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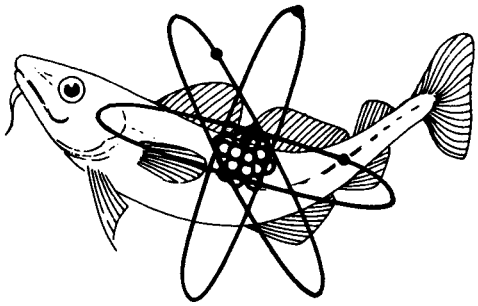

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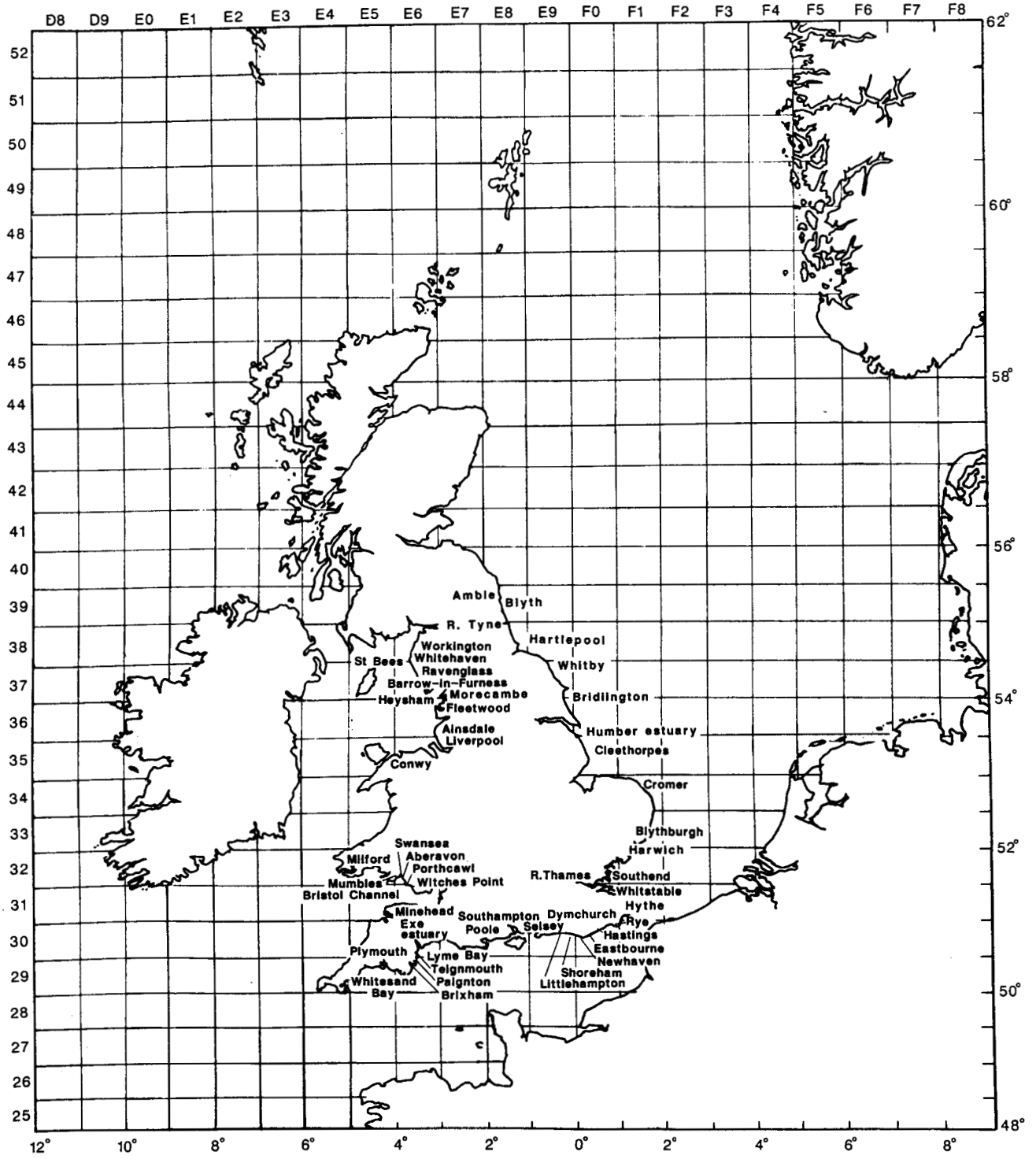

Figure 1 Sites and areas from which fish and shellfish samples were collected, showing ICES statistical rectangle codes.

1. Introduction

Until about 1982, the main purpose of collecting fish and shellfish contaminant data was to establish the distribution of contaminant levels in the marine environment, i.e. the fish and shellfish were used as indicators. The data were also used to obtain a general idea of the quality of fish for human consumption and to assess the risk posed by the contaminant levels to fish and shellfish stocks. It is now apparent that, for the most part, neither fish and shellfish nor man are at risk from the levels of contamination generally found around our coasts. However, there is a considerable interest in using fish and shellfish to establish the effectiveness of past and future reductions in inputs of contaminants brought about as a consequence of controls on discharges to the marine environment.

Since 1982, it has been realized that in order to meet these various objectives it is desirable to use sampling strategies specifically designed for the purpose and that this is essential if the data are to be used for assessing temporal trends, an objective which is increasingly coming to the fore. As these changing objectives have been recognized our sampling strategies have changed, and as a result the data collected during those years prior to about 1982 are not fully comparable. Nevertheless, as the data were collected at public expense it is considered desirable that they be made available to the general scientific community and to informed lay-readers, even though some of the results are rather dated. In future, it is intended that reports will be prepared annually and will deal with other aspects of environmental quality, e.g. contaminant levels in water as well as in fish and shellfish.

In line with the policy of publishing the results of investigations undertaken by its scientists, earlier reports in this series, produced by the Fisheries Directorate of the Ministry of Agriculture, Fisheries and Food (MAFF), have already given information on the levels of chemical contaminants in fish and shellfish stocks exploited by fishermen in England and Wales (Portmann, 1979; Murray, 1979, 1981; Murray and Portmann, 1984), the most recent of which dealt with fish and shellfish sampled in 1976. The present report summarizes the information obtained since that time and includes all of the 1984 and some of the 1985 data, which were available at the time of going to press (Appendix 1). More recent data are presented either in the appropriate tables, or have been added to them as comments.

Some of the data on contaminants in fish and shellfish included in this and earlier reports in the series have also been presented in the various reports of the MAFF Steering Group on Food Surveillance (e.g. MAFF, 1983, 1986).

As indicated above, samples included in this report were taken primarily for the purpose of general monitoring of contaminants in fish and shellfish. In several instances results are available for the same species collected over several years, particularly from some inshore areas where it was thought that contamination problems might occur. However, it must be emphasized that the data were not collected for trend monitoring purposes, for which a recent detailed assessment by the International Council for the Exploration of the Sea (ICES) has shown that the sampling requirements in respect of area, size of fish, time of year and frequency of collection need to be very stringently controlled and based on statistical requirements set by planned subsequent statistical analysis. Consequently, some caution should be borne in mind when the data are referred to as indicating trends. A separate special trend programme, started in 1982 and incorporating proper statistical design, is being undertaken using the guidelines produced by ICES (ICES, 1984) and these results will be published elsewhere.

Further papers will also be produced on other discrete studies undertaken during the last few years. These have included investigation of differences brought about by biological factors (e.g. accumulation of contaminants with age) and geographical factors (spatial variation of contaminants in fish).

2. Methods

2.1 Sampling

The fish and shellfish samples reported on here were generally taken by trawl or dredge using MAFF research vessels, but some commercial fishing vessels were used when this was the most cost-effective means of obtaining samples at the desired time. The areas from which samples were taken are indicated in Figure 1; emphasis was placed on inshore areas where contamination problems were thought most likely to occur. Mussels were collected from the shore at low water; crab samples were purchased from local sources.

Whenever possible, samples consisted of ten or more individuals, but where a species was less common, fewer were taken for analysis. Fish and shellfish are described in this report by their common names. (Full specific names are given in Appendix 2.)

2.1.1 Fish

The length, weight and sex of each fish was noted before tissue samples were taken. In the early years covered by this report, the muscle tissues of individual fish were generally analysed separately for metals, but from 1982 onwards, duplicate analyses of pooled muscle tissue were sometimes undertaken. This change was in line with the ICES guidelines for the use of biota for chemical monitoring (ICES, 1984), which indicated that such analyses were adequate for quality assurance programmes. Because organochlorine pesticides and PCBs are lipophilic (i.e. accumulate in fatty tissue rather than water), analyses of these residues were carried out mainly on liver tissues, which in most fish species contain high levels of lipid (fat). However, although liver residues give a better indication of contaminant levels around the coast of England and Wales, muscle concentrations are of more interest from a quality assurance point of view. Accordingly, where comparatively high residues of pesticides/PCBs were found in liver tissue, analysis of the corresponding muscle tissue was also undertaken. The amount of liver tissue available from many species is limited and sometimes analysis of only a single bulked sample could be made.

2.1.2 Shellfish

Shellfish were generally analysed for metals on a bulked tissue basis. Concentrations of pesticides are extremely low in most molluscs and crustaceans and hence analysis for these compounds was not always carried out; when analyses were carried out, bulk tissues again were used. Generally, molluscs were analysed on a whole tissue basis, but in the case of scallops and queens, only the muscle tissue was analysed. With regard to the crustaceans, whole shrimps and the tail meat of Nephrops were analysed. Crabs were analysed only for cadmium, the contaminant of special interest for this species, using the hepatopancreas (brown meat) and the claw muscle (white meat).

2.2 Analysis

Concentrations of copper, zinc, cadmium and lead were determined by conventional flame atomic absorption spectrophotometry (AAS) of a solution prepared from a nitric acid (or in the case of the earlier samples nitric acid/peroxide) digest. Mercury was determined by an automated cold vapour AAS technique based on the method of Kirkwood (1976). The method routinely used for detecting cadmium and lead is not capable of detecting these elements in fish or shellfish tissues at concentrations normally below 0.2 mg kg^{-1} wet weight. Although this concentration is considerably exceeded in some shellfish species, levels in fish muscle are generally at, or below, the detection limit. Because concentrations were so low, the analysis of fish muscle for cadmium and lead has not been carried out since 1982.

Analyses were made of the following organochlorine residues: α and γ HCH, dieldrin, DDT (including its metabolites DDE and TDE which together are referred to as Σ DDT), PCBs and, in later samples, HCB. Following n-hexane soxhlet extraction of the fish or shellfish tissues, residues were determined by gas liquid chromatography, using electron capture detection after alumina and silica column clean-up and separation.

3. Results

In the last report in this series, Murray and Portmann (1984) stated that subsequent publications would not include detailed results of all analyses undertaken, as levels found in samples from many areas were very low and there was no cause for concern. In this report, therefore, emphasis is placed on studies of areas where contamination is known to occur, although some recent data from uncontaminated areas are also included. For some of the latter, e.g. parts of the English Channel, only the one sample was in fact taken during the period covered by the report. For others, more data are available but, in order to avoid the reproduction of very extensive tabulations, these are not reported here. All of the tables are presented together in Appendix 1. To simplify presentation, only one set of results of liver analysis per sample is given throughout the tables but, for most of the more recent fish samples, further data are available.

It must be emphasized that any omissions have been made purely in the interests of simplifying presentation, thus, for example, where data exist for intermediate years but have been omitted they are similar to the results which are reported.

In the tables, the first value given for cadmium in crab is the concentration in the claw meat; the second is that in brown meat.

The results obtained from samples of fish and shellfish taken around the coasts of England and Wales are presented in Table 1 (North sea coast), Table 2 (English Channel) and Table 3 (west coast/Irish Sea). For each area, data are presented showing the concentration of metals in fish muscle and pesticides/PCBs in fish liver, followed by results for shellfish tissue. Where the shellfish did not come from exactly the same areas as the fish, the point of capture is indicated. All concentrations are expressed on a wet weight basis. The percentage of dry matter in muscle and of fat (lipid) in liver are included to allow conversion of the data to a dry and lipid weight basis, respectively.

