NATIONAL RIVERS AUTHORITY

AWDURDOD AFONYDD CENEDLAETHOL

WELSH REGION

RHANBARTH CYMRU

[redacted]

AAC

NRA

Guardians of the Water Environment

Diogelwyr Amgylchedd Dŵr

Pests: B|3

Polychlorinated Biphenyls and Organochlorine Pesticides in Eels from Welsh Rivers

Report No. RT/WQ/RCEU/95/1 & SE/EAU/95/2

N S Weatherley, G L Davies & D S Ellery
NRA Welsh Region
Rivers House
St Mellons Business Park
Cardiff CF3 OLT

CONTENTS

EXECUTIVE SUMMARY

1. Organochlorine concentrations in the muscle tissues of 179 eels at 41freshwater sites across the Welsh Region were surveyed during July to September 1993. The main objective was to describe the regional distribution of contamination by PCBs and organochlorine pesticides, in order to assess potential risks and to provide a basis for possible further investigations.

2. Concentrations were reported as ug kg^{-1} wet weight, with a detection limit of 2 ug kg^{-1}. 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.

3. Isomers of HCH were below detection at most sites, though mean gamma-HCH (lindane) levels of c. 10 ug kg^{-1} occurred in the Taff. Of the 'drins', only dieldrin was widespread at 10 - 100 ug kg^{-1}, despite its ban in sheep dip in 1989.

4. DDT residues were dominated by pp'-DDE, a breakdown product of DDT, with total residue concentrations averaging 73 ug kg^{-1}. The results were in the lower part of the range reported elsewhere in the UK.

5. Total PCB burdens expressed as Arochlor 1260 were > 50 ug kg^{-1} at 76 % of sites and > 100 ug kg^{-1} at 46 % of sites. The range of concentrations was comparable with that shown by other UK data. Thus the critical threshold of 50 ug kg^{-1}, proposed by Mason for consumption by otters (see references), was exceeded in many catchments. However, other recent literature suggests that this limit is lower than can be supported by available data. Here, there was no clear relationship at a catchment level between PCBs in eels and otter populations which are generally healthy.

6. 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 substantial.

7. 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 the risks, to develop effective monitoring techniques and to explore methods of control.

1. INTRODUCTION

Organochlorine pesticides, including DDT and dieldrin, were widely introduced into agriculture in the 1950s. At about the same time, production of synthetic polychlorinated biphenyls (PCBs) was increasing for a variety of industrial applications. The high chemical stability and electrical resistance of PCBs led to their extensive use. Closed uses include transformers, capacitors, heat transfer and vacuum pump fluids. Open uses include fire retardants, plasticizers, lubricating and cutting oils. The same properties make PCBs extremely persistent in the environment and they have been detected since the early 1970s in most materials and locations, including remote polar regions. The input of PCBs to the UK environment peaked in the 1960s, but concern over effects on marine mammals, birds and humans led to global ban on production in the late 1970s (Harrad et al., 1994; Tanabe, 1988). DDT and dieldrin were also banned in the UK in the late 1980s for their toxicity and bioaccumulative properties.

A substantial proportion of the PCBs released in industrial countries has 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. Although there have been significant decreases in soil PCB concentrations over 2 to 3 decades, the remaining anthropogenic and environmental sources will continue to slow rates of decline, especially in long-lived organisms. PCB contamination is therefore likely to remain a cause of concern for the forseeable future, although it should be seen in the context of many other toxic, persistent, organic and inorganic chemicals (Johnson and Vine, 1993). Limited data indicate that the toxicity of PCBs to fish and aquatic invertebrates is lower than that of several other substances of concern, but attention to PCBs is justified by their persistence, bioaccumulation potential and toxicity to mammals. As organochlorine substances are particularly fat soluble and resistant to enzymatic degradation, they may accumulate in biota to concentrations many times higher than in lower levels of the food chain. Characteristics of PCB congeners and other substances in this study are summarized in Appendix 1.

In Wales, PCBs were produced at the Monsanto plant near Newport until 1977. Elevated concentrations have been found in sediments around the plant discharge to the Severn Estuary (Davies & Robinson, 1994). Other localized cases of contamination have been reported in relation to uncontrolled sources such as contaminated land leachate (see Discussion). The profile of PCBs as contaminants of the UK freshwater environment has been raised recently by studies of concentrations in otter spraints (Mason 1989; Mason & Macdonald 1993a, 1993b, 1993c). Mason proposed that dietary sources of PCBs and organochlorine pesticides in fish were a significant constraint on otter populations in several major river catchments. This concern triggered recent surveys in North West and Northumbria Yorkshire NRA Regions (IERC, 1993a, 1993b).

There is little systematic information on the distribution of PCBs in Welsh freshwaters. Rivers, estuaries and coastal waters have been monitored regularly since 1989 for PCBs due to their inclusion on the UK Red List. The results show concentrations in water almost entirely below the detection limit of 5 ng l^{-1}. This illustrates the need to sample appropriate indicators of contamination to improve our understanding of the distribution of PCBs and organochlorine compounds in Welsh rivers. Eels were selected as a bio-monitor here, as in several other studies, because of their longevity, limited movement during freshwater residence and high fat content. They were also of interest as prey for piscivorous birds and otters. The overall aim was to describe the regional distribution of organochlorine contamination in order to assess potential risks and to provide a basis for possible further investigations.

