ENVIRONMENT AGENCY

REVIEW OF ORGANOCHLORINE PESTICIDE AND POLYCHLORINATED BIPHENYL BIOACCUMULATION IN FISH AND FISH EATING MAMMALS

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ENVIRONMENT AGENCY

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EXECUTIVE SUMMARY

Many chemicals present in the environment have been found to bioaccumulate in both terrestrial and aquatic organisms. Chemicals of concern include metals, such as, mercury and lead as well as organic compounds, particularly the chlorinated organics. Some of the latter pose a significant ecological threat due to their toxicity, persistence in the environment, and their bioaccumulation potential. This report identifies and reviews work that has been undertaken in the UK by the NRA, Environment Agency and external bodies with respect to the bioaccumulation within aquatic organisms of two groups of chemicals; organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs). The majority of work within the Environment Agency has related to the study of these compounds in fish/eels and otters and therefore this report concentrates on these animals.

The MAFF Working Party on Pesticide Residues (WPPR) coordinates the monitoring of pesticide residue levels in both home produced and imported food, human tissues, wildlife and the environment. The Fish and Fish Products sub-group specifically looks at bioaccumulants in fish flesh, and between 1980 and 1983 undertook a study of organochlorine pesticide residues in fish in England. The highest concentrations were found in eel muscle and pike livers. A number of subsequent studies have been undertaken by regulatory bodies such as MAFF, DoE and the Environment Agency with the majority of work being undertaken on eels. A MAFF survey in 1992 of commercial eel fisheries found high levels of dieldrin which led to limits being set on the consumption of eels from some commercial fisheries. In addition to these large national collaborative surveys, R&D projects and Regional operational investigations have been undertaken by the NRA and subsequently the Environment Agency. Specific surveys have been undertaken on the Mersey where high concentrations of PCBs and DDT were detected in fish and a survey in Southern Region suggested mercury, PCBs, DDT and lindane were biomagnified. In addition a national R&D project undertaken on behalf of the NRA has selected criteria for identifying substances of concern and procedures for monitoring bioaccumulants.

The above work has highlighted a number of problems related to obtaining and assessing information on the bioaccumlation of compounds. These include analytical problems related to the low levels of contaminants involved, a lack of understanding of pesticide transport processes in aquatic environments, movement of fish between polluted and non-polluted sites and the use of different analytical methods which makes comparison and assessment of data difficult. Where specific target substances are being monitored for, it may be necessary to carry out monitoring using appropriate tissue in relevant species to identify difficulties e.g. compartmentalisation monitoring of relevant tissue. Long-term pollution by high levels of PCBs, for example, may be more clearly demonstrated by liver tissue analysis, whereas fish muscle should be used to evaluate pollution from organic mercury. The need for a central focus within the Environment Agency for collating information on bioaccumulation and coordinating work both between functions and external bodies has been identified.

The majority of work that has been undertaken on top predators has been undertaken on otters. Pollution is thought to be a strong candidate for the decline in otter populations since the 1950s and due to their significant consumption of fish, otters are thought to be particularly vulnerable to bioaccumulating pollutants such as OCPs and PCBs. Lindane, dieldrin, DDT and PCBs were

detected in otters during a UK survey between 1982 and 1985. Subsequent surveys have detected OCPs and PCBs in both otters and their spraints. Initial research suggested that increased levels of these compounds in fish would have an effect on the reproductive capability of otters. However, more recent work has shown that otters are able to reproduce and survive in urban areas where levels of concern have been exceeded.

Current work on bioaccumulation in otters undertaken by the Agency relates to post mortems on otters killed on roads. Carcasses are analysed for PCBs, organochlorines and heavy metals. This work commenced in April 1995 and is ongoing; a report of the findings will be produced.

Work on otters has tended to be co-ordinated on a National basis, unlike fish and eels where the majority of work (with the exception of the National eel surveys) has been undertaken on an ad hoc basis. However, many of the issues regarding collation and assessment of data which have been identified in fish studies, also apply to otters and need to be addressed. In particular a study of the fluxes of OCPs and PCBs through food chains and different environmental pathways on a catchment basis should be considered. This will help to develop dynamic models and aid in targeting monitoring. It would also enable understanding of the significance of concentrations found in the environment.

It is recommended that a National focus is developed within the Agency for the co-ordination of work on bioaccumulation and for liaison with external bodies. The latter include, for example, the Institute of Terrestrial Ecology (ITE) who have undertaken work on pesticide residues in birds and terrestrial mammals, the Sea Mammal Unit based at St. Andrews University and the Joint Nature Conservation Council (JNCC) who have developed a framework for otter conservation in the UK. This focal group within the Agency should co-ordinate work to address some of the key issues that have been raised with respect to collating and assessing data. Establishment of a National database containing information on OCPs and PCBs from monitoring data already present within the Environment Agency will assist in developing a national work programme for the collection of data on these substances. Monitoring has also been undertaken on a range of other bioaccumulants of concern e.g. metals and dioxins. It is intended to incorporate this data within the National database and these chemicals will also be considered in the development of a National bioaccumulation programme.

1 Scope and Purpose of Review

Many chemicals present in the environment have been found to bioaccumulate within both aquatic and terrestrial organisms. Chemicals of concern include metals such as mercury and lead, and organic compounds. With respect to the latter, organochlorine compounds are of most concern and two specific groups, organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs), will be considered in this report.

A number of studies have been undertaken within the UK to determine the degree of bioaccumulation in aquatic organisms. These have been undertaken by the Environment Agency (or its predecessors and referred to in this report as "the Agency") and other external bodies, and range from National surveys to Regional investigations. This report reviews the main pieces of work with particular reference to fish and otters and identifies the associated problems in obtaining and assessing information on bioaccumulation.

The main purposes of this review are to identify the extent of available information, collate and review data and consider how such work should be progressed. Recommendations are made for establishing a consistent approach to co-ordinate work both within the Agency and between other interested parties such as other regulatory bodies.

2 Introduction

2.1 *Definition of Bioaccumulation*

Bioaccumulation is the uptake and sequestration of contaminants by organisms from their ambient environment. This term is used synonymously with the term 'bioconcentration'. The ratios of contaminant levels in organisms to those in the environment are generally known as bioconcentration factors rather than bioaccumulation factors, although these two terms cannot be meaningfully separated in most instances (Phillips 1993).

Bioaccumulation of contaminants by organisms may take place via a number of different routes, including directly from the surrounding medium, such as air, soil, sediment and water, or through food chains or webs. The term biomagnification is often employed to describe the latter process, particularly when concentrations increase up trophic levels towards top predators, (Phillips 1993). The term bioaccumulation in the context of this review will be used as a generic descriptor to cover both bioconcentration and biomagnification.

Routes of uptake assist in defining the overall ecological importance of contaminants. Contaminants taken up and sequestered by organisms from their surrounding environment may be of significant toxicity within the tissues, and may therefore exert either sub-lethal or lethal effects. Contaminants bioaccumulated up food chains may ultimately affect top predators including humans. By looking at bioaccumulation, the twin goals of protecting organisms other than humans from toxic impacts, and protecting human health, are addressed (Phillips 1993).

2.2 *Nature and extent of problem*

Organochlorine substances (OCs) or chlorinated organics are used widely throughout the world. They are amongst those compounds that are heavily bioaccumulated and may exert significant toxic effects on organisms. A number of these substances, however, have been banned from use, e.g. DDT and dieldrin, or have had their use restricted, eg PCBs, due to their harmful ecological effects. Organochlorines have been detected in wildlife on a global basis, including dolphins, polar bears, seals, otters, raptors, alligators and fish. Research has shown that some of these compounds cause significant deleterious effects on organisms including: mortality, cancer induction, reproductive and teratogenic effects, and alteration of nervous and immune systems, cellular, ultrastructural and structural features. A well known example of the latter is egg shell thinning in raptors.

Although a significant amount of work has been undertaken worldwide in relation to the bioaccumulation of chemicals within organisms, a number of difficulties exist in relation to obtaining and assessing the data. These include analytical problems related to the low levels of contaminants involved, a lack of understanding of pesticide transport processes in aquatic environments, movement of fish between polluted and non-polluted sites and the use of different analytical methods which makes comparison and assessment of data difficult. Interpreting contamination data within Agency regions is also difficult as there is often lack of historic data

to identify long term trends. One of the greatest areas of concern with data on organochlorine pesticide and PCB levels in fish and other aquatic biota is scarcity and variability.

2.3 *Current legislative requirements of the Agency*

A wide range of EC Directives and other national and international legislation require the monitoring of water quality in relation to set standards. Such Directives include the Dangerous Substances Directive (76/464/EEC), Freshwater Fisheries Directive (78/659/EEC), Surface Water Abstraction Directive (75/440/EEC) and Bathing Water Directive (76/160/EEC). The main Directive relating to control of to OCs and PCBs and the degradation products of these substances is the Dangerous Substances Directive.