Where metal analysis of individual fish was carried out, the range of contaminant values in a sample is given below the mean. Where analysis of

duplicate bulked samples has been undertaken, both results are listed in the tables, below the mean.

As previously mentioned, fish muscle now is not considered suitable for analysis for cadmium and lead but fish liver has been suggested as an alternative sampling substrate. Concentrations measured in muscle and liver have been included in the tables. From these results it can be seen that concentrations of cadmium and lead are generally at, or below, detection limits.

The results of analyses of pesticides/PCBs in fish muscle, carried out where levels were found to be comparatively high in fish liver, are given in Table 4.

The time-series of data available for concentrations of mercury in fish flesh are given in Table 5 and of Σ DDT and PCBs in liver in Tables 6 and 7, respectively. In Tables 6 and 7 the maximum levels of contaminants found at any one time are listed, avoiding some of the difficulty which inevitably arises when comparing non-standardized samples of varying fat content.

Evaluation of the results has been assisted by reference to standards or guidelines which have been developed for the various contaminants by organizations such as the European Commission, the Joint Monitoring Group (JMG) of the Oslo and Paris Commissions and the Food and Agriculture Organization (Codex Alimentarius). These, together with the general food standard regulations and guidelines which apply in England and Wales are shown in Appendix 3. Also shown are the ranges of levels of the contaminants which, on the basis of past experience, would normally be expected to occur in samples of fish and shellfish taken from areas around England and Wales which are not subjected to any particular sources of contamination, i.e. they represent 'background' levels. Expressions such as low, moderate and high are used in the text when comparison are made with these expected ranges. The terms 'lower', 'medium' and 'upper' refer to JMG guidelines. These guidelines refer to the ranges of contaminant concentrations which would be expected to occur, based on the results submitted by all the countries which participate in the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions. They do not necessarily imply any risk to human health or to the environment but are used simply to indicate a possible need for action. Thus, if levels are in the 'upper' category, investigation to establish the source of contamination would be considered to be of much high priority than would be necessary if the levels found were in the 'lower' category.

3.1 The North Sea coast

The results are summarized in Table 1(a-d).

3.1.1 Tyne area

Metal levels generally in fish and shellfish from this area were found to be low (Wood and Franklin, 1983) and the more recent results summarized in Table 1(a) confirm this. The mean mercury concentrations found in each species were virtually all below 0.15 mg kg^{-1} wet weight and many were in the 'lower' JMP category. The one exception was Nephrops in 1978, when the level was 0.28 mg kg^{-1}. The latest (1984) value was considerably lower (0.19 mg kg^{-1}). With regard to copper and zinc, concentrations were low, except for the sample of dab in which the zinc concentration was higher than normal, though still well below the guideline limit for foodstuffs

(Appendix 2). High levels of copper and zinc were found in sprats; this was expected, since analyses were carried out on whole fish and included liver tissue in which these elements are accumulated to much greater concentrations than in muscle. Cadmium in shellfish was found only at low to moderate concentrations; lead concentrations in all shellfish were below 1.0 mg kg^{-1} wet weight.

Concentrations of organochlorine pesticide residues were generally low in liver tissue from fish species, excepting the 1982 sample of cod where Σ DDT exceeded 2 mg kg^{-1} wet weight, probably because these fish were unusually large. In contrast, the concentration in smaller cod (average length 52 cm) taken in 1984 was only 0.44 mg kg^{-1}. Even in the 1982 sample, pesticide concentrations in the fish muscle (Table 4) were very low. Levels of PCBs were generally low and give no cause for concern.

Concentrations of organochlorine pesticides and PCBs in shellfish were rarely much above detection limits.

3.1.2 Humber area

The analytical results from samples taken from this area (Table 1(b)) indicate that the levels of metal contamination in fish and shellfish tissue give no cause for concern. Mercury concentrations were in the 'lower' or 'medium' ranges and copper and zinc concentrations lay within the expected (Appendix 3) range for fish muscle and shellfish.

Levels of cadmium and lead in the samples of shellfish examined from this area in the 1977-84 period were fairly low. There are no commercially exploited mussels (Mytilus) in the Humber estuary as they are difficult to obtain from the region; none was analysed during the 1978-84 period. However, two samples were obtained in 1985 (Table 1(b)). Concentrations of cadmium in both samples were below 1.0 mg kg^{-1} wet weight, though conversion of the concentrations found at one station (Bull Fort) to the dry weight value would result in them just entering the JMP 'upper' category. However, it is worth noting that these were in poor condition and would not have been regarded as edible. Lead concentrations were below detection limits.

Concentrations of PCBs and most organochlorine pesticide residues in fish liver were at low or moderate levels, except for dieldrin, which was found in concentrations considerably higher than the expected range. The levels of dieldrin, however, represent a marked reduction compared with those found previously in the Humber. In the mid-1970s, concentrations of dieldrin in cod and whiting liver at times exceeded 2 mg kg^{-1} wet weight, contamination probably being caused by the discharge of effluents by the mothproofing industry, which in the past used dieldrin for this purpose.

Concentrations of organochlorine pesticides and PCBs in fish muscle (Table 4) and shellfish (Table 1(b)) were low.

Arsenical wastes are discharged to the Humber estuary, and the concentration of arsenic was therefore determined in a number of samples of fish taken from this area in 1977. The results from this study, which have already been reported (Murray and Norton, 1982), indicated that levels were similar to those in fish collected from areas remote from anthropogenic sources of arsenic.

3.1.3 Southern Bight

The more recent samples confirmed previous findings, i.e. that heavy metal concentrations in fish are in the low to moderate range (Table 1(c)). Similarly, the levels of organochlorine pesticides were low in both fish liver and muscle and in shellfish. There is some indication from Table 6 that Σ DDT levels may have decline in recent years.

The main determinand of interest in this area is PCB, the levels of which were unusually high in fish liver in the late 1960s to mid-1970s. The results from samples collected from this and other areas in the period covered by this report are summarized in Table 7. It must be remembered that caution is needed when comparing recent data with those obtained earlier, as samples were collected primarily for the purpose of assessing contamination distribution and not for trend studies; nevertheless, the high levels found in the Southern Bight in 1975 do not appear to have been reached since that time. During the period covered by this report levels showed no consistent pattern, the 1982 and 1983 values for cod liver remaining in the JMP 'upper' level category. Concentrations of PCBs in cod muscle (Table 4) and in molluscs (Table 1(c)) were in the 'medium' or 'lower' classification levels which gave no cause for concern.

3.1.4 Thames Estuary

Early surveys of this area indicated contamination of fish muscle with mercury (MAFF, 1973) and of fish liver with some pesticides and PCBs (Murray, 1979); accordingly, samples have been obtained for most years between 1977 and 1984 (Tables 5, 6 and 7).

Recent samples (Tables 1(d) and 5) indicate a considerable reduction of mercury levels in fish flesh, all concentrations, even those in individual species, falling below 0.3 mg kg^{-1} wet weight. The overall species average concentration in 1984 of 0.13 mg kg^{-1} is less than a third of that recorded in the early 1970s; this follows a reduction of inputs in recent years to less than one-sixth of the 1972 value (JMG, 1984). Thus, although it should be emphasized that the samples were not collected specifically for trend assessment purposes, there is a clear indication of a fall in the concentration of mercury in fish over the period of this report. To assess this more accurately, a separate trend analysis programme is being carried out in this area using samples consisting of large numbers of immature plaice. Analysis of the results so far obtained shows that there has been a reduction in the mean mercury concentration in the muscle of these plaice from 0.08 mg kg^{-1} in 1980 to 0.06 mg kg^{-1} in 1983.

The concentration of mercury in shellfish was low, except for one high level (0.60 mg kg^{-1}) in the whelk sample collected in 1977. The mercury concentrations in two whelk samples collected in 1985 were only 0.13 and 0.14 mg kg^{-1} wet weight.

The levels of copper and zinc in Thames fish and shellfish were generally within the expected ranges, though in a number of flatfish concentrations of zinc were near the top of the expected range. The cadmium concentration in the whelk sample was fairly high, but only in the 'medium' category in both mussel samples. Lead levels were unremarkable.

The levels of organochlorine pesticide and PCB residues in fish livers in 1983 reveal higher than normal dieldrin levels in some species and an elevated pp DDE concentration in whiting. However, the pp DDT level was

fairly low, indicating that the source of the contamination was not recent (DDE is a degradation product of DDT). Similarly high values were not recorded in 1984 (Table 1(d)).

The maximum concentrations of Σ DDT and PCBs found in fish livers during the period covered by this report are listed in Tables 6 and 7. There appears to be little consistent pattern in the results for the Thames area, although there is some indication of a reduction in concentrations of PCBs in the livers of the round fish species; levels have generally been in the 'medium' range for a number of years, representing a very considerable improvement over the situation in the mid-1970s. A reduction can also be noted in Σ DDT levels if 1984 and mid-1970s concentrations are compared, though some occasional high values have been recorded in the 1977-83 period.

Residues of Σ DDT and PCB in fish muscle (Table 4) were generally at moderate concentrations, apart from those found in flounder muscle in 1983, where the PCB concentration at 0.06 mg kg^{-1} was in the JMP 'upper' category. The 1984 value was only 0.025 mg kg^{-1}, and even the 1983 level was well below that which would be likely to constitute a hazard to human health. Although there are no standards laid down in the UK for PCBs in fish, the US Tolerance Level for PCBs in fish and shellfish is 5.0 mg kg^{-1} wet weight (Nauen, 1983).

3.2 The English Channel

Earlier surveys of contaminant levels in fish and shellfish indicated no areas of serious contamination, and sampling since 1977 has generally been only of an *ad hoc* nature.

3.2.1 Eastern Channel

Mercury levels in fish samples taken from several areas along the eastern Channel were generally in the 'medium' JMP category; all concentrations in shellfish were low (Table 2(a)). Similar moderate concentrations of the other metals were found in the fish and shellfish samples though, as in other Channel areas, levels of cadmium in scallops were considerably higher than those in the other molluscs. This may indicate that this species naturally accumulates cadmium in its muscle tissue; however, some contamination of muscle tissue by cadmium is possible from the digestive gland, which is known to accumulate this metal, when scallops are stored frozen for any length of time (Uthe and Chou, 1985).

Organochlorine pesticide levels in fish and shellfish were usually low; fairly high concentrations of PCBs were recorded in the livers of cod from Rye and whiting from Hastings, but the level of PCBs in the muscle of the former sample was low (Table 4). Unfortunately, not enough of the whiting muscle was available for organochlorine analysis. The PCB concentration in liver of whiting, collected in 1985 off Hastings, was only 3.0 mg kg^{-1} wet weight.

3.2.2 Central Channel

Mercury concentrations found in all fish from this area were low (Table 2(b)). Levels of mercury in shellfish varied, with some moderate levels recorded in mussels. Copper and zinc concentrations were fairly high in pilchard, as would be expected for this lipid-rich species. Quantifiable

concentrations of cadmium were found in pilchard muscle and the level in scallops was also high (see eastern Channel). However, concentrations in mussel samples, in clams and in crab brown meat, were only low or moderate.

Organochlorine pesticide and PCB residues were low in all fish and shellfish sampled.

3.2.3 Western Channel

Concentrations of mercury found in all fish and shellfish sampled were in the 'lower' or 'medium' categories, with most being well below 0.1 mg kg^{-1} wet weight (Table 2(c)). As in the Central Channel, copper and zinc levels were high in pilchard. Cadmium concentrations were low in the molluscan samples, but high in crab brown meat. Accumulation of cadmium in the brown meat of crabs, to concentrations well above that which would be expected from a knowledge of anthropogenic sources, has been noted previously (Murray, 1981); in earlier years concentrations have been well above those reported here.