2. METHODS

2.1 Sample collection and preparation

Approximately 50 sites were selected initially across the Region to represent upland and lowland catchments, agricultural and industrial areas, locations away from any known PCB sources and those known or potentially affected by local sources. Some sites adjacent to those sampled by other workers for otter spraints and dipper eggs were included (see Discussion). The final suite of sites was determined by the presence of eels, which were absent from some upland catchments, the location of reaches suitable for electrofishing and the availability of fishing teams.

Eels were collected in July - September 1993 using standard electrofishing techniques, with the aim of selecting 5 individuals c. 300 mm in length from each site. The fish were stored frozen in polythene bags. In the laboratory, total body length was measured to the nearest millimetre, and whole bodies with the skin removed were sent for analysis by the NRA National Laboratory Service, Llanelli Laboratory. As analyses for other recent NRA studies have been carried out at the University of Liverpool Industrial Ecology Research Centre (IERC), subsamples of 5 eels from each of 2 sites were sent here for AQC purposes.

Ageing was carried out by the NRA National Fish Ageing Centre at Brampton (Anglian Region). Otoliths were removed by dissection, heat treated and mounted for reading. Quality control involved two independent readings and comparison of results from a sub-sample read by two external experts.

2.2 Chemical analysis

Details of the IERC laboratory methods are given elsewhere (IERC, 1994a). At the Llanelli Laboratory, samples of 5 g of homogenized fish muscle were dehydrated with anhydrous sodium sulphate and extracted by n-hexane. Total n-hexane extractable lipids were determined gravimetrically after evaporation of the solvent and drying to constant weight at 105°C. Samples were cleaned-up on alumina columns, and organochlorines measured by Hewlett-Packard 5890 Series II Gas Chromatograph with twin electron capture detectors, operated in dual column mode with splitless injection. The main analytical and confirmation columns were respectively an SGE BP5 and SGE BP10, both 30 m x 0.32 mm id x 0.50 um film thickness. Multilevel internal standard calibration was used with linear fit on both columns. Injection volume was 2.0 ul, with helium carrier gas and column head pressure 12 psi.

Arochlor 1260 equivalent concentrations were estimated from the sum of PCB congeners using a multiplication factor of 3.6 (IERC, 1994b).

2.3 Data analysis

Unless otherwise stated, analyses were performed on $\log_{10}$ transformed concentrations expressed in wet weight, with values less than the detection limit converted to 1 ug kg^{-1}. Results are presented for individual substances and for total PCBs or the sum of the 7 congeners measured (SUM PCB) and total DDT isomers and breakdown products (SUM DDT). Where all values in a sum were below detection the sum was set as 1 ug kg^{-1}. Visual inspection of the regional and within site concentration distributions indicated that log transformation was appropriate to approximate Normality. Treatment of data below detection limits varies in the literature and can introduce some bias in the results. However, in this study, any bias for determinands at concentrations of concern was likely to be trivial, whilst estimated means close to 1 ug kg^{-1} cited here for completeness should be regarded as invalid and the median should be considered the appropriate summary statistic.

Parametric statistics were considered valid for most determinands. Cluster analysis was carried out with the PRIMER package, applying the Bray-Curtis similarity index (Plymouth Marine Laboratory, 1992). SUM PCB, Arochlor 1260 and SUM DDT were excluded from multivariate analyses which included their constituents.

3. RESULTS

3.1 Eel age and length

The mean eel age over all sites was 10.5 years, range 5 - 24, with significant differences in age between sites. Geometric mean length was 346 mm, range 210 - 590 mm, also differing significantly between sites. Lipid content showed relatively high variation with mean 10.0 %, standard deviation 7.48. Approximate organochlorine concentrations in lipid can therefore be obtained by applying a 10x conversion factor to the wet weight data presented.

3.2 Effects of age and length on bioaccumulation

Preliminary regression of log.wet weight organochlorine concentrations on age or log.length, treating all eels as one population, showed no significant relationships. This might be expected if between-site differences masked the effects of age or length. Site effects were allowed for by including each site as a dummy independent variable with age or length in a multiple regression (Table 1). In these analyses, the effect of age in increasing tissue concentrations was significant at 5 % for PCB 101 and PCB 180, whilst that of length was significant at 5% in the case of pp'-TDE, PCB 101, PCB 138, PCB 153, PCB 180, SUM PCBs and Arochlor 1260. (The correlation between age and log.length was 0.561, $p < 0.01$.) However, the contributions of age or length to increasing the percentage variance in concentration explained by the regressions were slight in each case (Table 1).

In summary, weak, positive relationships between tissue concentrations of some organochlorines and eel age or length were detected. For the purposes of all further analyses in this paper, any such effects were ignored (see Discussion).

3.3 Regional data

Regional organochlorine concentrations

For each substance, with the exceptions of alpha and beta-HCH, there were highly significant concentration differences between sites as shown by both oneway ANOVA and by the non-parametric Kruskal-Wallis test (Table 2, Appendix 2; raw data in Appendices 3 and 4).