The Dangerous Substances Directive has been implemented in the UK through the Surface Waters (Dangerous Substances) (Classification) Regulations 1989 and 1992. Under the Directive substances have been classified as List 1 or List 2, with List 1 substances being the most harmful. EU Member States are required to set water quality standards to control the input of List 2 substances into the aquatic environment. The EC are responsible for the control of List 1 substances and have set statutory standards for a number of these substances. In addition to a requirement to monitor water quality to ensure compliance with these standards, the Regulations require that sediment and/or shellfish and/or fish samples should be collected downstream of discharges on an annual basis and analysed for a number of these List 1 substances. Standards have not been proposed for these media however, and instead the Directive sets down a stand-still provision which requires that levels do not increase significantly with time. List 1 substances include a number of organochlorine compounds which are listed below:-

Hexachlorocyclohexane (all isomers)	DDT (all isomers),
Aldrin	Isodrin
Dieldrin	Endrin
Pentachlorophenol	Hexachlorobenzene
Hexachlorobutadiene	Trichlorobenzene

With respect to the standstill provision, in practice, only sediments are sampled on a national scale by the Agency. Contamination surveys in fish are usually investigative in nature following pollution incidents, or take place in areas where bioaccumulants are thought to be a problem. Otters are the only mammals currently being monitored by the Agency for contaminants. This is done under a national contract to carry out post mortems and tissue analysis on carcasses (the majority being road traffic accidents) found in England and Wales (see section 6.2).

PCBs are included on the UK Red List of substances identified as of priority for the reduction of inputs to the North Sea. As a result PCBs have been monitored by the Agency in rivers, estuaries and coastal waters since 1989. Freshwater samples are taken at the lowest freshwater influence on estuarine/coastal waters (usually Harmonised Monitoring points) 12 times per year. The Agency undertakes monitoring at Harmonised Monitoring points as part of the Harmonised Monitoring Programme. This programme was set up by the Department of the Environment

(DoE) in 1974 to provide a network of sites at which river quality data at the lower end of catchments can be collected and analysed in a nationally consistent manner. The reporting of North Sea data is coordinated by the Agency's North Sea Group with the data processing managed and collated by the National Centre for Toxic and Persistent Substances (TAPS). The TAPS Centre reports the data to the DoE.

The third North Sea Conference held at the Hague in 1990 saw Ministers reiterate their previous commitments concerning the input of hazardous substances to the North Sea. Agreements were made to phase out and destroy all identifiable PCBs by 1999.

The above gives an overview of the legislation in relation to water quality and monitoring of environmental levels in the aquatic environment. These chemicals however enter the environment by other routes such as disposal of waste and air emissions, which are controlled through other environmental legislation e.g. the control of PCBs under the EC Marketing and Use Directive. PCBs and OCPs entering the aquatic environment will bind to sediments due to their low water solubility and high lipophilic nature. In estuaries and coastal waters the main transport mechanism is likely to be adsorption to suspended solids. Water column monitoring will not necessarily pick this up and other monitoring is also carried out by the Agency, e.g. monitoring PCBs in sediment and biota as part of the UK National Monitoring Plan, to ensure that an adequate picture of the extent of pollution is obtained.

In addition to national and international legislation relating to water quality, the Agency has statutory duties concerning various conservation and wild life legislation e.g. the Conservation of Natural Habitats and of Wild Fauna and Flora Directive (92/43/EEC), Wildlife and Countryside Act 1981 and the Biodiversity Convention 1992.

3. Source and use of PCBs and OCPs

3.1 *Polychlorinated Biphenyls*

PCBs have been produced under a wide range of trade names including, Aroclor, Clophen, Kanechlor, Phenclor and Fenclor. Commercial PCBs are produced by chlorination of biphenyl with a ferric catalyst, yielding a mixture of PCB isomers and congeners. There are 209 possible PCB congeners (individual chemical species within groups of structurally similar organic compounds). The more common products are Aroclors 1242-1260, Clophens A30-A60 and Kanechlors 300-600, (Niimi 1993).

PCBs have been used extensively for a host of industrial applications, including; plasticisers, dielectric fluids, lubricating and cutting oils, and as fire retardants because of their chemical and thermal stability. It has been estimated that the UK manufactured 66,500 tonnes of PCBs between 1951 and 1976. Approximately 27000 tonnes was exported, with approximately 8,000 tonnes thought to be still in use in the UK in, for example, transformers and capacitors, (DoE, 1994).

3.2 *Organochlorine Pesticides*

Organochlorine pesticides used for the control of insect pests were introduced into agriculture in the 1950s. Insecticides such as DDT, DDE and dieldrin were widely used by the farming industry. In addition, organochlorine pesticides are still used in sheep dips, timber preservatives and as sprouting suppressants, e.g. tecnazene and chlorpropham.

Certain restrictions have been placed on the use of organochlorines over the last twenty years and some have been controlled by EC Directives since the mid 1980's (See Section 2.3). Due to concerns over their toxicity, persistence and bioaccumulative properties, DDT and dieldrin were banned from use in the UK in 1984 and 1989 respectively. These have now been replaced by organophosphorus pesticides. Aldrin which rapidly degrades into dieldrin was also banned as an insecticide in 1989 and restrictions have been placed on others such as PCP and lindane (NRA, 1995).

Lindane remains approved for agricultural use in the UK for control of wireworms and leatherjackets. It is used largely for seed treatments, mainly oil seed rape, but is also used on sugar beet, arable crops, soft fruit, grassland, vegetables and glasshouse crops. It is used to a lesser extent in wood preservatives, in domestic products as an insecticide for the treatment of scabies and head lice, and in public hygiene products.

3.3 Future Risks

3.3.1 Polychlorinated Biphenyls

A substantial proportion of the PCBs released in industrial countries have been degraded or exported by atmospheric transport, but important reservoirs remain in closed systems, sewage sludge, refuse-derived fuel, landfill and environmental compartments, particularly soils and aquatic sediments, (Weatherly *et al.*, 1995). Measured levels of PCBs in the aquatic environment are lowest for the oceans and coastal marine waters. Routine monitoring by the Agency shows concentrations almost entirely below the monitoring detection limit of 5ng/l in marine waters. However, due to the persistence of PCB's in the environment and their potential toxic and bioaccumulative properties to organisms, PCB's remain a cause for concern.

3.3.2 OC pesticides

Due to the restrictions placed on the use of a number of the organochlorine pesticides, eg DDT and dieldrin, there has been an observable decline in the levels of these compounds detected in the environment. Monitoring data at the Harmonised Monitoring Sites for lindane (gamma HCH) and dieldrin, both on List 1, show the downward trend of these OC pesticides over the past twenty years (see Figures 1 and 2).

The persistent and bioaccumulative properties of these compounds however, along with the continued use of a number of organochlorine pesticides, eg lindane and tecnazene, means that there is still a requirement for continued environmental monitoring.

Figure 1 Gamma HCH in rivers in Great Britains (% distribution of concentrations)(Data from Harmonised Monitoring Sites)

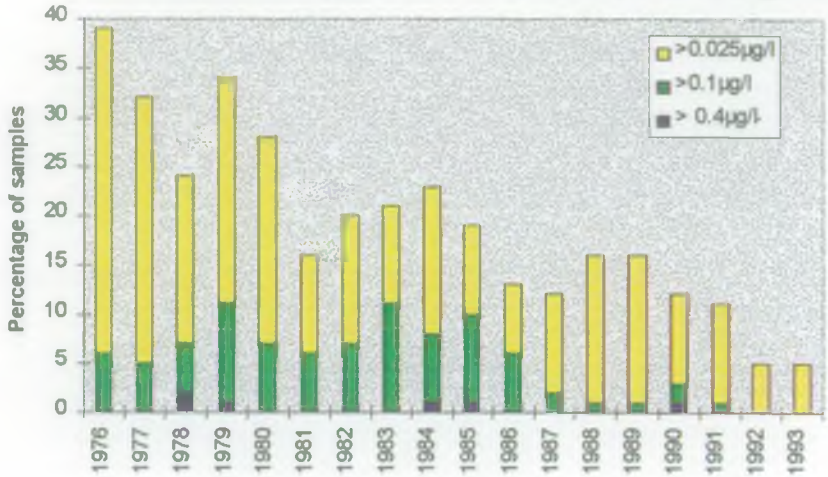
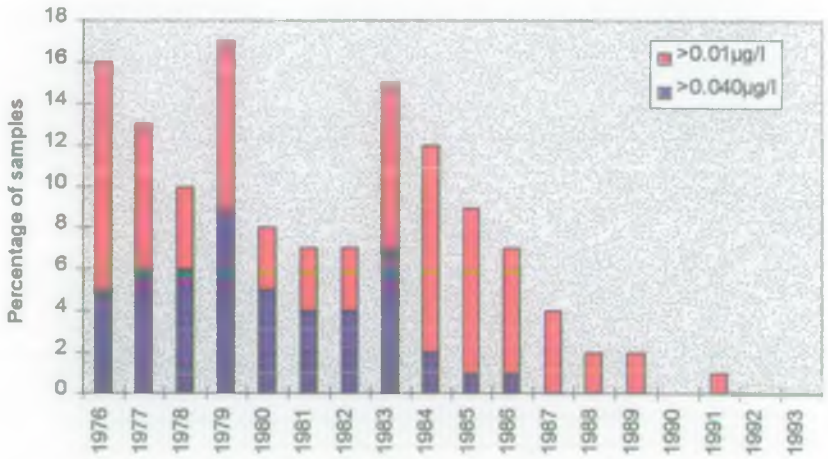