Concentrations of pesticides and PCBs were unremarkable in all tissues analysed and there was no evidence of the occasional very high PCB residue levels noted for some species in previous reports (Murray and Portmann, 1984). However, as before, the highest values were found in livers of whiting from the Plymouth area although, even in those fish, concentrations in the muscle tissue (Table 4) were extremely low.

3.3 The west coast/Irish Sea

3.3.1 Bristol Channel

There was little indication of any substantial contamination by metals, pesticide or PCB residues in the fish samples taken from this area (Table 3(a)). An exception occurred in large rays which contained above average concentrations of both mercury in muscle tissue (0.39 mg kg^{-1}) and PCBs in liver (7.2 mg kg^{-1}). The reason for these high levels in this one species is not known but unusually high concentrations of mercury have been found previously in ray samples (Murray and Portmann, 1984). PCB concentrations in the ray muscle were low (Table 4).

There was some indication of higher than usual levels of contamination of shellfish tissue with cadmium and lead. This was not unexpected as the Bristol Channel has in the past received, and to some extent still does receive, large inputs of cadmium and lead from both natural and man-made sources and atmospheric deposition is believed to be an important source of these metals in this area (Murray and Norton, 1982). A reduction in industrial inputs of cadmium and lead in the early 1970s has led to some improvement in the levels of these contaminants in mussels (Murray and Portmann, 1984).

3.3.2 Swansea Bay

Levels of mercury in fish have been determined regularly, as the bay received a discharge containing mercury from a chloralkali plant until operations ceased in 1982. The most recent complete set of results (Table 3(b)) shows little contamination of fish muscle, with mercury concentrations being in the 'medium' or 'lower' JMP categories.

The time series of mercury data (Table 5) indicates that even when the plant was in operation, concentrations were never high, the maximum overall area mean concentration being 0.16 mg kg^{-1} wet weight in 1978. There is some indication of a slight fall since that time but the results are not entirely comparable throughout the period, the very low 1982 figure, for example, being due to samples having to be taken slightly further offshore than usual.

Copper levels in fish muscle from this area were all low. Zinc concentrations were moderate in the round fish but at the top of the expected range for the flatfish species sampled.

Relatively high concentrations of a number of metals were found in the mussel samples collected in 1978 from Swansea Bay (Murray, 1982). The area was sampled again in 1985; the limited data available to date (from Aberavon, Table 3(b)) indicate some improvement since the 1978 survey.

Organochlorine pesticide levels in fish liver and the one sample of mussels analysed from Swansea Bay were fairly low, apart from γ HCH in whiting and Σ DDT in cod which were higher than the expected range. PCB concentrations in liver were also moderately high in these two species and in flounder. Levels of all residues in fish muscle (Table 4) were such as to give no cause for concern.

3.3.3 Liverpool Bay

From previous work it was known that fish from Liverpool Bay were likely to contain elevated levels of mercury; high concentrations of some pesticide residues and PCBs had also been found in the livers of some fish species. A considerable number of data have therefore been collected for this area during the period covered by this report.

Mercury data for this area are given in Tables 3(c) and 5*, from which it can be seen that between 1977 and 1985 mercury levels remained fairly high. However, the present situation represents a considerable improvement over that pertaining in the early 1970s when inputs were much higher (JMG, 1984) and the average concentration of mercury in fish flesh was about double that found in the last few years.

This area is subject to discharges from chloralkali plants and thus to the provisions of the EC Mercury Directive (Council Directive 82/176/EEC of 22 March 1982, on Limit Values and Quality Objectives for Mercury Discharges by the Chlor-alkali Electrolysis Industry). Consequently, since 1982, it has been necessary to determine whether or not the Environmental Quality Standard (EQS) of 0.3 mg mercury per kg mixed wet fish flesh (see Appendix 3) has been complied with. For this purpose the weighted mean is calculated, which takes into account the species' commercial landings. Utilizing the data in Table 5, the value of this weighted mean was 0.29 in 1982, 0.26 in 1983, 0.27 in 1984 and 0.23 in 1985, thus showing that the Environmental Quality Standard has been complied with in recent years.

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*All mercury data available to date are summarized in Table 5. This includes results from some of the samples obtained for the Study on Spatial Variation in Contaminant Concentrations in Liverpool Bay which was carried out in 1983-85. Results quoted for some species are therefore different from those in Table 3(c), which were based only on those fish analysed for the full range of contaminants.

From data shown in Table 5 it would appear that no significant reduction in mercury levels in fish flesh has taken place since 1977, though it should again be emphasized that trend analysis was not the purpose for which these samples were collected and hence any conclusions should be treated with some caution. Because of the importance of being able to accurately assess temporal trends in mercury in fish flesh, a separate programme with this as its objective has been underway since 1982. Preliminary analyses of the data suggest that a slight decrease may have occurred. The study of the spatial distribution of contaminants in the north-east Irish Sea, which will be published elsewhere, indicates that the area of highest mercury contamination found in Liverpool Bay does not extend far offshore, although it is apparent that levels of mercury are elevated over a considerable part of the north-eastern Irish Sea.

With regard to the other metals (Table 3(c)), there is no indication of serious contamination of fish by copper, zinc, cadmium or lead, though in 1982 detectable concentrations of cadmium were found in both plaice and flounder livers. Similarly, in the shellfish sampled, only the concentrations of lead in mussels from Liverpool were above the normal expected ranges for the metals (including mercury) and even then the concentration was still less than half that specified in the Food Regulations (Appendix 3).

High concentrations of organochlorine pesticide residues were found in some of the livers of fish caught in 1983 (Table 3(c)). For example, total DDT exceeded 2 mg kg^{-1} wet weight in two samples of cod and whiting liver, though only a little of this appeared to be from recent contamination (i.e. the pp DDT fraction was low). In some species, considerably higher values have been recorded in the past (Table 6). However, there is no clear indication of a reduction in concentration over the period 1977-84.

Concentrations of PCBs in the livers of a number of species were also high in 1983. As with Σ DDT, there is no clear indication of a decline in levels in the last few years (Table 7) though, in general, concentrations were considerably less than those recorded in the mid-1970s. Except for the 1984 plaice sample, where the PCB level was in the upper JMG category, pesticide/PCB residue levels in fish muscle (Table 4) were generally low.

3.3.4 Morecambe Bay

This is another area which has been regularly monitored due to the occurrence of high mercury concentrations in fish flesh. Although inputs directly to the area from a chloralkali factory have been much reduced since the early 1980s, data in Table 3(d) indicate that mercury contamination of some species still occurs, with an exceptionally high concentration being found in whiting in 1983 (0.60 mg kg^{-1}). The reason for such high levels in this species (which is not in fact landed in any quantity from Morecambe Bay) is unknown. The 1984 and 1985 concentrations were considerably lower than in 1983, at 0.44 and 0.27 mg kg^{-1} wet weight. Largely because of levels in whiting, the time series (Table 5) indicates, as in Liverpool Bay, that no significant reduction in overall mean mercury levels in fish flesh has occurred in recent years, though concentrations are generally much less than those found in the early 1970s. Because Morecambe Bay receives discharges from the chloralkali industry, EQS monitoring (see Appendix 3) must be carried out; the weighted mean mercury concentration in fish flesh calculated for this purpose was 0.18 mg kg^{-1} wet weight in 1982, 0.24 in 1983, 0.22 in 1984 and 0.21 in 1985. For consistency, the samples of Morecambe Bay fish used for this purpose have been taken every year from well inshore

(the Lune Deeps area). Most of the fish landed commercially now come from further offshore where, from the Study on Spatial Variation in Contaminant Concentrations, mercury levels have been found to be lower.

There is no indication, from the fish data, of serious contamination by the other metals. This is supported by the shellfish data where, as in Liverpool Bay, all metal concentrations, including those for mercury, were moderate or low. Organochlorine pesticide and PCB levels in shellfish were also low but there was some elevation of concentrations in the livers of certain fish species. In cod liver, residues of a number of these compounds were at, or slightly above, the upper end of the expected range, in whiting, concentrations of DDE, TDE and PCBs were above normal and concentrations of PCBs were also high in flounder and dab. There is, unfortunately, little background information on pesticide/PCB levels from this area. Somewhat lower PCB concentrations were generally present in samples collected in 1984 (Table 3(d)) compared with those found in 1983.

Concentrations of all pesticide/PCB residues were low in fish muscle (Table 4).

3.3.5 St Bees Head/north-eastern Isle of Man area

Samples from this area (Table 3(e)) indicated that the elevated levels of some contaminants, noted in Liverpool and Morecambe Bays, did not extend northwards to any great extent. Generally, concentrations of mercury in the fish flesh and levels of organochlorine pesticides and PCB residues in fish liver were much lower than those found in fish from Liverpool and Morecambe Bays. The cadmium concentration in Whitehaven mussels was fairly high, possibly due to local inputs from the processing of phosphate ore, but the level in mussels from the Ravenglass estuary and in brown crab meat were low. Considerable information should become available for the area when results from the Study on Spatial Variation in Contaminant Concentrations in fish from the entire north-eastern Irish Sea area, carried out between 1983 and 1985, are completed. Analyses carried out so far confirm that levels of contamination are lower than those found in Liverpool and Morecambe Bays.

4. Summary and conclusions

1. The fish and shellfish sampling programme carried out by MAFF between 1977 and 1984 was directed mainly to areas where there is a potential for contamination from land-based sources.

2. The programme has indicated that there is a considerable variation of contaminant levels around the coasts of England and Wales.

3. Whilst the results obtained do not in general give any cause for concern, it is apparent that levels of certain contaminants have been, and in some cases still are, relatively high in a few areas.

4. No North Sea coastal area now appears to be seriously contaminated, the mercury levels in fish from the Thames Estuary having undergone considerable reduction. Concentrations of some organochlorine pesticide and PCB residues remain above normal in some North Sea areas, but levels are generally lower than those previously reported.

5. The levels of metals and organochlorine pesticides and PCBs in fish and shellfish taken from the English Channel are relatively low.

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6. Of the areas examined, the level of contamination is highest in the Irish Sea off the north-west coast. High concentrations of mercury have been found in some species taken from Liverpool and Morecambe Bays, although fish from these areas continue to satisfy the quality standard (EQS) laid down by the EC and the Paris Convention. High levels of some organochlorine pesticides and PCBs have also been found in fish livers from Liverpool Bay. However, even in these areas there has been an improvement relative to the situation in the early 1970s.

7. Analysis of samples of fish muscle, from areas where fish livers contained above-normal levels of organochlorine pesticides and PCBs, indicated that concentrations of these substances are much lower in the fish muscle (often by a factor of 100) and give no cause for concern.

