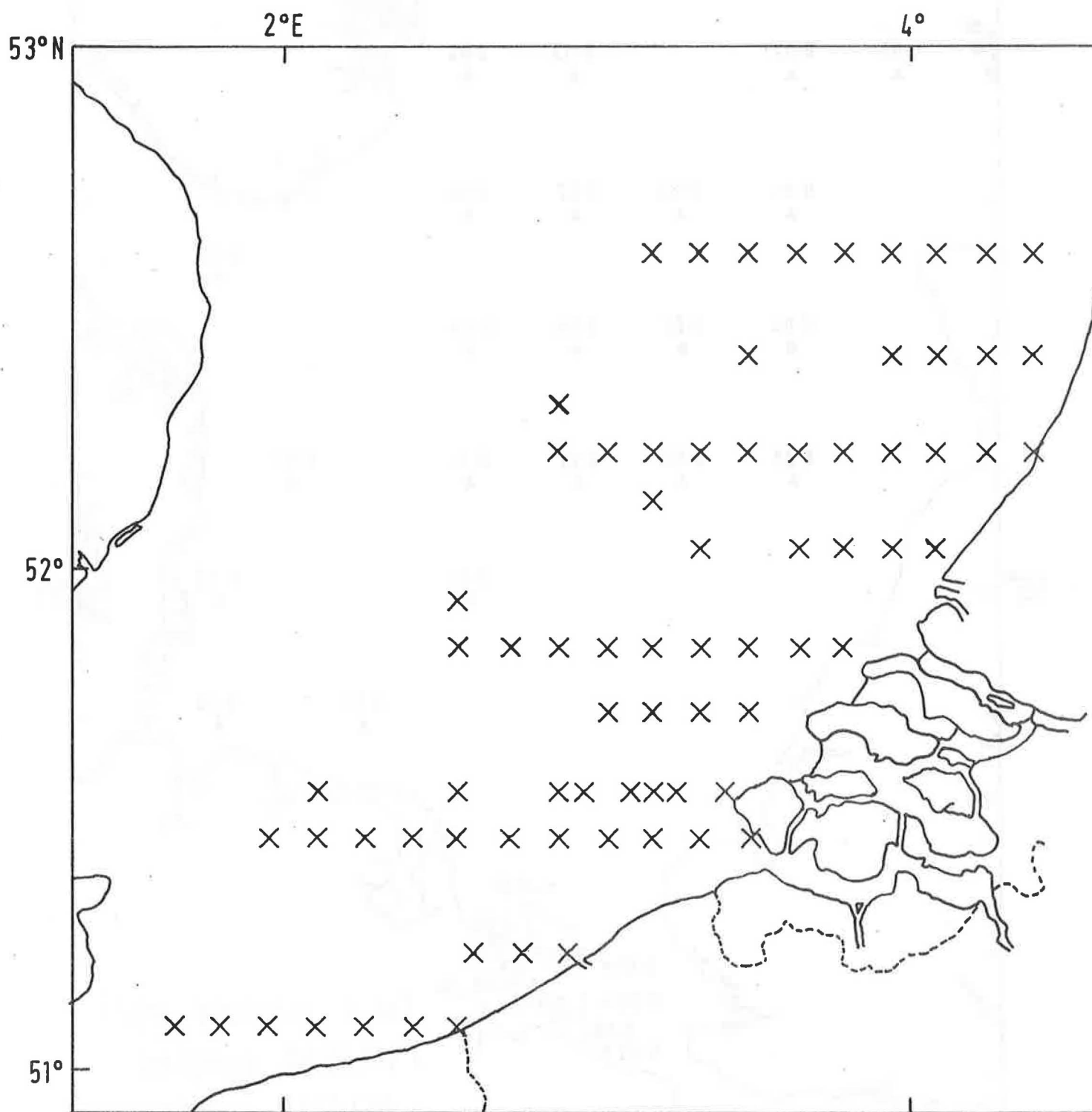


Figure 16 Stations occupied during Belgian "dissolved" metal surveys in the southern North Sea.