Eel tissue concentrations of the HCH isomers exceeded detection limits at few sites, with mean concentrations of gamma-HCH reaching approximately 10 ug kg^{-1} at only 2 sites on the Taff. Aldrin was not detected in any sample and endrin was found at only 8 sites (all means < 10 ug kg^{-1}). Dieldrin was widespread in eel tissues, with means in the range 10 - 100 ug kg^{-1} at 80 % of sites (Fig. 1, Appendix 2).

Of the DDT residues only pp'-DDT (overall mean 6.0 ug kg^{-1}), pp'-DDE (mean 22.8 ug kg^{-1}) and pp'-TDE (mean 6.0 ug kg^{-1}) frequently exceeded 10 ug kg^{-1}. SUM DDT concentrations were < 50 ug kg^{-1} at 51 % and > 100 ug kg^{-1} at 7 sites (maximum 303 ug kg^{-1}).

The frequency of detection and overall mean concentration of the 7 PCB congeners tended to increase with IUPAC number or degree of chlorination, although PCB 180 concentrations were lower than expected from this trend (Fig. 1). At 73% of sites, mean concentrations of most congeners were < 10 ug kg^{-1} and SUM PCBs were < 50 ug kg^{-1}. Arochlor 1260 concentrations were > 50 ug kg^{-1} at 76 % of sites and exceeded 100 ug kg^{-1} at 46 % of sites.

Site specific data and relationships between sites

Site scores on the first two axes of the PCA, in conjunction with site groupings obtained by cluster analysis, suggested a pattern of contamination which could be interpreted broadly in terms of known site characteristics (Figs. 2 - 5, Table 3).

Eight sites in Group A had the highest concentrations of PCBs (SUM PCB 82 - 910 ug kg^{-1}, Arochlor 1260 316 - 3300 ug kg^{-1}) in addition to moderate levels of DDT isomers. This group comprised sites on the Lwyd (2 sites), Sirhowy, Taff (2 sites), Llynfi, lower Dee and Clywedog (Dee catchment), all of which have potential industrial sources of PCBs in their catchments. The upper Taff, Seiont and Alyn also had SUM PCB concentrations > 50 ug kg^{-1}.

The majority of sites, 28, could be placed in one category, Group B. These sites had SUM PCBs generally < 50 ug kg^{-1}, though Arochlor 1260 values exceeded 100 ug kg^{-1} at 11 sites. SUM DDT concentrations were in the range 10 - 100 ug kg^{-1} or more in the cases of the Frome and upper Senni. The catchments included the upper and middle reaches of rivers with rural to intensive agriculture, and the lower reaches of rivers in relatively industrial areas. Further subdivision based on the cluster analysis was not readily interpreted, though a sub-group of 4 southwest Wales sites including the upper and lower Teifi had low concentrations of PCBs and DDTs.

Group C contained 3 rural lowland catchments and 1 upland afforested site. Concentrations of PCBs were low and DDT isomers < 50 ug kg^{-1} at these sites, whilst at Llyn Coron (= Group D) no mean organochlorine concentration exceeded 10 ug kg^{-1}.

3.4 Relationships between organochlorines

Pearson product moment correlation showed a high degree of co-correlation between tissue concentrations of most substances, apart from alpha-HCH and beta-HCH which were usually below detection limits (Table 4). Principal Components Analysis (PCA) revealed a clear association between the 7 PCB congeners which were most strongly correlated with the first component, accounting for 42.2 % of the variance in the data set (Fig. 6). The pesticides, including dieldrin, gamma-HCH, major DDT isomers and breakdown products formed a separate group, correlated strongly with the second principal component which represented a further 13.7 % of the variance. The positions of other substances in the PCA may not be meaningful because of their very low concentrations in most eels (op-DDE, op-TDE, alpha-HCH, beta-HCH, endrin).

This analysis provided circumstantial evidence that sources and environmental pathways were related for PCB congeners, and also amongst the DDT compounds, and that SUM PCB and SUM DDT could therefore reasonably be used to summarize distribution patterns.

3.5 Analytical Quality Control

Results from the NRA and IERC Laboratories for each determinand at each site were compared by paired t-test of log-transformed data (Table 5). Only 2 in 27 tests showed significant differences though the NRA mean values were higher on 21 out of 27 cases (Chi-square 8.33, $p < 0.01$). This indicated relatively small but consistent differences between the Laboratories.

4. DISCUSSION

Organochlorine distribution in context

The range of PCB concentrations in Welsh eels in this survey was comparable with data reported from rural and industrial sites elsewhere in the UK (Table 6). The mean of Welsh sites was lower than those from large surveys in England/Wales and northern Britain (MAFF, 1989; Kruuk et al., 1993). Most Welsh eels also had lower PCB levels than those found in other European river and North Sea eels by studies cited in IERC (1994). In approximate terms, eels in many rural UK sites have PCB loadings of < 50 - 100 ug kg^{-1} Arochlor 1260, whilst those in industrial areas or apparently affected by local sources may exceed 100 or in some cases 1,000 ug kg^{-1}.