Figure 2 Dieldrin in rivers in Great Britain (% distribution of concentrations) Data from Hamonised Monitoring Sites)



4. Organisms of Concern

Although organochlorine contaminants have been detected in a wide range of organisms this review only considers fish and otters. The majority of the available data relates to fish and in particular, eels. The latter have been the subject of most of the bio-monitoring work carried out within the Agency due to their importance as a prey item in the diet of the otter and heron, their longevity, limited migration during freshwater residence and high fat content. The environmental concerns arising from the toxicity of OCPs and PCBs, and the resulting legislative controls, means that the Agency must continue to monitor for those contaminants that bioaccumulate or are likely to bioaccumulate in biota.

Other organisations, such as the Institute of Terrestrial Ecology (ITE) and the Sea Mammal Unit have monitored organochlorine residues in birds, terrestrial organisms and PCBs in seals and porpoises respectively. It will be important in future to liaise with these organisations to share data and, where possible, co-ordinate monitoring programmes. Close liaison will have the benefit of reducing cost, avoiding duplication of work, targeting catchments and species more effectively and help to standardise and overcome difficulties in analyses.

5. Fish/eels

5.1 Past Work

Several studies have been carried out by regulatory bodies in the UK including the Ministry of Agriculture Fisheries and Food (MAFF), DoE and the Environment Agency to investigate the contamination of the aquatic environment with organochlorine substances.

The MAFF Working Party on Pesticide Residues (WPPR) was established in 1977 by the Steering Group on Food Surveillance and the Advisory Committee on Pesticides (ACP). The group was set up to coordinate the monitoring of pesticide residue levels in both home produced and imported food, feedstuffs, human tissues, wildlife and the environment. The Fish and Fish Products (FFP) sub-group of the WPPR looked at bioaccumulants in fish flesh and comprised members from MAFF, SOAFD (Scottish Office Agriculture Fisheries Department), DANI (Department Agriculture Northern Ireland), NRA (National Rivers Authority), DoE, DoH (Department of Health) and LGC (Laboratory of the Government Chemist).

A pilot study by the WPPR looking at OCP contaminants in freshwater fish was carried out between 1980 and 1983 at sites in central England. This showed that the highest concentrations of contaminants were found in eel muscle and pike liver. A decision was made to carry out further work on eels as they have a comparatively high proportion of fat in their muscle tissue, are likely to accumulate OCPs more readily and are the most easily sampled species. The survey area was extended to cover the whole of the UK.

Many of the studies undertaken by the NRA arose from the WPPR's recommendations to carry out further eel surveys as a result of the pilot study carried out by the FFP in 1980-1983.

The first of these studies was a more comprehensive survey of freshwater eels which took place between March 1986 and August 1987. Samples were obtained from 62 sites in the U.K. (21 in England and 2 in Wales) largely from the same sampling sites used for the Harmonised Monitoring Scheme. The samples were analysed for OCPs including dieldrin. Other contaminants i.e. mercury and PCBs were also analysed for this exercise. A summary of the results obtained for the 1986-1987 survey are shown in Tables 2 and 3 of Appendix 1.

The study indicated that although some sites were comparatively free of contamination, eels from others had unexpectedly high levels of certain pesticides. Concern was raised over DDT at some sites where the ratio of isomers indicated that the source of contamination could have been recent use of the pesticide, despite total withdrawal of all agricultural uses on 1 October 1984.

It was decided that further monitoring of UK eels on a National basis should continue. This was primarily due to concerns over a potential threat to the health of regular consumers of eels with high residue levels, and the potential risk to those organisms for which eels are a major dietary component, eg, fish eating birds and otters. Tables 1a and 1b below summarise various standards and guide values of concern for OC pesticides and PCBs in food for humans and otters respectively.

Table 1a Limit and Guide values for OCPs and PCBs in food - Humans

Substance	Standard	Concentration (mg/kg)
Dieldrin	Reporting limit for Dieldrin in eels (MAFF 1993)	0.1
	DoH (1988), MAFF food safety limit	0.1
	MAFF acceptable daily food intake	0.007
	US food tolerance limit	0.0002
	Dutch food tolerance limit	0.0003
Lindane (γ-HCH)	EU and US food tolerance limits	0.0002-0.0005
γ-HCH	UK statutory MRLs for meat products	0.1
α- HCH	UK statutory MRLs for meat products	0.02
β- HCH	UK statutory MRLs for meat products	0.01
DDTs (total)	UK MRL	0.1
	US food tolerance limit	5
PCBs (total)	Total PCB US food tolerance limit	2
	Oslo & Paris Commission (low)	<0.01 ✢
	Oslo & Paris Commission (medium)	0.01-0.05 ✢
	Oslo & Paris Commission (upper)	>0.05 ✢

✢ - for fish muscle on a wet weight basis.

Table 1b Limit and Guide values for OCPs and PCBs in food - Otter Conservation

Substance	Standard	Concentration (mg/kg)
Dieldrin	UK levels in fish (Mason & Macdonald, 1993c)	0.05
Lindane*	UK levels in fish (Mason & Macdonald, 1993c)	0.05
DDT*	UK levels in fish (Mason & Macdonald, 1993c)	0.05
PCBs	Dutch levels in fish (Walter,1990)	0.025
PCBs	UK levels in fish (Mason&Macdonald,1993b):-	
	'safe' for otters	<0.026
	'borderline' for otters	0.026-0.050
	'action required' for otters	0.05

* Default value proposed for total OC pesticides.

In 1992 a National "Commercial" eel survey took place (See Table 4, Appendix 2 for results) in which the NRA participated by providing eel samples for the Fish and Fish Products sub-group to analyse. This survey spanned six Regions within the NRA (Anglian, Severn-Trent, Southern, Thames, Wessex and Yorkshire) and examined pesticide residues in eels collected from commercial fisheries. The results showed that eels from the majority of rivers surveyed had dieldrin levels above the reporting limit of 0.1mg/kg, and three (R. Thames 0.204 mg/kg, R. Humber 0.228 mg/kg and Lower Ouse 0.379 mg/kg) gave cause for concern. Only one sample however was above 0.3mg/kg, which is the highest "expected" value given in Food Surveillance Paper No. 25. Repeat samples were taken from these three sites to verify the results. MAFF issued a press release relating to the consumption of eels from the Humber, Yorkshire Ouse and Inshore Thames fisheries suggesting that consumption should be limited to approximately 500g per month. Eels from the rivers Itchen, Severn, Test and Trent were found to contain lower levels of dieldrin and advice on the consumption of eels from these areas was set at 1500 g per month. Other survey areas contained low or very low residues of dieldrin and were not considered to be of concern.

An Environmental Survey of Contaminants in the Freshwater Eel 1995/96 has recently taken place in the UK with samples still being analysed. This is a collaborative survey between the Agency the Scottish Environment Protection Agency (SEPA) and MAFF undertaking pesticide residue analysis. The is Agency giving assistance through the collection of eel samples. The survey is similar to the 1992 FFP eel survey but is more widespread covering approximately 30 sites in England and Wales, including some used to monitor water quality. The range of determinands has been extended to include heavy metals and PCBs. Additional determinands (as requested by the TAPS centre) will be analysed for in some areas where there are local concerns, eg. tecnazene in the River Nene, pentachlorophenol in some areas of the North East and permethrin in the North West.

An NRA R&D Report, ***Body Burdens in Fish*** (Johnson and Vine 1993) provides a framework for the selective criteria that should be adopted for identifying and targeting substances of concern for bioaccumulant monitoring in fish. It describes a procedure for monitoring bioaccumulants in appropriate fish species and for the identification of affected fisheries. A proposed list of target substances of concern was drawn up based on their toxicity, potential for bioaccumulation, persistence, legislative control and nationwide use pattern (see Table 5 of Appendix 3). It is suggested that these substances should be monitored for in fish tissues within Agency regions. It is the Agency's statutory duty to protect the health of wild fish populations in order to safeguard their recreational and commercial value. However, concerns have been raised that repeated sampling of wild fish populations to provide sufficient tissue for analysis incurs the risk of detrimentally depleting stocks. In order to avoid this possibility a two tier programme for monitoring target substances has been proposed in the report. This is described in Appendix 3, Section 3.1.