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Appendix 1 Tables 1-7

Abbreviations used in the tables

(L) Liver tissue analysed for cadmium or lead

B Analysis carried out on bulked tissue

B(W) Analysis carried out on bulked whole tissue

NA Not analysed

Δ Additional, unreported data available from the area for this species

Table 1 North Sea coast. The concentration of heavy metals in fish muscle/ shellfish and the concentration of pesticides/ PCBs in fish liver/ shellfish (mg kg^{-1} wet weight)

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(a) TYNE AREA: FISH												
Cod Δ	39E8	Mar 1982	20	77		0.09 (0.06-0.14)	0.2 (<0.2-0.5)	4.6 (2.6-8.2)	<0.2 (L)	<0.2 (L)	20	
Whiting Δ	"	Feb 1984	25	29	B	0.07 (0.07;0.07)	0.3 (0.3;0.3)	3.3 (3.1;3.5)	NA	NA	19	
Haddock	"	Nov 1977	12	29		0.05 (0.03-0.12)	0.3 (<0.2-0.4)	3.9 (3.1-4.7)	<0.2	<0.2	21	
Plaice Δ	"	Jun 1979	10	34		0.11 (0.04-0.30)	0.3 (<0.2-0.5)	4.8 (3.3-7.6)	<0.2 <0.2 (L)	<0.2 <0.2 (L)	17	1984 Hg concentration = 0.04 mg kg^{-1}
Dab	"	Apr 1977	14	20		0.11 (0.03-0.25)	0.3 (0.3-0.4)	11.0 (7.5-17.0)	<0.2	<0.2	20	
Lemon sole	"	Jun 1978	25	29		0.04 (0.02-0.08)	0.2 (<0.2-0.4)	3.3 (1.7-6.7)	<0.2	<0.2	21	
Sprats	"	Mar 1982	25	12	B(W)	0.02 (0.02;0.02)	1.1 (1.0;1.1)	22.0 (22.0;22.0)	<0.1	NA	17	

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(a) TYNE AREA: FISH															
Cod Δ	39E8	Mar 1982	20	77		0.057	0.039	0.020	0.33	1.2	0.75	0.42	4.0	26	1984 Σ DDT concentration = 0.44 mg kg^{-1}
Whiting Δ	"	Feb 1984	25	29	B	0.02	0.03	0.007	0.10	0.20	0.11	0.04	1.1	40	
Haddock	"	Nov 1977	12	29		0.015	0.035	0.01	0.09	0.06	0.15	0.08	0.46	31	
Plaice Δ	"	Jun 1979	10	34		0.004	0.007	0.005	0.18	<0.002	0.02	0.02	0.11	33	
Dab	"	Apr 1977	14	20		0.004	0.02	0.01	0.10	0.04	0.05	<0.002	0.04	6	
Lemon sole	"	Jun 1978	25	29		0.005	0.008	<0.001	0.034	NA	0.022	0.012	0.18	8	
Sprats	"	Mar 1982	25	12	B(W)	NA	NA	NA	NA	"	NA	NA	NA	NA	

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(a) TYNE AREA: SHELLFISH												
Nephrops Δ	39E8	Nov 1978	22	-	B	0.28	20	16	<0.4	<0.2	22	1984 Hg concentration = 0.19 mg kg^{-1}
Pandalus borealis	"	Apr 1978	30	-	B	0.14	15	35	0.4	<0.2	27	
Pink shrimp	"	Apr 1977	55	-	B	0.10	16	20	<0.4	<0.2	21	
Mussels	Amble	Aug 1978	56	5.6	B	0.05	1.9	16	<0.2	0.8	22	
"	Blyth	Jul 1978	53	4.1	B	0.09	1.5	30	0.7	0.9	14	
"	Hartlepool	Jul 1978	63	3.7	B	0.12	1.0	40	0.4	0.6	16	
Crab	Whitby	Sep 1977	10	15.7					<0.2/2.9			

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(a) TYNE AREA: SHELLFISH														
Nephrops Δ	39E8	Nov 1978	22	-	B	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<1
Pandalus borealis	"	Apr 1978	30	-	B	<0.001	0.001	0.001	0.001	0.001	0.002	0.001	<0.001	2
Pink shrimp	"	Apr 1977	55	-	B	<0.001	0.002	0.001	0.003	0.002	<0.002	<0.002	0:01	<1
Mussels	Amble	Aug 1978	56	5.6	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
"	Blyth	Jul 1978	53	4.1	B	"	"	"	"	"	"	"	"	"
"	Hartlepool	Jul 1978	63	3.7	B	<0.001	0.005	0.003	0.019	0.002	0.007	0.014	0.034	1.0

Table 1 *continued*

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(b) HUMBER AREA: FISH												
Cod	36E9/36F0	Oct 1983	26	40		0.10 (0.04-0.31)	0.3 (0.2-0.4)	3.6 (2.7-6.5)	NA	NA	19	1984 Hg concentration = 0.08 mg kg^{-1}
Whiting	"	"	30	33		0.10 (0.03-0.18)	0.3 (0.2-0.5)	3.5 (2.9-6.2)	"	"	19	1984 Hg concentration = 0.08 mg kg^{-1}
Flounder	"	"	24	33		0.12 (0.02-0.26)	0.4 (0.2-0.6)	4.9 (3.5-7.9)	"	"	20	1984 Hg concentration = 0.08 mg kg^{-1}
Sole	"	"	5	26		0.09 (0.04-0.18)	0.3 (0.3)	4.1 (3.6-4.9)	"	"	21	1984 Hg concentration = 0.06 mg kg^{-1}

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(b) HUMBER AREA: FISH														
Cod	36E9/36F0	Oct 1983	26	40		0.052	0.024	0.013	0.57	0.37	0.34	0.11	2.5	38
Whiting	"	"	30	33		0.017	0.024	0.034	0.36	0.27	0.31	0.15	3.7	44
Flounder	"	"	24	33		0.006	0.008	0.004	0.32	0.021	0.12	0.037	0.93	21
Sole	"	"	5	26		<0.001	0.005	0.003	0.12	0.018	0.05	0.021	0.22	9

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(b) HUMBER AREA: SHELLFISH											
Pink shrimp	36F0	May 1977	76	-	B	0.08	14	40	<0.4	<0.2	21
Brown shrimp	"	"	55	-	B	0.07	22	32	<0.4	<0.2	22
Whelks	"	"	38	8.0	B	0.12	27	140	1.4	<0.2	25
Crab	Bridlington	Jul 1978	11	15.8					<0.2/5.6		
Mussels	Bull Fort, Humber	Jul 1985	49	4.6	B	0.04	1.8	35	0.84	<0.6	13
"	Cleethorpes	Jan 1985	71	3.5	B	0.02	1.7	28	0.48	<0.6	16

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(b) HUMBER AREA: SHELLFISH														
Pink shrimp	36F0	May 1977	76	-	B	<0.001	0.005	0.003	0.005	0.002	<0.002	<0.002	<0.001	<1
Brown shrimp	"	"	55	-	B	<0.001	0.003	0.002	0.004	<0.002	<0.002	<0.002	0.005	<1
Whelks	"	"	38	8.0	B	<0.001	0.007	0.006	0.004	0.001	<0.002	0.03	<0.05	<1
Mussels	Bull Fort, Humber	Jul 1985	49	4.6	B	<0.001	<0.001	0.001	0.005	0.001	<0.001	<0.001	0.017	<1
"	Cleethorpes	Jan 1985	71	3.5	B	<0.001	<0.001	0.002	0.021	0.006	<0.001	0.008	0.058	2

Table 1 continued

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(c) SOUTHERN BIGHT: FISH												
Cod	Δ	33F2/34F2	Jul 1983	25	48		0.09 (0.05-0.19)	0.3 (0.2-0.5)	3.4 (2.9-3.9)	NA	NA	20
Whiting		"	Nov 1982	12	34	B	0.10 (0.10;0.10)	0.2 (0.2;0.2)	4.0 (4.8;3.2)	<0.2 (L)	<0.4 (L)	20
Plaice	Δ	"	Dec 1983	25	35		0.08 (0.03-0.25)	0.2 (0.2-0.3)	4.4 (2.5-7.3)	NA	NA	19

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(c) SOUTHERN BIGHT: FISH															
Cod	Δ	33F2/34F2	Jul 1983	25	48		0.029	0.018	0.010	0.20	0.26	0.056	0.081	5.7	36
Whiting		"	Nov 1982	12	34	B	0.034	0.025	0.021	0.15	0.11	0.28	0.04	1.4	60
Plaice	Δ	"	Dec 1983	25	35		0.003	0.004	0.003	0.013	0.012	0.005	0.011	0.46	7

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(c) SOUTHERN BIGHT: SHELLFISH												
Whelks	34F2	Apr 1978	5	70		0.16	42	180	1.8	<0.2	26	
Mussels	Blythburgh	Aug 1978	52	4.9	B	0.06	1.5	17	0.3	1.1	22	
"	Harwich	Sep 1984	72	4.5	B	0.05	1.0	20	0.4*	<0.4*	16	*1982 results
Crab	Cromer	Jul 1978	10	14.0					<0.2/6.8			

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(c) SOUTHERN BIGHT: SHELLFISH														
Whelks	34F2	Apr 1978	5	70		<0.002	<0.002	<0.002	0.005	0.002	0.002	<0.002	0.003	<1
Mussels	Blythburgh	Aug 1978	52	4.9	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
"	Harwich	Sep 1984	72	4.5	B	"	0.002	0.002	0.005	0.002	0.003	0.001	0.017	<1

Table 1 continued

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(d) THAMES ESTUARY: FISH													
Cod	Δ	32F1	Mar 1983	25	49	B	0.13 (0.13;0.13)	0.3 (0.2;0.3)	3.2 (3.3;3.1)	NA	NA	18	
Whiting	Δ	"	Jun 1983	10	29	B	0.14 (0.14;0.14)	0.2 (<0.2;0.2)	3.4 (3.3;3.4)	"	"	18	
Plaice	Δ	"	Jun 1983	30	27	B	0.06 (0.06;0.06)	0.4 (0.3;0.4)	6.1 (5.1;7.0)	<0.2 (L)	<0.1 (L)	19	
Flounder	Δ	"	Jun 1983	25	28	B	0.28 (0.25;0.30)	0.3 (0.3;0.3)	5.5 (5.1;5.8)	0.3 (L)	0.3 (L)	17	
Sole	Δ	"	Jun 1983	50	27	B	0.12 (0.10;0.13)	0.3 (0.3;0.2)	6.0 (4.2;7.3)	0.2 (L)	<0.1 (L)	20	Fish analysed in two batches
Dab	Δ	"	Jun 1983	25	25	B	0.11 (0.11;0.11)	0.2 (0.2;0.2)	3.7 (3.6;3.7)	0.3 (L)	<0.1 (L)	19	
Herring		"	Jan 1979	23	21		0.19 (0.09-0.29)	1.3 (0.4-2.4)	8.2 (6.4-11.0)	<0.2 (L)	<0.4 (L)	26	
Sprats		"	Jan 1981	12	-	B(W)	0.05 (0.05;0.04)	NA	NA	<0.2	<0.2	-	
Thornback ray		"	Jun 1983	14	48	B	0.15 (0.15;0.14)	0.2 (0.2;0.2)	3.5 (3.5;3.5)	NA	NA	22	

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(d) THAMES ESTUARY: FISH																
Cod	Δ	32F1	Mar 1983	25	49	B	0.027	0.017	0.054	0.49	0.013	0.11	0.13	1.1	43	1984 dieldrin concentration = 0.31 mg kg^{-1}
Whiting	Δ	"	Jun 1983	10	29	B	0.026	0.025	0.038	0.46	0.90	0.28	0.27	4.3	18	1984 dieldrin and pp DDE concentrations = 0.28 and 0.24 mg kg^{-1} respectively
Plaice	Δ	"	Jun 1983	30	27	B	0.005	0.002	0.016	0.081	0.10	0.032	0.022	0.60	13	
Flounder	Δ	"	Jun 1983	25	28	B	0.005	0.003	0.010	0.31	0.28	0.10	0.053	1.6	5	
Sole	Δ	"	Jun 1983	50	27	B	<0.001	0.002	0.003	0.019	0.006	0.005	0.005	0.20	3	Fish analysed in two batches
Dab	Δ	"	Jun 1983	25	25	B	0.007	0.048	0.047	0.18	0.23	0.037	0.045	1.7	23	
Herring		"	Jan 1979	23	21		0.005	0.007	0.012	0.039	0.025	0.035	0.044	0.26	6	
Sprats		"	Jan 1981	12	-	B(W)	0.006	0.009	0.008	0.02	<0.001	0.041	0.043	0.15	15	
Thornback ray		"	Jun 1983	14	48	B	0.010	0.015	0.012	0.017	0.26	0.51	0.20	1.5	21	