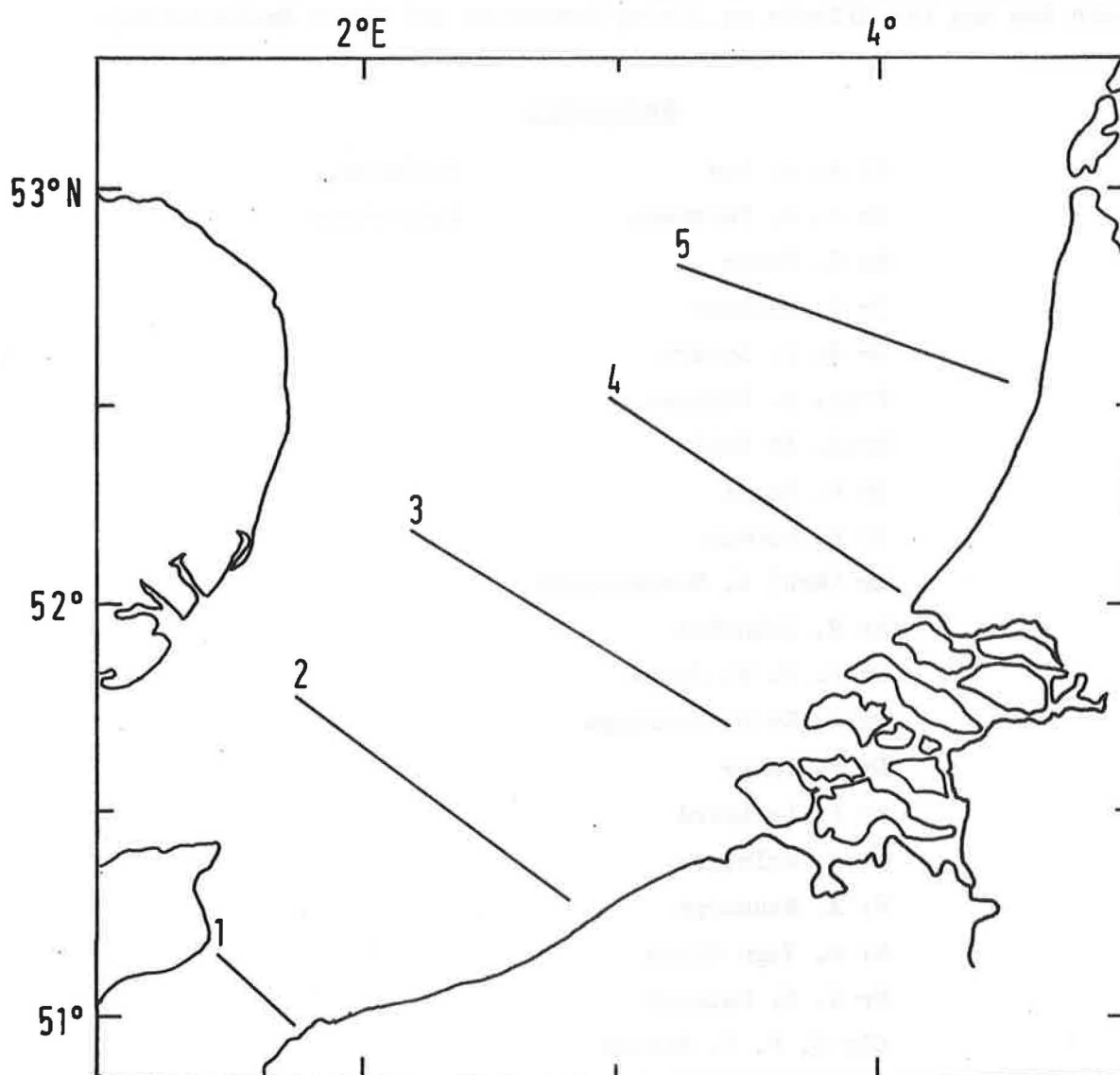


Figure 17 Sections worked during Netherlands "dissolved" metal surveys in the southern North Sea.