Concentrations of dieldrin, lindane and DDT residues showed a similarly wide range which was broadly comparable with other UK data and the lower part of the MAFF (1989) England/Wales concentration distributions (Table 6). All the dieldrin results were lower than those found in known contaminated reaches in South West England (Hamilton, 1985).

Specific locations

Some of the reaches more highly contaminated with PCBs in this survey are associated with known or potential sources. The Clywedog site and the main River Dee are downstream of an industrial landfill and sediments in the Clywedog are strongly contaminated with PCBs (Law et al., 1991). The lower Lwyd site is in the vicinity of the Rechem International waste incineration plant (Ball et al., 1993), however the levels in eels here were similar to those at the upstream location.

At the catchment scale, relative organochlorine burdens in eels showed some correspondence with those in otter spraints (Mason & MacDonald, 1993a). Both data sets indicated low PCB levels in West Wales, with the exception of the Cleddau, and moderate to high levels in parts of the Usk, Wye, Tawe and Dee. At the Lugg site (site 3, Wye) where eels were also sampled by Mason (unpublished data), total PCBs in our study contained c. 100 ug kg^{-1} Arochlor 1260, about twice that reported by Mason, though the source of this difference is not clear.

The Dulais was the only site included here in a catchment where dipper eggs had also been sampled for PCBs (Ormerod & Tyler, 1990, 1992). PCBs in eels in the Dulais were relatively low but in dipper eggs slightly above average. Moreover, the low contamination in eels in the forested Hirnant did not support Ormerod & Tylers' suggestion that plantations might enhance inputs by scavenging airborne PCBs. Nevertheless, more detailed investigations are required if PCB fluxes and ecosystem relationships are to be established with any certainty.

Environmental significance

Total PCB concentrations exceeded US tolerance levels for human consumption of 2,000 ug kg-1 in the Clywedog but at no other site (when expressed as Arochlor 1260 equivalents). The sum of DDT-related compounds was less than 10 % of the US tolerance limit of 5,000 ug kg^{-1} in all cases. Limits adopted by some European states and the US for dieldrin and lindane are < 1 ug kg^{-1} (Appendix 1), below the limits of detection in this study, and were exceeded at least at 98% and 22 % respectively of Welsh sites. However, in the UK, MAFF have advised that human consumption of eels should be limited where eels contain around 100 ug kg^{-1} dieldrin (MAFF, 1993).

The significance of organochlorine concentrations in biota is poorly understood. There are few data relating body burdens in fish to either lethal or sub-lethal toxicity (Johnson and Crane, 1991). Thus it is not possible to assess the implications of the data presented here for fish populations, except that acute effects appear unlikely. Some evidence was found here of organochlorine tissue burdens increasing with eel age, suggesting a value in integrating exposure over a number of years. But these effects were weak and in general are not well elucidated (IERC, 1994b). The possible errors in correcting for age and growth effects indicate the need for parallel monitoring of different species and environmental compartments. Brown trout for example are relatively short-lived and sedentary so they may provide a more responsive measure of recent contamination (Johnson and Vine, 1993). A choice of species is also necessary as none are ubiquitous.

Mason & Macdonald (1993b) proposed a limit for otter consumption of 50 ug kg^{-1} total PCBs in fish, above which reproductive impairment could occur. This threshold was exceeded at three-quarters of Welsh sites in the present survey. However, the estimated limit was based on data for mink, which are known to be particularly sensitive to organochlorine toxicity, and has not been supported clearly by field data. Kruuk et al. (1993) found healthy otter populations in areas where PCB burdens in eels substantially exceeded 50 ug kg^{-1}. They concluded that the role of PCBs in impairing otter reproduction was likely to have been exaggerated. Comparing our eel PCB data with the distribution of otters in Wales in 1991 (Andrews et al., 1993) revealed no clear relationship at the catchment scale. We therefore have no firm basis from which to infer the importance to otters of the results presented here, though there is a need for more detailed investigation including the critical levels of PCBs in otter diets.

In studies of organochlorines in UK dipper eggs, including Wales, increasing PCB concentrations were related to slight egg shell thinning (Ormerod & Tyler, 1990, 1992). Any relationship with concentrations in dipper eggs and other ecosystem compartments remains to be elaborated, though Mason & Macdonald (1993b) noted a significant rank correlation between PCB levels in otter spraints and dipper eggs on a catchment basis. Regionally, the pattern of relative congener concentrations did not correspond with our data, as PCB 118 was most abundant in dipper eggs and PCBs 138 and 153 were dominant in eel muscle.

Most surveys of PCB distribution have either analysed samples for total PCBs determined against an Arochlor standard, or have summarised results in terms of the sum of congeners measured, often the ICES 7. Whilst this provides a convenient overview, it is being recognised increasingly that an improved understanding of the problem is likely to depend on consideration of individual congeners. The biological significance of contaminant levels depends on the contribution of different congeners which vary in physical and chemical characteristics and in toxicity (Appendix 1). This has prompted certain recent studies to expand the ICES 7 suite to c. 25 (Law, 1994). Although adequate toxicological data are not yet available for each substance, more detailed information on contamination should assist the diagnosis of impacts, help prioritise any needs for development and provide an important baseline for future work.