Table 1 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(d) THAMES ESTUARY: SHELLFISH												
Pink shrimp	32F1	May 1977	55	-	B	0.11	12	36	<0.2	<0.4	22	
Brown shrimp	"	May 1981	57	-	B	0.08	18	23	<0.4	<0.4	-	
Whelk	"	May 1977	5	7.0	B	0.60*	80	180	4.2	<0.2	21	*1985 Hg concentrations = 0.13 and 0.14 mg kg^{-1}
Mussels	Southend	Oct 1982	68	5.1	B	0.06	2.5	29	0.8	0.5	14	
"	Whitstable	Sep 1978	82	3.8	B	0.06	1.6	25	1.0	0.9	18	

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(d) THAMES ESTUARY: SHELLFISH														
Pink shrimp	32F1	May 1977	55	-	B	<0.001	0.002	0.001	0.003	0.002	<0.002	<0.002	0.01	<1
Brown shrimp	"	May 1981	57	-	B	<0.001	<0.001	0.002	0.003	0.002	0.002	<0.001	0.007	1
Whelks	"	May 1977	5	7.0	B	<0.001	0.004	0.002	0.01	0.006	0.03	<0.002	0.02	<1
Mussels	Southend	Oct 1984	72	4.9	B	<0.001	<0.001	<0.001	0.005	0.001	<0.001	<0.001	0.035	<1
"	Whitstable	Sep 1978	82	3.8	B	NA	<0.002	<0.002	0.004	0.003	0.004	<0.002	<0.05	<1

Table 2 English Channel. The concentration of heavy metals in fish muscle/shellfish and the concentration of pesticides/PCBs in fish liver/shellfish (mg kg^{-1} wet weight)

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(a) EASTERN CHANNEL: FISH											
Plaice	31F1 (Hythe)	Jun 1979	10	38		0.17 (0.07-0.34)	<0.2 -	4.7 (3.7-5.5)	<0.2	<0.2	20
Mackerel	"	May 1979	5	35		0.14 (0.06-0.22)	1.0 (0.7-1.3)	6.6 (5.0-11.3)	<0.2	<0.2	22
Cod	30F0 (Rye)	May 1980	34	29		0.11 (0.06-0.16)	0.3 (<0.2-0.6)	4.3 (3.0-5.0)	<0.2	<0.2	19
Sole	"	May 1980	23	29		0.15 (0.04-0.45)	0.2 (0.1-0.4)	3.6 (2.8-4.7)	<0.2	<0.2	16
Dab	"	May 1980	30	21		0.12 (0.05-0.41)	0.3 (<0.2-0.6)	5.4 (4.1-6.8)	<0.2	<0.2	19
Whiting	30F0 (Hastings)	Jan 1977	9	29		0.18 (0.08-0.40)	0.3 (<0.2-0.4)	4.6 (3.2-6.5)	<0.2	<0.2	19
Plaice	"	Apr 1981	10	29	B	0.07 (0.06;0.08)	0.3 (0.3;0.3)	6.5 (6.3;6.6)	NA	NA	19
Dab	"	Jan 1977	11	23		0.10 (0.06-0.20)	<0.2 -	4.6 (3.4-6.4)	<0.2	<0.2	22
Mackerel	"	Sep 1980	24	31	B	0.05 (0.04;0.05)	0.7 (0.6;0.7)	4.5 (3.9;5.1)	NA	NA	25
Thornback ray	"	Jan 1977	10	41		0.11 (0.09-0.13)	0.3 (0.3-0.4)	5.5 (4.5-9.2)	<0.2	<0.2	23

Table 2 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(a) EASTERN CHANNEL: FISH															
Plaice	31F1 (Hythe)	Jun 1979	10	38		0.005	0.010	0.010	0.07	0.05	0.08	0.09	0.44	10	
Mackerel	"	May 1979	5	35		0.002	<0.001	<0.001	0.011	<0.001	0.067	<0.001	0.27	3	
Cod	30F0 (Rye)	May 1980	34	29		0.023	<0.001	<0.001	<0.001	0.47	<0.001	<0.001	4.6	15	
Sole	"	May 1980	23	29		<0.002	<0.002	<0.002	0.007	0.007	0.010	0.007	<0.05	<1	Pesticide analysis is on muscle tissue
Dab	"	May 1980	30	21		0.008	<0.001	<0.001	<0.001	0.061	<0.001	<0.001	0.79	7	
Whiting	30F0 (Hastings)	Jan 1977	9	29		0.032	0.038	0.02	0.32	0.73	0.48	0.12	6.9	46	1985 PCB concentration 3.0 mg kg^{-1}
Plaice	"	Apr 1981	10	29	B	0.015	0.003	0.008	0.050	0.065	0.049	0.023	0.76	6	
Dab	"	Jan 1977	11	23		NA	NA	NA	NA	NA	NA	NA	NA	NA	
Mackerel	"	Sep 1980	24	31	B	0.005	0.002	0.002	0.005	0.052	0.003	0.006	0.46	6	
Thornback ray	"	Jan 1977	10	41		0.008	0.014	<0.001	0.044	<0.001	0.027	0.001	0.95	27	

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(a) EASTERN CHANNEL: SHELLFISH											
Scallop	Newhaven	May 1978	5	13.8	B	0.04	0.9	36	4.0	1.2	21
Mussels	Dymchurch	Sep 1978	65	4.0	B	0.04	1.4	17	0.3	0.8	25
"	Hastings	Jul 1978	53	4.8	B	0.05	1.2	16	<0.2	1.3	21
"	Eastbourne	Aug 1978	50	5.4	B	0.03	1.3	14	0.2	0.7	17
Crab	Newhaven	May 1978	8	14.6					<0.2/3.9		

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(a) EASTERN CHANNEL: SHELLFISH															
Scallop	Newhaven	May 1978	5	13.8	B	<0.001	<0.001	<0.001	0.001	<0.001	0.003	<0.001	0.009	<1	
Mussels	Dymchurch	Sep 1978	65	4.0	B	NA	<0.002	<0.002	0.002	0.009	0.009	0.010	0.10	2	Pesticide results from 1977 sample
"	Hastings	Jul 1978	53	4.8	B	"	0.005	<0.002	0.002	0.005	0.006	0.008	0.10	<1	"
"	Eastbourne	Aug 1978	50	5.4	B	"	NA	NA	NA	NA	NA	NA	NA	NA	

Table 2 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(b) CENTRAL CHANNEL: FISH											
Plaice	30E8/E9 (Poole)	Aug 1978	19	23		0.03 (0.01-0.04)	0.4 (0.2-0.6)	5.1 (3.0-7.0)	<0.2	<0.2	20
Mackerel	"	Nov 1977	10	29		0.04 (0.02-0.08)	0.8 (0.5-1.0)	6.7 (3.5-10.0)	<0.2	<0.2	-
Pilchard	"	Aug 1978	11	23		0.07 (0.04-0.10)	1.2 (0.5-2.5)	19 (7-40)	0.3 (<0.2-0.5)	<0.2	28

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)	HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(b) CENTRAL CHANNEL: FISH														
Plaice	30E8/E9 (Poole)	Aug 1978	19	23	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.17	8	
Mackerel	"	Nov 1977	10	29	NA	0.003	<0.002	0.006	0.010	0.006	0.010	0.40	10	
Pilchard	"	Aug 1978	11	23	"	0.017	0.009	<0.002	0.02	0.042	0.13	NA	6	Pesticide analysis is on muscle tissue

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(b) CENTRAL CHANNEL: SHELLFISH											
Scallop	Littlehampton	May 1978	5	12.8	B	0.06	2.1	48	9.0	0.8	22
Mussels	Shoreham	Aug 1978	50	4.8	B	0.20	1.1	15	0.2	1.5	16
"	Selsey	Jul 1978	50	3.5	B	0.06	1.5	10	<0.2	1.1	16
Clam	Southampton Water	Sep 1978	20	4.4	B	<0.02	3.0	19	<0.2	1.0	15
Mussels		Sep 1978	52	5.6	B	0.02	1.7	17	0.3	0.9	23
Mussels	Poole	Sep 1978	75	4.6	B	0.26	1.4	22	1.1	0.9	26
Crab	Selsey	Jul 1979	9	16.5					<0.2/6.1		

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(b) CENTRAL CHANNEL: SHELLFISH															
Scallop	Littlehampton	May 1978	5	12.8	B	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.003	0.006	<1	
Mussels	Shoreham	Aug 1978	50	4.8	B	NA	<0.002	<0.002	<0.002	0.005	0.004	0.007	0.10	<1	Pesticide results from 1977 sample
"	Selsey	Jul 1978	50	3.5	B	"	NA	NA	NA	NA	NA	NA	NA	NA	
Clam	Southampton Water	Sep 1978	20	4.4	B	"	"	"	0.007	0.061	<0.002	<0.002	<0.05	<1	
Mussels		Sep 1978	52	5.6	B	-	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.05	<1	
Mussels	Poole	Sep 1978	75	4.6	B	NA	<0.002	<0.002	0.003	<0.002	0.004	<0.002	<0.05	<1	

Table 2 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(c) WESTERN CHANNEL: FISH											
Cod	29E6 (Brixham)	Feb 1977	13	46		0.11 (0.07-0.24)	<0.2	3.8 (1.9-8.5)	<0.2	<0.2 21	
Plaice Δ	"	Jul 1978	28	36		0.10 (0.03-0.27)	0.2 (<0.2-0.4)	5.8 (4.4-7.0)	<0.2	<0.2 22	
Whiting	29E5 (Plymouth)	Jan 1983	13	30	B	0.08 (0.07;0.08)	<0.2	3.0 (3.0;2.9)	NA	NA 19	
Plaice Δ	"	Jan 1983	12	29	B	0.05 (0.05;0.04)	<0.2	3.7 (3.6;3.8)	"	" 18	
Mackerel Δ	"	Oct 1982	10	33		0.07 (0.02-0.16)	0.8 (0.5-1.1)	3.5 (3.0-4.0)	"	" 27	
Lemon sole	"	Feb 1978	10	31		0.06 (0.04-0.08)	<0.2	4.1 (3.3-5.0)	<0.2	<0.2 22	
Pilchard	"	Dec 1977	12	23		0.05 (0.03-0.08)	1.3 (0.7-2.0)	14 (10-35)	<0.2	<0.2 33	
Monkfish	"	Mar 1979	8	42		0.15 (0.08-0.20)	<0.2	4.2 (3.2-6.5)	<0.2 <0.2 (L)	<0.2 <0.2 (L) 19	

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(c) WESTERN CHANNEL: FISH															
Cod	29E6 (Brixham)	Feb 1977	13	46		NA	NA	NA	0.05	0.14	0.04	0.04	2.1	32	
Plaice Δ	"	Jul 1978	28	36		0.004	0.024	0.032	0.042	0.034	0.05	0.03	0.50	14	
Whiting	29E5 (Plymouth)	Jan 1983	13	30	B	0.034	0.044	0.017	0.35	0.47	0.25	0.30	4.0	63	
Plaice Δ	"	Jan 1983	12	29	B	<0.001	0.005	0.003	0.023	0.019	0.009	0.029	0.20	3	
Mackerel Δ	"	Oct 1982	10	33		<0.001	0.008	0.008	0.17	0.071	0.12	0.23	0.55	10	
Lemon sole	"	Feb 1978	10	31		0.007	0.016	0.007	0.028	<0.001	0.061	0.027	0.53	17	
Pilchard	"	Dec 1977	12	23		0.03	0.007	0.002	0.01	<0.002	0.02	0.01	0.34	8	Pesticide analysis is on muscle tissue
Monkfish	"	Mar 1979	8	42		0.019	0.017	0.007	0.09	0.08	0.10	0.12	1.6	8	

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(c) WESTERN CHANNEL: SHELLFISH											
Scallop	Lyme Bay	Apr 1978	10	11.3	B	0.04	1.2	40	2.8	1.3	23
Mussels	Exmouth	Aug 1978	44	6.1	B	0.05	1.4	15	0.3	1.3	18
"	Teignmouth	Sep 1978	50	6.5	B	0.04	1.7	17	0.5	1.8	26
"	Plymouth Sound	Aug 1978	50	2.6	B	0.07	1.4	22	0.3	1.4	22
"	Whitesand Bay	Aug 1978	50	4.7	B	0.06	3.8	50	0.3	1.0	21
Crab	Paignton	Oct 1978	10	19.3					<0.2/16.3		
"	Plymouth	May 1980	15	16.3					<0.2/11.7		