An environmental fate study carried out by the University of Liverpool on ***Persistent Organic Compounds Within The Mersey Estuary***, showed that muscle tissue of fish from the Mersey Estuary contained high concentrations of total PCB and total DDT. This was also the case for certain analogues of HCH (hexachlorocyclohexane), notably methyl HCH which were detected in some Mersey fish (See Appendix 3, Section 3.2 for a summary of the report).

The sparsity and variability of data on pesticide levels in fish is a significant problem. For certain pesticides, such as lindane, concentrations may vary over several orders of magnitude between clean and polluted sites. In addition the study of bioaccumulation by fish within natural or near-natural ecosystems is made extremely complex by the diversity of the possible routes a chemical may take before entry into the fish. Patterns such as migration of fish, linked with their feeding habits and reproductive strategies, will have a major effect on the potential for exposure to chemicals (Solbé, 1993). The report ***The occurrence of selected chemical pollutants (simazine, lindane and permethrin) in river fish*** (1994), produced by the Institute of Freshwater Ecology for the DoE, has identified several difficulties associated with the monitoring and effects of pesticide residues in cyprinid fish (dace, gudgeon, roach and chub) from the main feeding niches within the family. These are summarised in Appendix 3, Section 3.3. .

What is clear from this investigation is that there is lack of understanding of pesticide transport processes in aquatic systems. Uptake mechanisms and criticality of different organs in different fish species with regard to pesticides makes the setting of protective and scientifically defensible standards for pesticides in freshwater and fish flesh very difficult at the present time.

Similar studies have been carried out within the Agency on eels. Following the 1988 MAFF National survey on eels which recommended further monitoring of potentially toxic and bioaccumulative substances in eel tissues, several regional eel tissue surveys have taken place. This has included NRA surveys by Welsh, Southern, North West and Wessex Regions.

The reports ***PCBs and Organochlorine Pesticides in Eels from North West England***, (NRA 1993), ***PCB and Organochlorine Pesticides in Eels from Welsh Rivers***, (NRA 1995), and ***A Report on the Eel Tissue Bioaccumulation Surveys of 1989 and 1992***, (NRA 1993) have looked at describing the regional distribution of potentially toxic and bioaccumulative contaminants in order to assess potential risks and to identify the need for further investigations. The latter study has recently been followed up by a further study in 1995 to monitor the present state of selected sites in South West Region from contaminants, and determine any possible threat to otters from contaminated eel tissue. This latest report is presently in draft form. Summaries of the major findings of these reports are given in Appendix 4.

In addition to assessing bioaccumulants in eels, a fourth study, ***Heavy metals, polychlorinated biphenyl and organochlorine pesticide residues in European eels Anguilla anguilla L. from Sussex Rivers***, (NRA, 1996), looked at the suitability of Sussex waters for recolonisation by otters. The environmental significance of contaminant burdens in eel tissue is discussed in terms of their likely adverse effects on range expansion in otters and possible human health implications.

The report concluded that there was strong evidence that mercury, PCBs, DDT, HCH and dieldrin were biomagnified from river water to sediment to eel. The extent of biomagnification was such that, even if contaminants were below the limit of detection in river water or sediment, detectable or elevated levels were found in eels. This was most notable with dieldrin with c. 85% of sites exceeding the MAFF human food acceptable daily intake level of 0.007 mg/kg, usually by large margins (see Table 1a).

5.2 Issues

The various sources of information outlined in the previous section gives an overview of the type of work both previously carried out and currently being undertaken by the Agency and other external organisations. In reviewing these sources of information, several key points have been highlighted including:-

- Levels of pesticides and PCBs found in muscle and fish liver are often low which makes analysis difficult.

- The environmental significance of OC pesticides and PCB concentrations in biota are poorly understood and there are very few data relating bioaccumulant levels in fish to toxic effect.

- There is a lack of understanding of pesticide transport processes in aquatic systems, this includes uptake mechanisms and criticality in terms of toxicity of different contaminants to different fish species.

- Fish may not necessarily be locally resident and may move between polluted and non-polluted sites. A choice of species is necessary as few are ubiquitous and it may be necessary to use several species at the same site.

- Data is scarce and variable within the Agency. Furthermore, different methods of analysis makes the limited data available very difficult to compare and interpret. Several years' data are necessary to identify the significance and extent of any spatial/temporal trends, and lack of comparative data makes evaluation difficult.

- Possible errors in correcting for age and growth effects in fish indicate the need for parallel monitoring of different species and environmental compartments for validation.

- The need to select and monitor appropriate tissue type(s) to indicate contamination, if present.

5.3 Present Work

The TAPS National Centre (soon to become the national centre for Ecotoxicology and Hazardous Substances) has begun to collate information on the bioaccumulation of pesticides and PCBs in fish and other biota. The results provided by the present FFP 1995/96 'Environmental' Survey of Contaminants in the Freshwater Eel will be reviewed by TAPS on completion. The Centre has already identified a network of Regional contacts throughout the Agency to lead on bioaccumulation issues. These Regional contacts will form a route for dissemination and collection of information.

5.4 Recommendations for Future Work

To address some of the difficulties identified in section 5.2 the following are proposed:-

- There should be an attempt to standardise measurement techniques by different laboratories so that data are comparable. For comparable data within the Agency samples from different Regions may be sent to the same laboratory for analysis. This is already undertaken for otters. All otter samples are analysed at the Agency's Exeter lab with the exception of SW Region. Where it is necessary to send samples to different laboratories, analysis should follow the same standard operational procedures.

- Where specific target substances are being monitored for, it may be necessary to carry out monitoring using appropriate tissue in relevant species to identify difficulties e.g. compartmentalisation monitoring of relevant tissue. Long-term pollution by high levels of PCBs, for example, may be more clearly demonstrated by liver tissue analysis, whereas fish muscle should be used to evaluate pollution from organic mercury.

- Bulking of fish tissue for a given site may be necessary where levels of pesticides and PCBs are low making analysis difficult.

- In view of the poor understanding of the environmental significance of the relationship between bioaccumulant levels in fish and toxic effects, it is necessary to establish toxic effects on fish in relation to tissue concentrations, and set standards in fish for monitoring rather than relying on water quality as a measure.

- A study of the fluxes of OCPs and PCBs through food chains and different environmental pathways on a catchment basis is needed. This is needed to develop dynamic models and improve the targeting of monitoring. This would be essential for the understanding of the significance of concentrations found in the environment.

- The Agency should establish a focal point for gathering all bioaccumulant data on organochlorine chemicals and other pesticides in order to establish a National database. The latter should eventually include information on other bioaccumulants of concern e.g. metals and dioxins as well as data from external bodies. The establishment of a central point within the Agency will greatly improve and assist in the collation, validation and dissemination of data and will help to eliminate duplication of work both within the Regions and between the Agency and external bodies. This will enable the Agency to develop a future National Work Programme on bioaccumulation in biota with coordinated monitoring.

6. Otters

As a natural progression from looking at pesticide and PCB accumulation in eels and other biota, concern has been raised that high residue levels of these compounds may present a potential threat to the long term health of top predators such as fish eating birds and otters. The following section reviews work that has been undertaken on otters, as the majority of work, within the Agency, on bioaccumulants in top predators has focused on this species. This is not to say however, that other mammals and fish eating birds should be overlooked in future reviews or collaborative work. A substantial amount of work on bioaccumulants for example, has been undertaken in birds and sea mammals by the Institute of Terrestrial Ecology at Monks Wood and the Sea Mammal Research Unit at Cambridge respectively.

6.1 Historical Perspective

Over the past 40 years, many theories have been put forward for the decline of the European otter (*Lutra lutra*). These have included habitat destruction, hunting and pollution. Whilst all these factors are likely to have contributed to the otters' decline since the mid-fifties, by far the strongest candidate is pollution. Otters consume approximately 1kg of food per day, mainly fish. They may therefore be especially vulnerable to bioaccumulating pollutants and, in particular contamination with organochlorine pesticides and PCBs. Chanin and Jefferies (1978) proposed that the decline of otters in Britain seen in the mid-fifties can be attributed to the introduction of dieldrin into agriculture. Indeed, over 80% of otters examined for organochlorine residues between 1963 and 1973 were contaminated with measurable quantities of dieldrin, with mean wet weight liver concentrations of 0.5 mg/kg (Jefferies *et al.* 1974). However, detailed data on organochlorine levels, which may lend support to the link between dieldrin and the otter decline, has never been made available (Mason *et al.* 1986).