5. RECOMMENDATIONS

1. The implications of observed PCB concentrations are unknown, but the need for further site investigations should be reviewed within the Catchment Management Programme, with first priority for the 5 reaches where SUM PCB > 100 ug kg^{-1}: Lwyd (Croesyceiliog), Sirhowy, Taff (Blackweir), Clywedog (Dee), and Dee (Eccleston Ferry). Secondary priority should be given to the 6 reaches where SUM PCB > 50 ug kg^{-1}: Lwyd (Ponthir), Taff (Rhydycar, Ynys Angharad Park), Llynfi, Seiont and Alyn.

2. In the absence of evidence of environmental impacts where SUM PCB < 50 ug kg^{-1} in eels, there is no compelling need at present for general monitoring.

3. There is a need for a standard National NRA approach to PCB analysis which should consider the feasibility and cost of increasing the standard analytical range of PCB congeners from 7 to c. 25.

4. There is no clear need for widespread monitoring of biological tissues for DDT compounds or dieldrin which are expected to decline gradually in the environment. Monitoring should be considered for specific sites, including the 7 here where SUM DDT > 100 ug kg^{-1}: Frome, Senni, Lwyd (Croesyceiliog), Sirhowy, Taff (Ynys Angharad Park, Blackweir) and Llynfi.

5. Lindane remains an authorized pesticide but relatively scarce in eels. No sites of concern were identified here and there is no need for general monitoring.

6. The 1995 eel survey, coordinated by MAFF/WPPR, should include 5 Welsh sites to represent a range of catchments: the 2 Welsh sites in the 1986 survey, the Cefni and Morlais, and the Dee (Eccleston Ferry), Taff (Blackweir) and Teifi (Llechryd).

7. The design feasibility, costs and benefits of a catchment based analytical study should be assessed. This should:

- Include key ecosystem compartments, including sediments, soils, air, water and biota.
- Address the relationships between contaminant concentrations, otter populations and other biota.
- Identify solutions to contamination in the catchment.
- Identify cost- and scientific-effective monitoring techniques.
- Provide guidance on the interpretation of contamination data.

6. ACKNOWLEDGMENTS

This project was dependent on staff in NRA Welsh Region for site selection and sample collection. Thanks are due to the NRA Llanelli Laboratory and Liverpool Industrial Ecology Research Centre for analytical services and advice. We are grateful to the NRA Brampton Laboratory in Anglian Region, Miran Aprahamian and Ian Naismith for ageing the eels. Comments on the manuscript were made by the Steve Brown, Richard Howell, Dave Mathias, Roger Milne and Terry Westwood.

7. REFERENCES

Andrews, E., Howell, P. & Johnson, K. (1993). Otter survey of Wales 1991. The Vincent Wildlife Trust, London.

Ball, D.J., Creaser, C.S., Foxall, C., Lovett, A.A., MacGuire, F.A.S. & Patteson, M.T. (1993). Polychlorinated biphenyls, dioxins and furans in the Pontypool environment. Report to Welsh Office, Environmental Risk Assessment Unit, University of East Anglia.

Davies, G., & Robinson, A. (1994). The Biological and Environmental Impact 'of the MONSANTO effluent, Severn Estuary. NRA Welsh Region report SE/EAU/94/1.

Harrad, S.J., Sewart, A.P., Alcock, R., Boumphrey, R., Burnett, V., Duarte-Davidson, R., Halsall, C., Sanders, G., Waterhouse, K., Wild, S.R. & Jones, K.C. (1994). Polychlorinated biphenyls (PCBs) in the British environment: sinks, sources and temporal trends. Environmental Pollution 85, 131 - 146.

Hamilton, R.M. (1985). Discharges of pesticides to the River Mole and Taw, their accumulation in fish flesh and possible effects on fish stocks. Journal of Fish Biology 27, (Suppl. A) 139 - 149.

Industrial Ecology Research Centre (1993a). PCBs and organochlorine pesticides in eels, otter spraints and aquatic vegetation from North East England. Report to NRA, University of Liverpool.

Industrial Ecology Research Centre (1993b). PCBs and organochlorine pesticides in eels from North West England. Report to NRA, University of Liverpool.

Industrial Ecology Research Centre (1994a). PCBs and organochlorines in eels from Rivers in Wales. Report to NRA, University of Liverpool.

Industrial Ecology Research Centre (1994b). Persistent organic compounds within the Mersey Estuary. NRA R&D Note 328, Bristol.

Johnson, I. & Crane, M. (1991). Body burdens and toxicity - review. NRA R&D Note 104.

Johnson, I. & Vine, S. (1993). Body burdens in fish. NRA R&D Note 193.

Jones, K.C. (1989). PCBs in Welsh soils: a survey of typical levels. Chemosphere 18, 1665 - 1672.

Kruuk, H., Conroy, J.W.H. & Carss, D.N. (1993). Otters, eels and contaminants. Report by ITE Banchory to Scottish Natural Heritage, no. NE/92/205.