Table 2 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(c) WESTERN CHANNEL: SHELLFISH															
Scallop	Lyme Bay	Apr 1978	10	11.3	B	<0.001	0.001	<0.001	0.001	0.002	0.007	0.004	0.01	<1	
Mussels	Exmouth	Aug 1978	44	6.1	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	
"	Teignmouth	Sep 1978	50	6.5	B	"	<0.002	<0.002	<0.002	0.003	0.003	0.003	0.10	2	Pesticide results from 1977 sample
"	Plymouth Sound	Aug 1978	50	2.6	B	"	NA	NA	NA	NA	NA	NA	NA	NA	
"	Whitesand Bay	Aug 1978	50	4.7	B	"	<0.002	<0.002	<0.002	0.013	<0.002	0.065	<0.05	1	

Table 3 West coast. The concentration of heavy metals in fish muscle/shellfish and the concentration of pesticides/PCBs in fish liver/shellfish (mg kg^{-1} wet weight)

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(a) BRISTOL CHANNEL: FISH											
Whiting	31E5/31E6	Mar 1983	24	31	B	0.09 (0.09;0.09)	0.3 (0.3;0.3)	2.8 (2.9;2.7)	NA	NA	19
Plaice	"	Mar 1983	11	35	B	0.15 (0.15;0.15)	<0.2	3.7 (3.3;4.0)	"	"	15
Sole	"	Sep 1977	5	29		0.12 (0.06-0.23)	0.3 (0.2-0.4)	5.8 (4.6-8.8)	<0.2	<0.2	21
Dab	"	Jan 1978	79	27		0.10 (0.03-0.30)	NA	NA	NA	NA	-
Mackerel	"	Sep 1977	25	32		0.07 (0.02-0.12)	1.0 (0.4-2.2)	5.1 (3.2-9.4)	<0.2	<0.2 (<0.2-0.2)	33
Hake	"	Sep 1977	25	33		0.06 (0.04-0.12)	0.2 (<0.2-0.3)	3.6 (2.5-6.0)	<0.2	<0.2	19
Brill	"	Mar 1983	3	31	B	0.04	0.2	4.8	NA	NA	19
Thornback ray	"	Mar 1983	9	68	B	0.39 (0.36;0.42)	0.3 (0.2;0.3)	4.3 (4.8;3.8)	"	"	24

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(a) BRISTOL CHANNEL: FISH														
Whiting	31E5/31E6	Mar 1983	24	31	B	0.026	0.034	0.035	0.22	0.26	0.07	0.14	3.3	61
Plaice	"	Mar 1983	11	35	B	<0.001	0.002	0.002	0.01	<0.001	0.01	<0.001	0.002	2
Sole	"	Sep 1977	5	29		0.001	0.020	0.020	0.09	0.04	0.06	<0.002	0.12	7
Dab	"	Jan 1978	79	27		NA	NA	NA	NA	NA	NA	NA	NA	-
Mackerel	"	Sep 1977	25	32		"	"	"	<0.002	0.051	0.15	0.14	0.57	9
Hake	"	Sep 1977	25	33		0.015	0.019	0.008	0.067	<0.001	0.12	0.034	2.8	39
Brill	"	Mar 1983	3	31	B	0.003	0.003	0.006	0.009	0.034	0.015	0.007	1.2	4
Thornback ray	"	Mar 1983	9	68	B	0.015	0.03	0.014	0.17	0.38	0.034	0.27	7.2	53

Table 3 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(a) BRISTOL CHANNEL: SHELLFISH											
Brown shrimp	31E6	Jun 1980	158	-	B	0.09	14	20	2.9	<0.2	19
Mussels	Minehead	Aug 1978	50	3.2	B	0.11	1.5	40	6.2	3.2	17
"	Witches Point	Aug 1978	50	3.1	B	0.20	2.5	38	1.4	2.5	17
"	Porthcawl	Aug 1978	50	5.2	B	0.13	1.4	40	3.0	3.1	15
Crab	Milford Haven	Jul 1978	5	16.5					0.1/13.7		

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(a) BRISTOL CHANNEL: SHELLFISH														
Brown shrimp	31E6	Jun 1980	158	-	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mussels	Minehead	Aug 1978	50	3.2	B	"	<0.002	<0.002	0.008	<0.002	<0.002	<0.002	0.1	1
"	Witches Point	Aug 1978	50	3.1	B	"	NA	NA	NA	NA	NA	NA	NA	NA
"	Porthcawl	Aug 1978	50	5.2	B	"	"	"	"	"	"	"	"	"

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(b) SWANSEA BAY: FISH											
Cod Δ	32E6	Apr 1983	20	33	B	0.13 (0.13;0.13)	<0.2	3.5 (3.3;3.6)	NA	NA	18
Whiting Δ	"	Apr 1983	16	33	B	0.08 (0.09;0.07)	<0.2	3.5 (3.2;3.7)	"	"	19
Plaice Δ	"	Apr 1983	25	28	B	0.06 (0.06;0.06)	<0.2 (<0.2;0.2)	5.8 (5.1;6.4)	"	"	18
Flounder Δ	"	Apr 1983	25	32	B	0.20 (0.18;0.21)	<0.2	6.4 (6.2;6.6)	"	"	16
Sole	"	Jul 1978	55	29		0.08 (0.02-0.42)	NA	NA	"	"	-
Dab Δ	"	May 1984	29	28	B	0.16 (0.17;0.15)	0.3 (0.3;0.3)	6.3 (6.1;6.4)	"	"	19
Hake	"	Jul 1981	9	29		0.11 (0.04-0.16)	NA	NA	"	"	19
Brill	"	Sep 1982	5	24	B	0.06 (0.04;0.08)	<0.2 -	6.2 (6.0;6.3)	"	"	20
Thornback ray Δ	"	Apr 1983	24	53	B	0.21 (0.20;0.22)	<0.2	3.2 (3.1;3.3)	"	"	22

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(b) SWANSEA BAY: FISH														
Cod Δ	32E6	Apr 1983	20	33	B	0.034	0.016	0.015	0.28	0.96	0.57	0.21	6.4	22
Whiting Δ	"	Apr 1983	16	33	B	0.028	0.032	0.069	0.28	0.30	0.12	0.15	4.2	52
Plaice Δ	"	Apr 1983	25	28	B	0.005	0.002	0.003	0.019	0.047	0.015	0.023	0.46	3
Flounder Δ	"	Apr 1983	25	32	B	0.007	<0.001	0.002	0.028	0.13	0.082	0.035	1.0	2
Sole	"	Jul 1978	55	29		NA	NA	NA	NA	NA	NA	NA	NA	
Dab Δ	"	May 1984	29	28	B	0.002	0.01	0.012	0.037	0.025	0.043	0.015	0.53	12
Hake	"	Jul 1981	9	29		<0.001	<0.001	<0.001	0.001	<0.001	0.005	0.001	0.12	12
Brill	"	Sep 1982	5	24	B	0.011	0.004	0.009	0.04	0.09	0.048	0.027	1.0	7
Thornback ray Δ	"	Apr 1983	24	53	B	0.015	0.015	0.026	0.21	0.22	0.067	0.071	2.6	17

Table 3 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(b) SWANSEA BAY: SHELLFISH											
Mussels	Aberavon	Jun 1985	126	4.2	B	0.05	1.9	28	0.9	2.2	13
"	Swansea	Aug 1978	53	5.0	B	0.13	1.8	47	4.5	4.1	15
"	Mumbles	Aug 1978	48	4.3	B	0.16	1.8	40	1.6	2.6	17

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(b) SWANSEA BAY: SHELLFISH														
Mussels	Aberavon	Jun 1985	126	4.2	B	<0.001	<0.001	NA	0.003	0.001	<0.001	<0.001	0.036	1
"	Swansea	Aug 1978	53	5.0	B	NA	NA	"	NA	NA	NA	NA	NA	NA
"	Mumbles	Aug 1978	48	4.3	B	"	<0.002	<0.002	0.004	0.006	0.005	0.005	<0.05	<1

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(c) LIVERPOOL BAY: FISH													
Cod	Δ	35E6/36E6 South	Sep 1983	25	38		0.35 (0.15-0.84)	0.2 (0.2;0.2)	3.5 (3.5;3.5)	<0.2 (L)*	<0.4 (L)*	20	* 1982 results
Whiting	Δ	"	Sep 1983	25	35		0.32 (0.13-0.69)	0.2 (0.2;0.2)	3.3 (3.2;3.4)	<0.2 (L)*	<0.4 (L)*	19	* 1982 results
Plaice	Δ	"	Sep 1983	24	34		0.27 (0.10-0.60)	0.3 (0.2;0.3)	4.8 (4.6;5.0)	0.4 (L)*	<0.4 (L)*	22	* 1982 results
Flounder	Δ	"	Oct 1983	25	31		0.23 (0.07-0.99)	0.2° (0.1-0.2)	5.3° (3.6-6.7)	0.4 (L)*	<0.4 (L)*	22	* 1982 results ° 1984 results
Sole	Δ	"	Sep 1983	25	27		0.25 (0.07-0.51)	0.3 (0.3;0.3)	4.4 (4.2;4.6)	<0.2 (L)*	<0.4 (L)*	22	* 1982 results
Dab	Δ	"	Sep 1983	25	24		0.21 (0.09-0.64)	0.3 (0.2;0.3)	4.5 (4.0;4.9)	<0.2 (L)*	<0.4 (L)*	21	* 1982 results
Mackerel		"	Apr 1982	29	31	B	0.23 (0.22;0.24)	1.1* (0.6-1.5)	7.2* (4.0-10.0)	<0.2*	<0.2*	23	* 1980 results
Lemon sole		"	Nov 1980	7	26		0.14 (0.07-0.35)	0.3 (0.2-0.7)	4.1 (3.2-4.6)	<0.2	<0.2	22	
Red gurnard		"	Sep 1977	27	24		0.27 (0.16-0.43)	0.3 (<0.2-0.4)	4.0 (2.4-5.3)	<0.2	<0.2	24	
Thornback ray		"	Sep 1981	10	38	B	0.29 -	0.4 -	3.2 -	<0.2	NA	20	

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(c) LIVERPOOL BAY: FISH																
Cod	Δ	35E6/36E6 South	Sep 1983	25	38		0.098	0.012	0.010	0.010	1.1	0.55	0.46	8.4	21	
Whiting	Δ	"	Sep 1983	25	35		0.054	0.031	0.034	0.20	1.3	1.3	0.20	7.1	49	
Plaice	Δ	"	Sep 1983	33	29		0.024	0.019	0.018	0.13	0.25	0.32	0.11	1.7	22	Pesticides from sample taken slightly to the north
Flounder	Δ	"	Oct 1983	25	31		0.022	0.021	0.026	0.071	0.14	0.17	0.026	0.94	21	
Sole	Δ	"	Sep 1983	25	27		<0.001	0.005	0.005	0.048	0.11	0.14	0.014	1.2	10	
Dab	Δ	"	Sep 1983	25	24		0.070	0.018	0.031	0.14	0.27	0.20	0.039	2.9	32	
Mackerel		"	Apr 1982	29	31	B	0.011	0.005	0.005	0.053	0.042	0.010	0.035	0.55	9	
Lemon sole		"	Nov 1980	7	26		0.050	0.045	0.075	0.23	0.14	0.25	0.47	1.1	18	
Red gurnard		"	Sep 1977	27	24		0.030	0.040	0.030	0.28	0.08	0.38	0.10	4.1	18	
Thornback ray		"	Sep 1981	10	38	B	0.029	0.011	0.008	0.21	0.16	0.031	0.025	2.2	14	