Other countries have shown a notable decline in otter populations. In Sweden measured levels of PCB residues in otter tissue were generally higher than from otters from neighbouring Norway, which have only low levels of PCBs (Olsson *et al.* 1981). It is thought that otters in Sweden may have had PCB residues at levels which may interfere with reproduction, but in any case, are generally higher than those known to cause reproductive impairment in experimentally dosed mink (*Mustela vision*) (Mason *et al.* 1986).

Much of the work relating to levels of contamination at which concern may be expressed over the well-being of otters has been put forward by Mason and co-workers. Mason *et al.* (1986) presented data on organochlorine burdens in 23 otters obtained in Britain between 1982-1985. High concentrations of PCBs (> 50mg/kg fat) were found in some animals, particularly those from eastern England. Dieldrin was also present despite its voluntary withdrawal from agriculture in Britain in 1975. Lindane was detected in 70% of the otters reflecting the widespread use of this compound in British agriculture, although concentrations were generally low. DDT and its derivatives were found in 91% of otters analysed and levels were elevated (> 50mg/kg fat) in 13% of otters, but it was considered that these concentrations were unlikely to have had any measurable effects.

Levels for PCBs in spraints have been presented by Mason *et al.* (1992). These are based on the single compartment model of de Varies (1989) and relate spraint concentrations to tissue concentrations, above which reproductive or health problems are likely to occur. The following hierarchy of concentrations were proposed, to assess contamination levels in spraints:

A. Critical levels:
1. Concentrations in spraints > 16mg/kg of PCB and dieldrin, singly or combined.
2. Concentrations in spraints of total OCs > 20mg/kg.

B. Levels of concern:
1. Concentrations in spraints > 9-16mg/kg of PCB and dieldrin, singly or combined.
2. Concentrations in spraints of total OCs >16-20mg/kg.

A 'no observable effect level' (NOEL) of 4mg/kg PCB in spraints was calculated. A value of 4 mg/kg is taken as the 'NOEL' for all individual contaminants. Concentrations less than the 'levels of concern', but above the 'NOEL' are considered as 'maximum allowable concentrations' (MAC). In addition Mason and Macdonald (1993b) proposed a limit for consumption by otters of 0.05mg/kg total PCBs in fish, above which reproductive impairment could occur. Standards have not been proposed for OC pesticides, but the same standards as for PCBs have been applied, though OC pesticides have proved to be less toxic than PCBs to mink (Mason 1993c).

Critical levels of concern and contamination levels of OC pesticides and PCBs were compared against target values for otter populations in western Britain (Mason and Macdonald, 1993a). Concentrations of dieldrin, DDE and PCBs were found to be significantly greater in spraint samples from lowland stretches. Over 50% of samples from these stretches had OC concentrations above the MAC, whereas most samples from the upland stretches had concentrations below the NOEL. It was suggested that colonization by otters of their former lowland range (from upland strongholds in Wales and England) is inhibited by OC contamination of their food chain, but, if contamination levels are reduced, spread will occur rapidly.

Similar investigations of spraint contamination in northern Britain revealed dieldrin, DDE and PCBs were significantly higher from English regions than those of Scotland. A trend of increasing contamination from west to east was identified (Mason and Macdonald, 1993b). Distribution of otters was inversely correlated to mean concentrations of dieldrin, DDE and PCBs in spraints, suggesting that organochlorines may still be exerting a negative impact on the species.

It should however be noted that the calculation of critical levels, levels of concern and the proposed limit for PCB consumption are based on experimental tissue levels of PCBs known to cause reproductive impairment in mink and not otters. Mink are known to be particularly sensitive to organochlorine toxicity, and proposed levels for otters have not been supported clearly by field data. Kruuk *et al.*, (1993) found healthy otter populations in areas where PCB burdens in eels substantially exceeded 50µg/kg. They concluded that the role of PCBs in impairing otter reproduction was likely to have been exaggerated.

More recent studies of organochlorines and PCBs in Scottish otter populations have been undertaken by Kruuk and Conroy, 1996. These have shown that OCs (dieldrin and DDE) appear to be low and unimportant and otter populations are thriving despite high levels of total PCBs (> 14ppm wet weight).

An NRA survey of organochlorine concentrations in the muscle tissue of eels at sites across the Welsh Region during July to September 1993 revealed that the threshold limit for consumption of eels by otters (0.05mg/kg total PCBs in fish) was exceeded at three-quarters of Welsh sites (Weatherly *et al.*, 1995). There was no clear relationship at a catchment level between PCBs in eels and otter populations which are generally healthy. This contrasts with the work of Mason (1993) that suggests that PCB contamination is exerting a negative impact on otter populations in some Welsh catchments.

At a regional otter strategy meeting held in June 1995 at NRA Anglian Region other examples were cited where otters released in heavily urbanised areas of Scotland, and otters with high body burdens of PCBs are surviving and breeding well. Otters on the R. Stort have (as part of the re-introduction programme) successfully flourished and bred, even though some parties argued that the levels of PCBs in otter droppings on the Stort were three times higher than some environmentalist considered safe. These recent findings indicate that otters are not as vulnerable to habitat degradation and chemical bioaccumulation as first thought. A similar meeting in April 1996 cited more examples of released otters breeding well within Anglian Region.

6.2 Present Work

Approximately 80 otters are killed on roads in England and Wales each year. This represents a valuable source of information and an Agency project is now in place to co-ordinate the collection of dead otters for post mortems and tissue analysis. All Regions, with the exception of South West, send dead otters to the Department of Pure and Applied Biology, University of Wales. For post mortems, otter morphology, physiology and diet along with some DNA work is undertaken. Animals collected in South West Region are sent to the Veterinary Investigation Agency, in Truro Cornwall. Post mortems carried out have special emphasis on veterinary pathology i.e. does the post mortem reveal any abnormalities in the otter which may be linked to pollutants? Samples from all regions are sent to the Agency Laboratory in Exeter to be analysed for PCBs, organochlorines and certain heavy metals.

A co-ordinated approach is essential to determine whether aquatic pollutants are bioaccumulating with the possibility of deleterious effects on otters. Current work on bioaccumulation in otters undertaken by the Agency relates to post mortems on otters killed on roads. Carcasses are analysed for PCBs, organochlorines and heavy metals. This work commenced in April 1995 and is ongoing; a paper of the findings ***The Health Status of Otters (Lutra lutra) in south west England*** is currently in press, and a more detailed report to the Agency is presently in draft form. The otter post mortem work will continue for the foreseeable future. A brief summary of ***The Health Status of Otters (Lutra lutra) in south west England*** and details of the procedures for the collection of dead otters by Agency and non-Agency staff with contact names can be found in Appendix 5.

6.3 Conclusions

It is now the view of many working in this field that otters are probably more robust and adaptable animals than previously believed. It would appear that preliminary findings in Britain show that otters are not harmed in terms of survival and reproduction by levels of PCBs and OCs which are claimed to cause reproductive damage in species such as mink.

The recent 1996 State of the Environment Report illustrated that a broad assessment made of the distribution of otters in Great Britain in 1993 showed that otters are beginning to return to river catchments as river quality improves. Populations in Wales are expanding and otters are beginning to move down the Rivers Severn and Teme. Otters have also been found in the Thames, the Avon as far as Coventry, and in tributaries of the River Severn below Tewkesbury. In order to aid this recovery, the Agency has a strategy to protect and encourage otter recolonisation.

Although very high levels of PCBs and OCs may affect otters, the return of otters to river catchments with improved water quality suggests that otters are not influenced by concentrations that were previously thought to harm them.

The most recent paper, ***The Health Status of Otters (Lutra lutra) in south west England*** (Appendix 5) produced as part of the continuing post mortem work on wild otters within the Agency concluded that otters within the south west of England are increasing and any problems that may be associated with uterine abnormalities from PCBs and OCs seen between 1990 and 1993 may represent part of a diminishing problem.

6.4 Recommendations for Future Work

An EU Life Project Application meeting looking at the best ways forward to achieve favourable conservation status for the otter in Britain and Europe was held in November 1995. In view of the current state of knowledge and contentious issues such as toxic health threshold levels, range distribution, variability of populations and re-introduction programmes; objectives needed to achieve favourable conservation for the otter and address the gaps in current knowledge were identified.

The contentious issue of whether bioaccumulants such as PCBs and OC pesticides were having a deleterious effect on otter populations was raised. One of the proposals, supported by the Agency is being put forward for EU Life funding by Dr. Fred Slater based at Cardiff University as a result of the round-table discussion is aimed at addressing this issue. It was concluded that exceedences of threshold environmental levels of PCBs set for otters on the basis of successful breeding in mink, may have being unproductive holding up positive conservation measures in parts of Europe for the protection of the otter. It is essential for conservation purposes that the situation should be clarified by the collection of substantiative data on the role of PCBs, OCs and heavy metals on otter condition and survival. It is proposed that otter fatalities from both Britain and Europe should be treated according to the following protocol:

a) A full post mortem of available animals be carried out to determine a range of conservation related parameters including age and pathological condition.

b) From the animals used in (a) livers, and any other specific organs, be removed for PCB, OC and heavy metal analysis.

c) Food chain elements from the catchments with and without otters analysed for parameters in (b) above, would place the otter within the overall spectrum of environmental variation, flagging areas of conservation priority.