Law, R.J. (Compiler, 1994). Collaborative UK marine mammal project: summary of data produced 1988-1992. MAFF Fisheries Research Technical Report No.97, Lowestoft.

Law, R.J., Allchin, C.R. & Dixon, A.G. (1991). PCBs in sediments downstream of a contaminated industrial site in North Wales. Marine Pollution Bulletin 22, 492 - 493.

Mason, C.F. (1989). Water pollution and otter distribution: a review. Lutra 2, 97 - 130.

Mason, C.F. (1993). Organochlorine pesticide residues and PCBs in eels (*Anguilla anguilla*) from some British freshwater reedbeds. Chemosphere 26, 2289 - 2292.

Mason, C.F. & Macdonald, S.M. (1993a). Impact of organochlorine pesticide residues and PCBs on otters (*Lutra lutra*): a study from western Britain.
Science Total Environment 138, 127 - 145.

Mason, C.F. & Macdonald, S.M. (1993b). PCBs and organochlorine pesticide residues in otter (*Lutra lutra*) spraints from Welsh catchments and their significance to otter conservation strategies. Aquatic Conservation: Marine and Freshwater Ecosystems 3, 43 - 51.

Mason, C.F. & Macdonald, S.M. (1993c). Impact of organochlorine residues and PCBs on otters (*Lutra lutra*) in eastern England. Science of the Total Environment 138, 147 - 160.

Ministry of Agriculture, Fisheries and Food (1989). Report of the Working Party on Pesticide Residues: 1985 - 1988. Food Surveillance Paper no.25. HMSO, London.

Ministry of Agriculture, Fisheries and Food (1993). Eels: Advice for consumers. News Release, Food Safety Directorate, London.

National Rivers Authority (1992). A review of data on the bioaccumulation of pesticides and PCBs in eels from the Lugg and Frome catchments. NRA Welsh Region report EAE/92/37.

Ormerod, S.J. & Tyler, S.J. (1990). Environmental pollutants in the eggs of Welsh dippers *Cinclus cinclus*: a potential monitor of organochlorine and mercury contamination in upland rivers.

Ormerod, S.J. & Tyler, S.J. (1992). Patterns of contamination by organochlorines and mercury in the eggs of two river passerines in Britain and Ireland with reference to individual PCB congeners. Environmental Pollution 76, 233 - 243.

Parkinson, A. & Safe, S. (1987). Mammalian biologic and toxic effects of PCBs. Environmental Toxin Series 1, 49 - 75.

Plymouth Marine Laboratory (1992). User Guide to PRIMER 3.1. Plymouth Marine Laboratory.

Tanabe, S. (1988). PCB problems in the future: foresight from current knowledge. Environmental Pollution 50, 5 - 28.

TABLE 1

Summary of multiple regressions of eel muscle organochlorine concentations (log. mg kg^{-1} wet weight) on either eel age or log length (mm) and sites as dummy variables. Regressions are of the form,

$$\log. \text{concentration} = a + bx + c_1 n_1 + \dots c_{40} n_{40}$$

where x = age or length, n_1 - n_{40} = site number, a, b, c are constants. NS denotes $p>0.05$, * $p<0.05$, ** $p<0.01$, ***$p < 0.001$ for the regression coefficient. The change in the coefficient of determination on including age or length in the regression is given under dr^2.

SUBSTANCE	AGE		LENGTH	
	b	dr^2	b	dr^2
dieldrin	0.0107^{NS}	+2.2	0.572^{NS}	+1.3
pp'-DDT	0.00583^{NS}	0.0	0.539^{NS}	+0.3
op'-DDT	-0.00631^{NS}	-2.8	-0.088^{NS}	-2.3
pp'-DDE	0.0128^{NS}	+0.1	0.379^{NS}	-0.6
op'-DDE	0.00692^{NS}	+6.8	-0.050^{NS}	+7.0
pp'-TDE	0.00458^{NS}	-0.7	0.616*	-4.1
op'-TDE	0.00318^{NS}	+0.6	0.094^{NS}	+0.5
∑ DDT	0.0112^{NS}	+1.1	0.390^{NS}	+0.6
PCB28	-0.00076^{NS}	+0.1	-0.046^{NS}	-1.5
PCB52	0.00342^{NS}	+1.3	-0.132^{NS}	-0.5
PCB101	0.0164*	+3.2	0.622*	-0.1
PCB118	0.00375^{NS}	-1.7	0.162^{NS}	-0.3
PCB138	0.00779^{NS}	+1.1	0.700*	+1.3
PCB153	0.0117^{NS}	+2.2	0.583*	+0.2
PCB180	0.0142*	+0.3	0.651**	+0.5
∑PCB	0.0178^{NS}	+1.6	0.911*	+0.8
Arochlor 1260	0.0196^{NS}	+1.7	0.994*	+0.9

TABLE 2

Summary of oneway ANOVA and Kruskal-Wallis tests for differences between mean and median concentrations respectively of eel muscle organochlorine concentrations in 41 Welsh Sites. Means are back-transformed from log values. Conventions for probability are as in Table 1.