Table 3 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(c) LIVERPOOL BAY: SHELLFISH											
Brown shrimp	35E6/36E6 South	Nov 1980	133	-	B	0.11	16.0	20	<0.4	<0.4	22
Prawn	"	Nov 1980	42	-	B	0.09	19.0	21	<0.4	<0.4	20
Whelks	"	Nov 1980	10	10.4	B	0.28	185	200	2.7	1.0	26
Scallop (meats only)	"	Feb 1981	-	-	B	0.02	0.3	23	0.8	<0.4	17
Queen	"	Nov 1980	24	3.1-8.5	B	0.08	5.3	54	0.8	<0.2	18
Mussels	Conwy	Sep 1978	50	6.4	B	0.06	1.7	17	0.4	1.2	23
"	Liverpool	Aug 1978	69	3.1	B	0.12	2.2	62	0.5	4.3	14
Cockles	*Ainsdale*	Jan 1977	59	3.0	B	0.10	1.2	28	<0.2	<0.2	14

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(c) LIVERPOOL BAY: SHELLFISH														
Brown shrimp	35E6/36E6 South	Nov 1980	133	-	B	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.035	1
Prawn	"	Nov 1980	42	-	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
Whelks	"	Nov 1980	10	10.4	B	0.025	0.005	0.01	0.01	0.02	0.08	0.035	0.25	<1
Scallop (meats only)	"	Feb 1981	-	-	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
Queen	"	Nov 1980	24	3.1-8.5	B	<0.001	<0.001	<0.001	0.02	0.035	<0.001	<0.001	0.06	1
Mussels	Conwy	Sep 1978	50	6.4	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
"	Liverpool	Aug 1978	69	3.1	B	"	<0.002	<0.002	0.031	0.023	0.060	<0.002	0.15	2
Cockles	Ainsdale	Jan 1977	59	3.0	B	<0.001	0.005	0.008	0.005	0.007	0.006	0.002	0.004	<1

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter	Notes
(d) MORECAMBE BAY: FISH													
Cod	Δ	36E6 North-east	Jun 1979	10	28		0.22 (0.17-0.31)	0.2 (<0.2-0.2)	2.4 (1.9-3.2)	<0.2 <0.2 (L)	<0.2 <0.2 (L)	17	
Whiting	Δ	"	Jul 1983	22	33		0.60 (0.32-0.98)	0.2 (0.2;0.2)	3.4 (3.6;3.2)	NA	NA	19	1984 Hg concentration = 0.44 mg kg^{-1}
Plaice	Δ	"	Jul 1983	25	34		0.17 (0.09-0.55)	0.3 (0.3;0.3)	5.6 (5.7;5.5)	"	"	21	
Flounder	Δ	"	Jul 1983	25	33		0.27 (0.13-0.40)	0.3 (0.3;0.3)	6.2 (6.0;6.3)	"	"	20	Hg results from two flounder samples included in Table 5
Sole	Δ	"	Jul 1983	25	28		0.17 (0.06-0.34)	0.2 (0.2;0.2)	4.8 (4.7;4.8)	"	"	21	
Dab		"	Jul 1983	25	28		0.33 (0.10-0.73)	0.3 (0.3;0.3)	5.2 (5.1;5.2)	"	"	22	
Mackerel		"	Jul 1983	25	32	B	0.07 (0.07;0.07)	0.8 (0.8;0.8)	4.2 (4.3;4.0)	"	"	27	
Thornback ray		"	Jun 1979	9	55		0.22 (0.12-0.37)	0.4 (0.3-0.6)	4.3 (3.4-4.8)	<0.2 <0.2 (L)	<0.2 <0.2 (L)	22	

Table 3 continued

Species		Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat	Notes
(d) MORECAMBE BAY: FISH																
Cod	Δ	36E6 North-east	Jun 1979	10	28		0.065	0.061	0.075	0.23	0.59	0.52	0.13	4.3	17	
Whiting	Δ	"	Jul 1983	22	33		0.029	0.022	0.019	0.19	1.7	1.5	0.16	6.4	22	1984 PCB concentration = 5.0 mg kg^{-1}
Plaice	Δ	"	Jul 1983	25	34		0.003	0.006	0.003	0.006	0.15	0.007	0.046	0.89	25	
Flounder	Δ	"	Jul 1983	25	33		0.015	0.010	0.010	0.006	0.005	0.15	0.034	1.2	21	1984 PCB concentration = 0.9 mg kg^{-1}
Sole	Δ	"	Jul 1983	25	28		0.008	0.015	0.010	0.002	0.005	0.019	0.008	0.41	15	
Dab		"	Jul 1983	25	28		0.019	0.019	0.014	0.091	0.18	0.018	0.054	1.3	41	1984 PCB concentration = 0.7 mg kg^{-1}
Mackerel		"	Jul 1983	25	32	B	0.002	0.004	0.002	0.007	0.025	0.013	0.008	0.18	6	
Thornback ray		"	Jun 1979	9	55		0.03	0.03	0.02	0.33	0.18	0.32	0.15	1.2	19	

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(d) MORECAMBE BAY: SHELLFISH											
Brown shrimp	36E6 North-east	Apr 1982	50	-	B	0.20	10.5	13	<0.1	1.1	22
Mussels	Fleetwood	Aug 1978	49	4.4	B	0.07	1.5	27	0.3	2.0	14
"	Heysham	Aug 1978	49	4.2	B	0.07	1.8	28	0.4	1.6	15
"	Morecambe	Aug 1978	52	4.2	B	0.06	1.8	25	0.3	1.9	17
"	Barrow	Aug 1978	49	5.3	B	0.10	1.1	25	0.6	2.6	19

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(d) MORECAMBE BAY: SHELLFISH														
Brown shrimp	36E6 North-east	Apr 1982	50	-	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mussels	Fleetwood	Aug 1978	49	4.4	B	"	<0.002	<0.002	0.012	0.006	0.006	<0.002	<0.05	1
"	Heysham	Aug 1978	49	4.2	B	"	<0.002	<0.002	0.005	<0.002	0.006	<0.002	<0.05	1
"	Morecambe	Aug 1978	52	4.2	B	"	<0.002	<0.002	0.010	0.004	0.012	<0.002	<0.05	2
"	Barrow	Aug 1978	49	5.3	B	"	NA	NA	NA	NA	NA	NA	NA	NA

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(e) ST BEES HEAD/NORTH-EAST ISLE OF MAN: FISH											
Cod	37E5/37E6	Nov 1977	13	49		0.15 (0.07-0.35)	0.3 (<0.2-0.6)	3.3 (2.8-4.0)	<0.2	<0.2	-
Whiting	"	Sep 1983	20	31	B	0.22 (0.20;0.23)	0.3 (0.3;0.3)	3.6 (3.5;3.7)	NA	NA	20
Plaice	"	Oct 1979	11	28		0.14 (0.07-0.34)	0.2 (<0.2-0.4)	6.1 (5.1-7.6)	<0.2 <0.2 (L)	<0.2 <0.2 (L)	23
Sole	"	Oct 1978	10	26		0.10 (0.04-0.27)	<0.2	3.6 (3.0-4.4)	<0.2	<0.2	-
Dab	"	Oct 1978	10	25		0.19 (0.14-0.25)	<0.2	5.0 (3.2-9.4)	<0.2	<0.2	-

Table 3 continued

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(e) ST BEES HEAD/NORTH-EAST ISLE OF MAN: FISH														
Cod	37E5/37E6	Nov 1977	13	49		NA	NA	NA	0.08	0.15	0.05	0.05	2.0	37
Whiting	"	Sep 1983	20	31	B	0.022	0.041	0.03	0.09	0.11	0.26	0.047	2.0	58
Plaice	"	Oct 1979	11	28		0.01	0.04	0.01	0.09	0.03	0.12	0.06	0.18	16
Sole	"	Oct 1978	10	26		NA	NA	NA	NA	NA	NA	NA	NA	NA
Dab	"	Oct 1978	10	25		"	"	"	"	"	"	"	"	"

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		Hg	Cu	Zn	Cd	Pb	% dry matter
(e) ST BEES HEAD/NORTH-EAST ISLE OF MAN: SHELLFISH											
Mussels	Ravenglass	Aug 1978	52	4.2	B	0.06	1.4	24	0.5	1.0	14
"	Whitehaven	Aug 1978	54	3.8	B	0.05	1.5	20	2.0	2.0	13
Crab	St Bees	Oct 1978	1	15.4					<0.2/2.7		
"	Workington	Oct 1978	2	8.8					<0.2/1.1		

Species	Area of capture	Date of capture	Number in sample	Mean length (cm)		HCB	α HCH	γ HCH	Dieldrin	pp DDE	pp TDE	pp DDT	PCB	% fat
(e) ST BEES HEAD/NORTH-EAST ISLE OF MAN: SHELLFISH														
Mussels	Ravenglass	Aug 1978	52	4.2	B	<0.001	0.004	0.002	0.017	<0.001	0.004	0.008	0.008	<1
"	Whitehaven	Aug 1978	54	3.8	B	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 4 The concentration of organochlorine pesticides and PCBs in fish muscle (mg kg^{-1} wet weight)

Area	Species	Date of capture	HCB	α HCH	γ HCH	Dieldrin	DDE	TDE	DDT	PCB
Tyne	Cod	Mar 1982	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.005
Humber	Cod	Oct 1983	<0.001	<0.001	<0.001	0.002	<0.001	0.006	<0.001	0.005
"	Whiting	Oct 1983	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	0.010
"	Flounder	Oct 1983	<0.001	<0.001	<0.001	0.005	0.002	0.004	0.002	0.025
Southern Bight	Cod	Jul 1983	<0.001	<0.001	<0.001	0.002	0.001	0.001	0.002	0.04
Thames	Cod	Mar 1983	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.004
"	Whiting	Jun 1983	<0.001	<0.001	<0.001	0.004	0.001	<0.001	0.002	0.031
"	Flounder	Jun 1983	<0.001	<0.001	<0.001	0.007	0.008	0.002	0.002	0.060*
Rye	Cod	May 1980	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	0.016
Plymouth	Whiting	Jan 1983	<0.001	<0.001	<0.001	0.002	0.004	<0.001	0.003	0.006
Bristol Channel	Ray	Mar 1983	<0.001	0.003	0.005	0.01	<0.001	0.003	0.004	0.028
Swansea Bay	Cod	Apr 1983	<0.001	<0.001	<0.001	0.002	0.005	0.002	0.003	0.050
"	Whiting	Apr 1983	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.011
"	Flounder	Apr 1983	<0.001	<0.001	<0.001	0.003	0.004	0.002	0.003	0.041
Liverpool Bay	Cod	Sep 1983	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.015
"	Whiting	Sep 1983	<0.001	<0.001	<0.001	0.002	<0.001	0.001	0.002	0.005
"	Flounder	Oct 1983	<0.001	<0.001	<0.001	0.003	0.002	<0.001	<0.001	0.017
"	Dab	Sep 1983	0.001	<0.001	<0.001	0.002	0.001	0.001	0.001	0.043
"	Plaice	Sep 1984	<0.001	<0.001	<0.001	0.004	0.003	0.003	0.003	0.069+
Morecambe Bay	Cod	Jun 1979	0.002	0.003	<0.002	0.004	0.004	0.002	0.001	<0.05
"	Whiting	Jul 1983	<0.001	<0.001	<0.001	0.002	<0.001	0.001	0.002	0.005
"	Flounder	Jul 1983	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	0.005
"	Dab	Jul 1983	<0.001	<0.001	<0.001	0.001	0.003	<0.001	<0.001	0.034

*1984 value 0.024.
+1985 value 0.038.