From such data a meaningful conservation strategy can be evolved for Britain and Europe involving uncontrollable pollutants e.g. PCBs and controllable pollutants e.g. OCs and heavy metals.

Much of this proposal is an extension of current work being carried out by the present Agency contract. If support is given to this initiative and collaboration gained with other national and international bodies, this will be a major advance to addressing current gaps in knowledge on these bioaccumulants of concern. It will help to decide whether it is still sensible to monitor for compounds such as PCBs which are being phased out, and cannot be physically removed from ecosystems or to look at other chemicals currently entering ecosystems that can be monitored and directly influenced.

There is a real need to monitor the effects of bioaccumulants on selected species in order to meet international obligations and to ensure the Agency is managing and regulating the environment acceptably. Any work undertaken by the Agency on otters must be linked with other interested parties, such as the JNCC who have developed, ***A Framework for Otter Conservation in the UK: 1995-2000.*** One of the key action points within this document establishes a need for research on the interaction between otters fish and pollutants.

7. OVERALL CONCLUSIONS AND RECOMMENDATIONS

Work undertaken by the Agency and external bodies on the accumulation of organochlorine pesticides and PCBs in fish/eels and otters from the UK has been identified and reviewed.

The majority of studies on eels have followed on from a collaborative national survey undertaken by the Fish and Fish Products sub-group of the MAFF Working Party on Pesticide Residues. This and subsequent studies have identified significant levels of a number of organochlorine pesticides in commercial and non-commercial eels which have resulted in restrictions being placed on the consumption on eels from certain commercial fisheries. A number of Regional investigations have been undertaken within the Agency, for example on the Mersey and Sussex rivers, which have found high concentrations of OCs and PCBs in fish. However there has generally been no central co-ordination of work in relation to this issue.

A number of key issues have been identified which affect the collation and assessment of such data. These include the need to be able to analyse for low concentrations in tissues, the lack of understanding of fate processes in the aquatic environment and the use of different analytical techniques which makes the comparison and assessment of data difficult. A central focal point to co-ordinate investigations on bioaccumulation within the Agency would enable greater co-ordination between functions in the Agency and strengthen links with external bodies.

Unlike fish and eels, work on otters has been mostly co-ordinated Nationally, However, many of the issues regarding collation and assessment of data which have been identified in studies in fish, also apply to otters and need to be addressed. In particular a study of the fluxes of OC pesticides and PCBs through food chains and different environmental pathways on a catchment basis should be considered. This will help to develop dynamic models and improve the targeting of monitoring. It would also enable understanding of the significance of concentrations found in the environment.

In summary it is recommended that a central focus is developed within the Agency to co-ordinate both work undertaken within the Agency and in collaboration with external bodies. A National focus would also assist in addressing a number of the key issues which affect the collation and assessment of data. Establishment of a National database containing information on OCPs and PCBs from monitoring data already present within the Agency and a National work programme for the collection of data on these substances will assist in developing a better understanding of their importance on the environment and biota.

This review has specifically considered data relating to the bioaccumulation of OCPs and PCBs. Data however, has also been collated on a range of other bioaccumulants of concern e.g. metals and dioxins. It is intended to incorporate this data within the National database and these chemicals will also be considered in the development of a National bioaccumulation programme.

8. GLOSSARY

Annex 1A - The list of 36 priority dangerous substances, agreed at the North Sea Conference for load reductions.
Bioaccumulation - Uptake and sequestration of contaminants by organisms from their ambient environment.
Congener - individual chemical species within groups of structurally similar organic compounds.
DANI - Department Agriculture Northern Ireland.
DDD - dichlorodiphenyldichloroethane
DDE - dichlorodiphenyldichloroethylene
DDT - dichlorodiphenyltrichloroethane
DoE - Department of the Environment.
DoH - Department of Health
EQS - Environmental Quality standard
FFP - Fish and Fish Products sub-group.
HCH - hexachlorocyclohexane
ICES - International Council for the Exploration of the Sea.
ITE - Institute of Terrestrial Ecology.
LGC - Laboratory of the Government Chemist
MAC - Maximum allowable concentration.
MAFF - Ministry of Agriculture Fisheries and Food.
MRL - Maximum residue level
NOEL - No observable effect level.
NRA - National rivers Authority.
OC - Organochlorine.
OSPARCOM - Oslo and Paris Commission.
PCB - Poly chlorinated biphenyl.
Pesticide - Any substance, preparation or organism prepared or used for destroying any pest.
Red List - The UK's initial priority list which preceded Annex 1A.
SOAFD - Scottish Office Agriculture Fisheries Department
TAPS - National Centre for Toxic and Persistent Substances.
WPPR - MAFF Working Party on Pesticide Residues.

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10. APPENDICES

APPENDIX 1 Summary of results obtained for the 1986/1987 WPPR eel survey.

Table 2: Organochlorine pesticide residues (mg/kg) in samples of eel muscle.
1,124 eels were obtained from sites in the UK during March 1986 to August 1987 and analysed for residues of organochlorine pesticides. The ranges of mean residues levels detected are given in this table with mean values in parentheses. (The mean values for each country were determined by calculating the arithmetical mean of the values obtained for each site within that country. Where the mean at any site was less than the limit of determination, a value of zero has been used in calculating the national mean.) The number of sites where the mean level was greater than the limit of determination is also given for each compound.

Source	No of Eels tested[a]	Sites	Mean length (cm)	Mean % of fat	HCB	α-HCH	β-HCH	γ-HCH	Dieldrin	pp'-DDE	pp'-TDE	pp'-DDT
England	206	21	46	12	ND-0.04 (0.07) 19	ND-0.4 (0.03) 13	ND-0.01 (0.002) 6	0.01-0.2 (0.05) 21	0.01-1.0 (0.3) 21	0.006-0.4 (0.1) 21	ND-0.3 (0.05) 20	ND-0.4 (0.07) 20
Scotland	803	33	35	12	ND-0.008 (0.001) 11	ND-0.01 (0.001) 2	NA	ND-1.5 (0.09) 32	0.01-1.2 (0.2) 33	0.03-1.0 (0.2) 33	NA	0.005-3.0 (0.4) 33
Northern Ireland	95	6	50	19	ND-0.04 (0.009) 11	0.001-0.008 (0.004) 6	ND-0.05 (0.02) 5	0.007-0.08 (0.02) 6	0.009-0.9 (0.2) 6	0.03-0.06 (0.05) 6	0.007-0.05 (0.02) 6	ND - 0
Wales	20	2	36	16	0.001, 0.002 (0.002) 2	ND, 0.002 (0.001) 1	ND - 0	0.004, 0.005 (0.005) 2	0.02, 0.3 (0.2) 2	0.01, 0.04 (0.03) 2	0.01-0.04 (0.03) 2	0.003, 0.1 (0.05) 2

Notes: NA Not analysed due to analytical difficulties.
ND Not detected (the limits of determination were 0.001 mg/kg, except for data from Northern Ireland where they were 0.002 mg/kg for dieldrin, pp'-DDE and pp'-TDE, and 0.005 mg/kg for pp'-DDT).
a: Eels from individual sites in Scotland were bulked before analysis: eels from other sites were analysed individually except for those from 1 site in Wales which were bulked due to their small size.
(After Table 21 WPPR 1985-88).

Table 3: Sampling sites in the UK where mean residue levels of organochlorine pesticides in samples of eel muscle exceeded the highest expected[a] levels.

1,124 eels were obtained from 62 sites in the UK during March 1986-1987 and analysed for residues of organochlorine pesticides (Table 2). The individual sampling sites where mean residue levels of organochlorine pesticides in eel muscle exceeded the highest expected[a] levels are given in this table. For each compound, the mean levels are listed in decreasing order of magnitude and where available, the range of values is also given.