SUBSTANCE	ANOVA		Kruskal-Wallis	
	mean	F value	median	H
alpha-HCH	1.02	1.28^{NS}	<2	85.2***
beta -HCH	1.01	0.84^{NS}	<2	83.8***
gamma-HCH	1.31	4.83***	<2	79.2***
dieldrin	16.77	5.02***	19.2	114.6***
endrin	1.18	1.62*	<2	54.7*
pp'-DDT	6.00	13.29***	7.85	141.6***
op'-DDT	1.57	5.97***	<2	107.4***
pp'-DDE	22.79	4.42***	22.8	114.1***
op'-DDE	1.29	2.97***	<2	80.39***
pp'-TDE	5.96	7.39***	8.16	121.1***
op'-TDE	1.48	8.26***	<2	113.3***
SUM DDT	73.24	6.90***	46.94	126.5***
PCB28	1.59	3.18***	<2	73.0**
PCB52	2.59	13.76***	<2	124.1***
PCB101	3.27	8.66***	3.4	117.0***
PCB118	5.49	9.99***	6.0	124.5***
PCB138	7.59	8.90***	8.4	122.0***
PCB153	7.58	9.80***	7.7	130.0***
PCB180	2.72	7.66***	2.7	121.2***
SUM PCB	28.03	10.24***	31.82	127.7***
Arochlor 1260	93.92	9.43***	115.20	127.2***

TABLE 3 Summary of site characteristics and mean organochlorin concentrations in eels. An increasing number of asterisks indicates increasing concentration class: <2 - <10, 10 - <50, 50 - <100, 100 - <500, 500 - <1,000, ≥ 1,000 ug kg^{-1}

	SITE	GRID REF	COMMENTS	α-HCH	β-HCH	γ-HCH	ALDRIN	DIELDRIN	ENDRIN	PP'-DDT	OP'-DDT	PP'-DDE	OP'-DDE	PP'-TDE	OP'-TDE	ΣDDT	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	ΣPCB	AROCHLOR	SIMILARITY GROUP
1	WYE	SO170389	MID CATCHMENT, RURAL	*	*	*	*	**	*	*	*	**	*	**	*	***	*	*	*	*	**	*	*	**	***	B
2	LUGG, AYMESTREY	SO426655	UPPER CATCHMENT, RURAL	*	*	*	*	**	*	**	*	**	*	*	*	***	*	*	*	*	*	*	*	*	**	B
3	LUGG, LUGWARDINE	SO546407	INTENSIVE AGRICULTURAL CATCHMENT	*	*	*	*	**	*	*	*	**	*	*	*	***	*	*	*	*	*	**	*	**	****	B
4	FROME	SO600421	INTENSIVE AGRICULTURAL CATCHMENT	*	*	*	*	***	*	**	*	***	*	**	*	****	*	*	*	*	*	*	*	**	***	B
5	USK	SO193199	MID CATCHMENT, RURAL	*	*	*	*	**	*	*	*	**	*	**	*	***	*	*	*	*	*	*	*	**	***	B
6	SENNI U/S DEFYNNOG BRIDGE	SN930268	UPLAND CATCHMENT RURAL	*	*	*	*	***	*	***	*	***	*	**	*	****	*	*	*	*	*	*	*	**	**	B
7	SENNI @ DEFYNNOG BRIDGE	SN925277	d/s STW	*	*	*	*	**	*	**	*	**	*	**	*	***	*	*	*	*	*	*	*	*	*	B
8	LWYD @ CROESYCEILIOG	SO300958	INDUSTRIAL CATCHMENT	*	*	*	*	**	*	**	*	***	*	*	**	****	*	**	**	**	**	**	*	****	****	A
9	LWYD @ PONTHIR	SO331924	INDUSTRIAL CATCHMENT	*	*	*	*	**	*	*	*	**	*	*	**	***	*	*	*	**	**	**	*	***	****	A
10	SIRHOWY	ST183916	INDUSTRIAL CATCHMENT	*	*	*	*	**	*	***	*	***	*	**	*	****	**	**	**	***	***	**	**	****	*****	A
11	TAFF,RHYDYCAR	SO045064	UPPER CATCHMENT, SEMI RURAL	*	*	*	*	**	*	**	*	**	*	*	*	**	*	*	*	**	**	**	*	***	****	B
12	TAFF,YNYS ANGHARAD PARK	ST073899	MID CATCHMENT INDUSTRIAL	*	*	*	*	**	*	****	**	****	*	**	*	****	*	**	**	*	**	**	*	***	****	A
13	TAFF, BLACKWEIR	ST171780	HARMONISED MONITORING POINT	*	*	**	*	**	*	***	*	***	*	**	*	****	*	**	**	***	***	***	**	****	*****	A
14	THAW	SS991739	LOWLAND CATCHMENT RURAL	*	*	*	*	**	*	*	*	*	*	*	*	**	*	*	*	*	*	*	*	*	*	C
15	NANT TRE-GOF	ST039724	LOWLAND CATCHMENT RURAL	*	*	*	*	*	*	*	*	**	*	*	*	**	*	*	*	*	*	*	*	**	**	C
16	LLYNFI	SS897844	INDUSTRIAL CATCHMENT	*	*	*	*	***	*	***	*	***	*	**	*	****	*	**	*	**	**	*	*	***	****	A
17	EWENNY	SS913778	INDUSTRIAL CATCHMENT	*	*	*	*	**	*	**	*	**	*	*	*	***	*	*	*	**	**	**	*	**	****	B
18	NEATH d/s MELINCOURT	SN817021	MID CATCHMENT, INDUSTRIAL	*	*	*	*	**	*	**	*	**	*	*	*	***	*	*	*	*	*	*	*	**	***	B
19	NEATH, TONNA	SN771989	HARMONISED MONITORING POINT	*	*	*	*	**	*	**	*	**	*	*	*	***	*	*	*	*	**	*	*	**	****	B
20	TAWE, GWYN ARMS	SN853205	UPPER CATCHMENT RURAL	*	*	*	*	**	*	**	*	**	*	*	*	***	*	*	*	*	*	*	*	**	***	B
21	TAWE, d/s MORRISTON	SN674999	HARMONISED MONITORING POINT	*	*	*	*	*	*	*	*	*	*	*	*	**	*	*	*	*	*	*	*	**	***	B
22	TAWE, FENDROD	SN672966	INDUSTRIAL CATCHMENT	*	*	*	*	**	*	**	*	**	*	*	*	**	*	*	*	*	*	*	*	**	****	B