Table 5 The concentration of mercury in fish muscle from areas considered to be contaminated to above-average levels - individual species results and overall area means (mg kg^{-1} wet weight)

	1970-72	1977-78	1979-80	1981	1982	1983	1984	1985+
THAMES ESTUARY								
Cod	0.36*	0.13	0.15	0.11	0.10	0.13	0.12	0.08
Whiting	0.42*	0.18	0.18	0.16	0.18	0.14	0.16	
Plaice	0.35*	0.19	0.09	0.08	0.08	0.06	0.09	0.04
Flounder	0.72*	0.29	0.25	0.26	0.29	0.28	0.18	0.17
Sole	0.24*	0.15	0.19	0.13	0.09	0.12	0.11	
Overall mean	0.42	0.19	0.17	0.15	0.15	0.15	0.13	
SWANSEA BAY								
Whiting	0.13†	0.23	-	0.15	0.06	0.08	0.12	
Plaice	0.09†	0.13	0.14	0.10	0.04	0.06	0.10	0.10
Flounder	0.15†	0.17	0.15	0.14	0.07	0.20	0.09	0.14
Dab	0.16†	0.09	-	0.15	0.10	0.10	0.16	
Overall mean	0.13	0.16		0.14	0.07	0.11	0.12	
LIVERPOOL BAY								
Cod	0.49*	0.29	0.26	0.37	0.26	0.30	0.28	0.27
Whiting	0.65*	0.41	0.35	0.22	0.29	0.31	0.41	0.32
Plaice	0.51*	0.28	0.25	0.23	0.26	0.29	0.26	0.15
Flounder	0.64*	0.33	0.32	-	0.33	0.23	0.19	0.20
Sole	0.29*	0.20	0.26	0.30	0.31	0.30	0.37	0.27
Dab	0.86*	0.34	0.35	0.33	0.35	0.28	0.29	0.25
Overall mean	0.57	0.31	0.30	0.29	0.30	0.29	0.30	0.24
MORECAMBE BAY								
Whiting	0.59•	0.26	0.41	0.30	0.34	0.60	0.44	0.27
Plaice	0.57*	0.34	0.43	0.17	0.16	0.17	0.16	0.16
Flounder	0.78*	0.34	0.53	-	0.27	0.20	0.27	0.31
Sole	0.61•	0.27	0.28	-	0.20	0.17	0.20	0.11
Overall mean	0.64	0.30	0.41		0.24	0.29	0.27	0.21

*Data from MAFF, 1971, 1973.
†Portmann, 1979.
•MAFF unpublished data, 1970-72.
+Preliminary data; a number of 1985 samples still to be analysed.

Table 6 DDT total in fish liver from areas considered to have been contaminated to above-average levels. Maximum sample mean concentration* (mg kg^{-1} wet weight)

Area/species	Mid-1970s (year in brackets)	1977/78	1979/80	1981	1982	1983	1984
SOUTHERN BIGHT							
Cod	0.61 (1975)	0.78	1.3	-	1.1	0.40	0.29
Whiting	1.7 (1975)	-	-	-	0.43	-	0.54
Plaice	0.31 (1975)	-	0.19	-	0.07	0.03	0.05
THAMES ESTUARY							
Cod	1.3 (1974)	0.76	1.0	0.70	0.31	0.25	0.31
Whiting	2.1 (1975)	0.71	-	1.9	0.61	1.5	0.58
Plaice	0.24 (1976)	0.09	0.45	0.21	0.24	0.15	0.11
LIVERPOOL BAY							
Cod	0.97 (1976)	-	1.1	1.2	1.1	2.1	1.1
Whiting	3.6 (1976)	2.6	3.1	1.6	2.5	2.8	1.7
Plaice	0.93 (1976)	0.53	0.40	0.56	0.21	0.68	0.70

*This is the highest mean value found in any one batch of fish taken from the area in question which was considered to allow the best comparisons to be made, given the variation which can be encountered in residue levels in non-standardized samples.

Table 7 PCBs in fish liver from areas considered to have been contaminated to above-average levels. Maximum sample mean concentration (mg kg^{-1} wet weight)

Area/species	Mid-1970s (year in brackets)	1977/78	1979/80	1981	1982	1983	1984
SOUTHERN BIGHT							
Cod	8.4 (1975)	4.7	6.2	-	7.1	5.7	1.5*
Whiting	16 (1975)	-	-	-	1.4	-	2.2
Plaice	1.9 (1975)	-	0.65	-	0.27	0.46	0.57
THAMES ESTUARY							
Cod	13 (1974)	7.5	3.2	3.9	1.1	1.1	2.3
Whiting	14 (1975)	5.6	-	7.8	5.0	4.3	3.1
Plaice	0.99 (1976)	0.34	0.60	0.60	0.28	0.60	0.26
LIVERPOOL BAY							
Cod	9.5 (1976)	-	3.3	4.6	2.7	8.4	4.4
Whiting	20 (1976)	5.7	12.9	5.4	4.6	7.1	4.0
Plaice	4.2 (1976)	1.4	1.2	1.5	0.40	1.7	3.6

*Sample taken further north than normal owing to shortage of fish.
Provisional 1985 value 2.5 mg kg^{-1} wet weight.

Appendix 2 Common and scientific names of fish and shellfish mentioned in the text

(a) Fish

Brill	*Scophthalmus rhombus*
Cod	*Gadus morhua*
Dab	*Limanda limanda*
Flounder	*Platichthys flesus*
Haddock	*Melanogrammus aeglefinus*
Hake	*Merluccius merluccius*
Herring	*Clupea harengus*
Lemon sole	*Microstomus kitt*
Mackerel	*Scomber scombrus*
Monkfish	*Lophius piscatorius*
Pilchard	*Sardina pilchardus*
Plaice	*Pleuronectes platessa*
Red gurnard	*Aspitrigla cuculus*
Sole	*Solea solea*
Sprat	*Sprattus sprattus*
Thornback ray	*Raja clavata*
Whiting	*Merlangius merlangus*

(b) Shellfish

Brown shrimp	*Crangon crangon*
Clam	*Mercenaria mercenaria*
Cockle	*Cerastoderma edule*
Crab	*Cancer pagurus*
Deep sea prawn	*Pandalus borealis*
Horse mussel	*Modiolus modiolus*
Mussel	*Mytilus edulis*
Norway lobster	*Nephrops norvegica*
Prawn	*Leander* sp.
Pink shrimp	*Pandalus montagui*
Queen	*Chlamys opercularis*
Scallop	*Pecten maximus*
Whelk	*Buccinium undatum*

Appendix 3 Standards/guidelines for contaminants in fish and shellfish

I Metals

(a) Mercury

The European and Paris Commissions have adopted an Environmental Quality Standard (EQS) for mercury, which requires that the mean concentration of mercury in the flesh of a representative sample* of fish, locally caught from areas receiving significant inputs of mercury, shall not exceed 0.3 mg kg^{-1} on a wet weight basis (EC Directives Nos 82/176 and 84/156). (*See explanatory note at end of appendix.)

For the purposes of the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions, the following arbitrary, purely descriptive, guidelines have been adopted.

	Fish flesh and crustaceans	Molluscs
Lower level	< 0.1 mg kg^{-1} wet weight	< 0.6 mg kg^{-1} dry weight
Medium level	0.1-0.3 mg kg^{-1} wet weight	0.6-1.0 mg kg^{-1} dry weight
Upper level	> 0.3 mg kg^{-1} wet weight	> 1.0 mg kg^{-1} dry weight

(b) Cadmium

There are no standards or guidelines in England and Wales for fish flesh. The expected values are < 0.2 mg kg^{-1} wet weight.

The JMP guideline for cadmium in mussels is as follows:

		Approximate equivalent
Lower level	< 2 mg kg^{-1} dry weight	(≡ < 0.4 wet weight)
Medium level	2-5 mg kg^{-1} dry weight	(≡ 0.4-1.0 wet weight)
Upper level	> 5 mg kg^{-1} dry weight	(≡ > 1.0 wet weight)

From past MAFF work, 'expected' values, i.e. using data from estuaries not known to be severely contaminated, would be up to 0.3 mg kg^{-1} wet weight for crustaceans. (Note: But up to 10 mg kg^{-1} wet weight for crab 'brown' meat.)

(c) Lead

From the Lead in Food Regulations 1979 (Great Britain - Parliament, 1979):

Lead in fish should not exceed 2.0 mg kg^{-1} wet weight, and
lead in shellfish 10.0 mg kg^{-1} wet weight.

From past work 'expected' values are 0.2-0.3 mg kg^{-1} wet weight in fish, up to 1.0 mg kg^{-1} wet weight in crustaceans, and up to 4.0 mg kg^{-1} wet weight in some molluscs.

(d) Copper

From the Food Standards Committee Report on Copper. Revised recommendations for limits for copper content of food (1956):

Levels of copper in food should not exceed 20 mg kg^{-1} wet weight (but higher levels in shellfish are permitted if copper is of natural occurrence).

From past work, 'expected' levels in fish up to 0.6 mg kg^{-1} wet weight (in excess of 1.0 mg kg^{-1} wet weight in fatty fish such as herring) up to 5.0 mg kg^{-1} wet weight for molluscs (with very much higher values for some gastropods) and 20-30 mg kg^{-1} wet weight for crustaceans.

(e) Zinc

From the Food Standards Committee Report on Zinc (1953). As a guideline:

Levels of zinc in food should not exceed 50 mg kg^{-1} wet weight (but higher levels are permitted in foods which naturally contain more than 50 mg kg^{-1}, such as herring and shellfish).

'Expected' values commonly found are up to 6.0 mg kg^{-1} wet weight in fish flesh (considerably more in fatty fish), up to 100 mg kg^{-1} wet weight in crustaceans and well in excess of 100 mg kg^{-1} wet weight for some molluscs.

II Pesticide PCBs

There are no standards in fish and shellfish from England and Wales.

(a) HCB

The 'expected' value is up to 0.10 mg kg^{-1} wet weight in fish liver.

(b) HCH

Codex alimentarius is 2 mg kg^{-1} in meat fat for γ HCH.

The 'expected' values are up to 0.05 mg kg^{-1} wet weight for each of α and γ HCH in fish liver.

(c) Dieldrin

Codex alimentarius is 0.2 mg kg^{-1} in meat fat.

The 'expected' values are 0.2-0.3 mg kg^{-1} wet weight in fish liver.

(d) Total DDT

Codex alimentarius is 5 mg kg^{-1} in meat carcase fat.

The 'expected' values are up to 0.5 mg kg^{-1} wet weight for each of DDE, TDE and pp DDT in fish liver.

(e) PCBs

JMP Guidelines are as follows (all mg kg^{-1} wet weight):

	Fish muscle	Cod liver	Flounder liver	Molluscs	Crustaceans
Lower level	< 0.01	< 2.0	< 0.50	< 0.02	< 0.01
Medium level	0.01-0.05	2.0-5.0	0.50-1.0	0.02-0.10	0.01-0.05
Upper level	> 0.05	> 5.0	> 1.0	> 0.10	> 0.05

III Explanatory note on the calculation of mercury mean concentrations for EQS purposes

The EQS for mercury in fish flesh is defined in Annex II of Directive 82/176/EEC (Section 1.1), in which it is stated that: 'The concentration of mercury in a representative sample of fish flesh chosen as an indicator must not exceed 0.3 mg/kg wet flesh.'

Species recommended for international monitoring programmes are cod (or hake), plaice, flounder and mackerel. In England and Wales 'indicator' species are chosen from cod, whiting, plaice, flounder, sole and dab - all six being analysed when present in an area (e.g. Liverpool Bay in Table 5 of the present paper).

To obtain an overall fish mercury concentration for EQS purposes, each individual species concentration is weighted according to the quantity of that particular species landed from the area in question, thus giving the 'representative sample' mean.

In Liverpool Bay, for example, the overall mean calculated in Table 5 has varied since 1982 from 0.24-0.30. However, landings from the area tend to be dominated by less contaminated flatfish species such as plaice. The weighted mean mercury concentration is therefore normally less than the arithmetic mean - since 1982, the former varied in Liverpool Bay between 0.23 and 0.29 mg kg^{-1} wet weight and the quality objective was therefore met each year.

References

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