Compound	Sampling site	Numbers of eels tested	Residue levels (mg/kg)		
			Mean	Range[b]	
α-HCH	River Skerne	10	0.4	0.2-	0.8
	River Thames (Beckton)	10	0.1	0.006-	0.5
β-HCH	River Lagan	15	0.05	0.01-	0.1
	River Foyle	12	0.04	Nd[c]-	0.1
γ-HCH	Culroy Burn	9	1.5		-
	Sincil Dyke	10	0.2	0.008-	0.4
	River Thames (Beckton)	10	0.2	0.005-	0.5
	Water of Leith	25	0.1		-
	River Almond	25	0.1		-
	River Eden	25	0.1		-
	River Great Ouse	10	0.09	0.002-	0.2
	River Lagan	15	0.08	0.02-	0.2
	River Ugie	25	0.07		-
	River Clyde	25	0.07		-
	River Skerne	10	0.07	0.01-	0.1
	River Avon (Saltford Weir)	10	0.07	0.01-	0.09
	River Wear	10	0.06	0.03-	0.1
	Dighty Water	25	0.06		-
	River Teviot	25	0.06		-
Dieldrin	River Lossie	25	1.2		-
	River Skerne	10	1.0	0.5-	1.7
	River Lagan	15	0.9	0.4-	2.8
	River Eden	25	0.9	-	
	Water of Leith	25	25	0.9	-
	River Avon (Hampton Ferry)	8	0.8	0.4-	1.1
	River Thames (Syon Park)	10	0.6	0.08-	2.4
	River Thames (QEII Reservoir)	10	0.6	0.1-	1.3
	Leeds/Liverpool Canal	10	0.5[d]	0.007-	4.1
	River Annick	25	0.4		-
	River Don	8	0.4	0.2-	1.3
	River Thames (Beckton)	10	0.4	0.02-	1.0
	River Avon (Saltford Weir)	10	0.4	0.1-	0.6
pp'-DDE	Whiteadder Water	25	1.0		-
	Lunan Burn	24	0.8		-
	River Eden	25	0.7		-
	Culroy Burn	9	0.6		-
	River Esk	25	0.6		-
pp'-DDT	Culroy Burn	9	3.0		-
	River Eden	25	1.2		-
	River Ugie	25	1.2		-
	River Irvine	25	0.9		-
	River Esk	25	0.9		-
	River Ythan	25	0.6		-

Notes: a: The highest expected levels of organochlorine compounds based on previous monitoring. Although these refer to fish liver, they have been applied to eel muscle which has a much higher fat content than most other fish and approaches that in the liver from a number of marine fish species on which the expected levels are based.

b: Scottish samples were bulked before analysis, therefore no data are available on individual eels.

c: Not detected. The limit of determination was 0.001 mg/kg.

d: High value due to one very contaminated specimen.

(After Table 22 WPPR 1985-88).

APPENDIX 2 Levels of organochlorine residues detected in eels. WPPR UK commercial eel survey 1992.

Table 4: WPPR Eel Survey - Organochlorine residues detected in eels obtained from UK commercial fishing areas in May-September 1992

Area Sampled	No of Residues found HCB	α-HCH	β-HCH	γ-HCH	Dieldrin	Endrin	DDT	
Lough Erne	(1)	*	*	*	*	*	0.02	*
Waveney	(2)	*	*	*	0.02		*	0.05 *
Lough Erne	(2)	*	*	0.008	*	*	0.06	*
Test	(3)	*	*	0.02	0.07	*	0.1	*
Severn	(3)	*	*	0.03	0.1	*	0.2	*
Thames (inshore)	(3)	*	*	0.03	0.2	*	0.1	*
Frome	(4)	*	*	0.009	0.05	0.006	0.03	*
Itchen	(4)	*	*	0.02	0.1	*	0.2 0.006	
Trent	(5)	0.006	*	0.03	0.08	*	0.1	0.09
Ouse (Yorkshire)	(5)	0.009	*	0.03	0.3	*	0.4	0.05
Humber	(6)	0.009	0.007	0.03	0.2	*	0.5	0.04

All residues are reported on a fresh muscle weight basis. Samples of 25-27 eels were bulked and then analysed.

* Not found at or above the reporting limit of 0.005 mg/kg. The pesticides chlordane and heptachlor were also sought in all samples but not found at or above the reporting limit of 0.05mg/kg. (After Annex 1 MAFF Food Safety Directorate News Release FSD 27/93).

APPENDIX 3 Summary of R&D studies on bioaccumulants in fish.

Table 5: Substances proposed for monitoring in the tissues of fish in a national programme. (After R&D Report " Body Burdens in Fish").

Substance	EC Number	Status Of EQS	Red List
Metals and organometallic substances:			
Cadmium	12	EC (List 1)	*
Mercury	92	EC (List1)	*
Tributyltin	115	National	*
Triphenyltin	125-127	National	*
Polyaromatic hydrocarbons:			
Benzo(ghi)perylene	-	-	-
Benzo(k)fluoranthene	-	-	-
Pyrene	-	-	-
Pesticides:			
Aldrin	1	EC (List 1)	*
Dieldrin	71	EC (List 1)	*
Endrin	77	EC (List 1)	*
Isodrin	-	-	*
DDT (DDD/DDE/TDE)	46	EC (list 1)	*
Azinphos-methyl	6	National	*
Endosulphan	76	National	*
Fenitrothion	80	National	*
Lindane	85	EC (list 1)	*
Pentachlorophenol	102	EC (list 1)	*
Triallate	-	-	-
Trifluralin	124	National	*

Notes * UK Red List Substance
- Not on UK Red List

3.1 Body Burdens in Fish

General monitoring of target substances (Tier 1) has been proposed biannually taking samples, in either the muscle of brown trout, eels, perch or roach, where possible and depending on the fishery involved. Monitoring of muscle for target substances (15 replicates from individual fish) is accompanied by water sampling and analysis, with additional use of water samples for fisheries subject to continuous discharges. Data on levels of target substances in the muscle and water samples are compared with relevant tissues or water column standards to identify impacted fisheries. If a fishery is identified as impacted, a more detailed site-specific (Tier 2) monitoring programme may be carried out using an appropriate discriminatory tissue in a relevant species to identify the cause of the problem.

The above approach to monitoring allows Agency regions a framework to determine which bioaccumulants need to be monitored locally in fish tissues based on their chemical and toxicological properties, but more so on specific knowledge of their level of use and likelihood of entering receiving waters.

3.2 Persistent Organic Compounds within the Mersey Estuary

This study showed that flatfish PCB concentrations from the Mersey Estuary were mainly in the "upper" (highest) category of concentrations as classified by the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions (OSPARCOM). Expression of PCBs as total PCB (ICES) or total PCB (Arochlor), were very high in the muscle of all species of flatfish from the Mersey Estuary. The range of total PCB (Arochlor) was 2-7 times higher at its mid-point than data for Liverpool Bay covering the last twenty years as reported by MAFF.

PCB congener numbers (#) 138 and #153 contribute much of the total PCB in fish, with #180 and # 101 in a significant supporting role. The lighter, less chlorinated, congeners #28 and #52 were absent from roundfish except those from the inner estuary, and were also present at low levels in many flatfish from the study area. Cod and whiting caught in the outer estuary showed low concentrations of total PCBs but the latter species showed higher levels in the inner estuary sites. Total PCB levels in Mersey Estuary fish were 20-200 times higher than for the north-west Atlantic Ocean and the Solway Firth.

Concentrations of total DDT, inclusive of all the isomers of DDT, DDD and DDE, were significantly elevated, especially in flounder from the inner Mersey Estuary. Total DDT was dominated by the isomers pp' DDD and pp'DDE. Cod and whiting contained much lower levels of total DDT than flatfish. Concentrations of pp'DDT in Mersey Estuary biota were measurable in all species but generally only at low levels.

There was no indication that flatfish and invertebrates from the Mersey Estuary and Liverpool Bay contain significant concentrations of the following regulated substances: mirex, methoxychlor, heptachlor, chlordane, hexachloroethane, hexachlorobenzene, the trichlorobenzenes, and dichlorobenzenes, except 1,4-dichlorobenzene, aldrin and endrin. Concentrations of dieldrin were above background levels but not seriously so.

In conclusion concentrations of total DDT and total PCBs in Mersey Estuary fish were notably higher than for the Irish Sea concentrations of these substances, and this was particularly true for total PCBs. Significant reservations exist as regards the acceptability of the total PCB levels in fish from the inner and the outer estuary though no statutory environmental or food standard limits apply in the European Community. The overall standing of the Mersey Estuary compared with the rest of Britain and the EC is difficult to judge. PCB and DDT concentrations aside, fish from the Mersey Estuary are seemingly no more contaminated than populations of the same species, especially flounder, in the Thames, the west of Scotland, the Seine and Loire estuaries on the English Channel and Atlantic coasts of France, respectively. It is also notable that the Mersey Estuary levels of total PCBs are lower than for the Seine and the Elb in Germany, though this presents only a perspective and not any form of justification for the PCB status of the Mersey fish.

There is still a large number of unidentified organic materials in Mersey fish that are not found in fish from clean estuaries. Further investigations of the chemical nature and geographical occurrence of the remaining unidentified compounds is considered to be warranted.

3.3 The occurrence of selected chemical pollutants (simazine, lindane and permethrin) in river fish.

Problems associated with pesticide residues in cyprinid fish (dace, gudgeon roach and chub) from the main feeding niches within the family:-

* Levels of pesticides found in muscle and fish liver are generally low and make analysis difficult.