International Council for the Exploration of the Sea

Working Group for an International Study of the Pollution of the  
North Sea and its Effects on Living Resources and their Exploitation.

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International Council for the Exploration of the Sea

Working Group for an International Study of the Pollution of the North Sea and its Effects on Living Resources and their Exploitation.

Questionnaire to determine sources of input to the North Sea

Details required of outfalls and other sources of wastes entering the North Sea

Notes

- 1 Include in Section A all outfalls which discharge wholly domestic sewage or combined outfalls discharging sewage and industrial wastes together.
- 2 Separate industrial outfalls should be given in Section B.
- 3 Section C should show location of major sources of potentially toxic stable substances.
- 4 Section D asks for details of dumping activities.
- 5 Section E asks for details of atmospheric fallout.
- 6 Include all sources of waste entering fresh or tidal waters which are considered to reach the North Sea.
- 7 For Sections A and B, divide coast into convenient geographical regions (large estuaries, lengths of open coast) and combine together discharges in each region. A suggested form of presentation is that given on pp. 40-1 of the ICES North Sea Report. Include maps wherever possible.
- 8 Details of radioactive wastes or discharges not required. Give details of heated wastes.

Section A Sewage or combined outfalls (i.e. sewage mixed with industrial waste)

- 1 Limits of area (also show on map).
- 2 Total dry weather flow ( $M^3/day$ ).
- 3 Total population served.
- 4 What percentage of flow is - domestic sewage?  
- from industry?
- 5 What percentage of flow is - discharged untreated?  
- receives settlement only?  
- receives settlement and biological treatment?  
- receives additional treatment?
- 6 Details of discharge in each area (say whether estimated or measured):

BOD (tonnes/year)	PCBs
COD (tonnes/year)	Chlorinated aliphatics
Nitrogen (tonnes/year)	Metals (say which)
Phosphorus (tonnes/year)	Other substances.
Pesticides	

- 7 What major industries contribute to flow?
- 8 What are main industrial wastes present?

Section B Industrial wastes (excluding those combined with sewage)

- 1 Limits of area (also show on map; these should, if possible, be the same as those in Section A).
- 2 Total flow ( $M^3/day$ ) from industrial sources (excluding those already shown in Section A).
- 3 Main industries producing waste, and flow ( $M^3/day$ ). Indicate those also shown in Section C.

(1)  
(2)  
(3)  
(4)

Others.

- 4 Total discharge of industrial wastes. (Show daily output (tonnes/day) of major wastes.)

BOD

COD

Minerals

Pesticides

PCBs

Metals (say which)

Chlorinated aliphatics

Other substances

Section C Location of industries handling potentially toxic stable substances

Produce map or other form of presentation showing areas on rivers, estuaries or on coast where these industries are located. Where possible give details of discharges, and quantities of substances discharged. Also, give details, where known, of amounts of wastes entering the open sea from rivers or estuaries. Industries to be considered include:

Ore mining

Iron and steel

Bulk chemicals (including chlorine-alkali)

Petrochemical

Metal plating (including block-making)

Metal refineries

Paper and pulp

Drug manufacture

Pesticides manufacture

Tanneries

Textile industries (e.g. where dieldrin is used for impregnation)

Hospitals.

Section D Dumping activities in the North Sea

(Include industrial waste, sewage sludge, colliery waste, harbour dredgings, spoil, household refuse, etc.)

- 1 Past dumping activities (during last 5 years).  
Regular or approved dumping activities.  
Irregular dumping activities not approved.

Give area of dump, date, quantity, composition, origin, whether in containers, or released into surface waters. Show location by reference to map.



2 Present dumping activities (during 1971).

Give details as for 1.

3 Planned dumping activities.

Give details as for 1.

Section E      Atmospheric fallout

Give details of national programmes to determine atmospheric fallout. Show areas of sampling, substances being measured. Give reference if published work available, and addresses of leading national authority.