* No relationship was found between fat content of an individual fish and pesticide content.

* Levels of other pollutants in rivers can have secondary effects on pesticide levels in fish by changing the relative availability of secondary food types.

* There is no clear consensus as to the mode of introduction of pesticides into fish. It is probable that the dominance of feeding as opposed to the water inputs will vary according to the lipophilic nature of the pesticide concerned.

* No significant differences in pesticide levels were detected between feeding types.

* The benefits of sampling the livers of fish to obtain greater lipophilic pesticide concentrations is offset by the relatively small size of the organ. Bulking of samples may be necessary.

* Fish may not necessarily be from a locally resident population. They may move between polluted and non polluted sites.

* Food "preferences" of fish exposed to pesticides can change due to effects either on the fish themselves or on their prey organisms. Change in food "preferences" of fish can be brought about by non-pesticide pollution.

* There is no systematic understanding of the levels of pesticides in either water or fish which cause measurable effects on fish.

APPENDIX 4 Summary of bioaccumulant studies in eels carried out within the NRA/Environment Agency.

4.1 PCBs and Organochlorine Pesticides in Eels from North West England

Samples of 40 eels taken by the NRA during July and August 1993 from the Rivers Eden, Till and North Tyne were analysed by the Industrial Ecology Research Centre (IERC) at the University of Liverpool. The levels of these contaminants were typical of those levels reported for eels taken from most other UK sites (MAFF, national Survey 1987).

4.2 PCB and Organochlorine Pesticides in Eels from Welsh Rivers

I) OC concentrations in the muscle tissues of 179 eels at 41 freshwater sites across the Welsh Region were surveyed JUL-SEP 1993, to describe the regional distribution of contamination PCB's and OC pesticides, in order to assess the potential risks and to provide a basis for further possible investigations.

ii) Concentrations were reported as µg/kg wet weight, with a detection limit of 2 µg/kg. Weak positive relationships were detected between eel age or length and the concentration of some determinands but no correction for age was applied in further analyses.

iii) Isomers of HCH were below detection at most sites, though mean gamma-HCH levels c. 10 µg/kg occurred in the Taff. Of the 'drins', only dieldrin was widespread at 10-100 µg/kg, despite its ban in sheep dip in 1989.

iv) DDT residues were dominated by pp'-DDE, a breakdown product of DDT, with total residue concentrations averaging 73 µg/kg. The results were in the lower part of the range reported elsewhere in the UK.

v) Total PCB burdens expressed as Arochlor 1260 were > 50 µg/kg at 76% of sites and > 100 µg/kg at 46% of sites. The range of concentrations was comparable with that shown by other UK data. Thus the critical threshold of 50µg/kg, proposed by Masons for consumption by otters, was exceeded in many catchments. However, other recent literature suggests that the limit is lower than can be supported by available data. Here, there was no clear relationship at a catchment level between PCB's in eels and otter populations which are generally healthy.

vi) Eleven sites with the highest PCB concentrations in the survey were identified for consideration within the Catchment Management Programme for possible further investigation. These were all in the lower reaches of industrialized catchments. Rural sites had relatively low levels of PCBs, so that although contamination was widespread, on present evidence there was no compelling concern that influxes from diffuse sources were established.

vii) The results of this study indicated that further monitoring and investigations of both PCB and organochlorine pesticide pollution should be targeted at known sources and affected catchments. A catchment based analytical study of sources, sinks and pathways should be considered to identify risks, to develop effective monitoring techniques and to explore methods of control.

4.3 A Report on the Eel Tissue Bioaccumulation Surveys of 1989 and 1992

I) Both liver and muscle samples were analysed from metal and organic contaminants from 28 sites (1989) and 17 sites (1992). Discussion was based on those elements for which EQSs exist.

ii) Mercury- Levels of mercury in fish tissue did not exceed the EQS of 0.3 mg/kg fish tissue at any of the survey sites, though a couple of sites had elevated levels close to the EQS and indicate a possible need for further investigation. In a vast majority of cases, the levels of mercury in muscle exceeded the levels in liver, indication that the pollution is of long term rather than short term nature.

iii) PCBs - Muscle contamination by PCBs was below the limit of detection in both '89 and '92. Unfortunately the limit of detection in '92 (100 µg/kg) was above the provisional standard. Contamination of liver tissue in '92 was below the limit of detection (50 µg/kg). In '89, however, levels at several sites exceeded 100 µg/kg.

iv) Dieldrin - Muscle and liver contamination by dieldrin was above the provisional standard at several sites in '89. Contamination levels by dieldrin declined to near or below the provisional standard at all sites by '92. This may be due to its ban in '89.

v) All exceedences of standards occurred in '89 only, indicating threat to otter populations in the area at these sites is reduced. However taking into account the long term nature of PCB and dieldrin contamination and the presence of only two years worth of data, there is strong requirement for further investigations at these sites.

vi) Most of the sites studied showed elevated levels of at least one chemical. However lack of comparative data makes evaluation difficult.

vii) There were no human health implications for any of the contaminants discussed.

This study has recently being followed up by a further study in 1995 to monitor the present state of selected sites in South West Region from contaminants, and determine any possible threat to otters from contaminated eel tissue. This latest report is presently in draft form.

APPENDIX 5 Post mortem analysis carried out on otters from South West Region and procedures for the collection of dead otters.

5.1 The Health Status of Otters (*Lutra lutra*) in south west England (in press).

Little pathological work has been undertaken on otters to investigate claims that OCPs, PCBs or any other agents are responsible for the decline of otters in Britain. As a consequence the Environment Agency commissioned post mortem analysis by the Dr. Vic Simpson of the Veterinary Investigation Unit in Truro, Cornwall. Otters collected as part of this project have undergone gross pathological and bacteriological examination, the overall objective, to establish the health status of the otter population in south west England and to determine the effects, if any, of exposure to environmental pollutants.

Post mortem examinations were carried out 77 wild otters found dead in south west England between 1988 and 1996. Road traffic accidents accounted for 83% of deaths. Nutritional states were good, with males generally in overall poorer condition than females. Gross pathological examination showed little evidence of infectious disease and results suggested a young, generally healthy population. Cases of adrenal hyperthropy were associated with stress factors and uterine abnormalities were seen in four females.

With the exception of bite wounds, the most significant observations related to uteri. Decline of the otter population has been attributed to the effects of PCBs and OCs, but there was little evidence of direct toxicity. Uterine atrophy and cystic dilations have been linked with PCBs in mink and seals respectively. It is suggested that the cystic and convoluted uteri seen in three adult otters in this study may have a similar aetiology. As the mean age for otters in this study was only two years, it is clear that factors affecting reproduction could seriously affect the population recruitment. Nevertheless, general agreement that the otter population in south west England is increasing and the uterine abnormalities seen between 1990 and 1993 may represent a diminishing problem.

APPENDIX 5 Otter Casualty Collection Procedures

5.1 DEAD OTTERS: PROCEDURES FOR ENVIRONMENT AGENCY CONSERVATION STAFF

Find and recieve corpse

Fill in waterproof record sheet with waterproof ink

Check whether corpse is fresh or not, then place in plastic bag and seal tightly

Photocopy completed record sheet and tape waterproof copy to outside of bag.

Is corpse fresh? (See below) Note: Fresh corpses are a priorit y

Yes

Arrange to chill corpse at - 20oC for two hours in a freezer, then transfer to a fridge at < 4oC

Conservation staff to contact Vic Simpson (SW Region) or Adeline Bradshaw (all other Regions) to arrange for immediate reception. See contact addresses below

Arrange for immediate transport to appropriate laboratory

No

Freeze corpse at -200C and leave in freezer until transport arranged

Conservation staff contact Vic Simpson/Adeline Bradshaw to arrange for reception when convenient

Arrange for immediate transport to appropriate laboratory

* Package corpse by wrapping second bag in insulating material (e.g. bubble wrap, corrugated cardboard or box filled with polystyrene beads or tightly screwed-up paper).
* Place in a sturdy box
* Label "biological specimen"
*Place back in fridge (fresh corpses only) or freezer (all others) until transport arrives

Vic Simpson
Veterinary Investigation Agency,
Polwhele, TRURO,
Cornwall, TR4 9AD
tel. 01872 560623
fax. 01872 223443

Adeline Bradshaw
Pabio, University of Wales,
P.O. Box 915,
Cardiff CF1 3TL
tel. 01222 874000 ext. 6735
fax. 01222 874305

Note : " Fresh Otters" have generally been dead for fewer than 24 h, do not smell and retain a bright, moist eye.

5.2 WHAT TO DO WITH A DEAD OTTER: ACTIONS FOR NON-ENVIRONMENT AGENCY STAFF