	SITE	GRID REF	COMMENTS	α-HCH	β-HCH	γ-HCH	ALDRIN	DIELDRIN	ENDRIN	PP'-DDT	OP'-DDT	PP'-DDE	OP'-DDE	PP'-TDE	OP'-TDE	ΣDDT	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	ΣPCB	AROCHLOR	SIMILARITY GROUP
23	GWENDRAETH FACH	SN461140	LOWLAND CATCHMENT RURAL	•	•	•	•	••	•	•	•	••	•	•	•	••	•	•	•	•	•	•	•	•	•	C
24	TYWI, NANTGAREDIG	SN491204	HARMONISED MONITORING POINT	•	•	•	•	•	•	•	•	••	•	•	•	••	•	•	•	•	•	•	•	••	•••	B
25	TYWI, DULAIS	SN697390	MID CATCHMENT, RURAL	•	•	•	•	••	•	••	•	••	•	•	•	••	•	•	•	•	•	•	•	•	••	B
26	MILTON STREAM	SN043029	d/s CAREW AIRFIELD	•	•	•	•	••	•	•	•	••	•	•	•	••	•	•	•	•	•	•	•	••	•••	B
27	NANT Y CI	SN072155	d/s ELECTRICITY SUB STATION	•	•	•	•	•	•	•	•	••	•	•	•	••	•	•	•	•	•	•	•	••	•••	B
28	E. CLEDDAU	SN072153	HARMONISED MONITORING POINT	•	•	•	•	•	•	•	•	••	•	•	•	••	•	•	•	••	••	•	•	••	••••	B
29	TEIFI d/s TREGARON	SN674585	UPPER CATCHMENT, RURAL	•	•	•	•	•	•	•	•	••	•	•	•	••	•	•	•	•	•	•	•	••	••	B
30	TEIFI, LLECHRYD	SN218436	HARMONISED MONITORING POINT	•	•	•	•	•	•	•	•	••	•	•	•	••	•	•	•	•	•	•	•	••	•••	B
31	SEIONT	SH544638	d/s DINORWIC POWER STATION	•	•	•	•	••	•	••	•	••	•	•	•	•••	•	•	•	••	••	••	•	•••	••••	B
32	CEFNI	SH461731	d/s STW	•	•	•	•	•••	•	•	•	••	•	•	•	••	•	•	•	•	•	•	•	••	••	B
33	LLYN CORON	SH375702	CONSERVATION INTEREST	•	•	•	•	•	•	•	•	•	•	•	•	••	•	•	•	•	•	•	•	••	•••	D
34	LLYN PENRHYN	SH310769	d/s RAF VALLEY, CONSERVATION INTEREST	•	•	•	•	•	•	•	•	••	•	••	•	••	•	•	•	••	••	•	•	••	••••	B
35	CONWY, OAKLANDS	SH808586	MID CATCHMENT, RURAL	•	•	•	•	••	•	•	•	•	•	•	•	••	•	•	•	•	•	•	•	••	••••	B
36	DEE, CLYWEDOG	SJ396483	d/s INDUSTRIAL ESTATE	•	•	•	•	••	•	•	•	••	•	••	•	•••	•	•••	••••	••••	••••	••••	••	•••••	••••••	A
37	DEE, LLANGOLLEN	SJ157433	UPPER CATCHMENT RURAL	•	•	•	•	••	•	•	•	•	•	•	•	••	•	•	•	•	•	•	•	••	•••	B
38	DEE, ECCLESTON FERRY	SJ405622	LOWER MAIN RIVER	•	•	•	•	••	•	•	•	••	•	••	•	••	•	•	•	••	••	••	•	••••	••••	A
39	DEE, HIRNANT	SH957323	UPPER TRIBUTARY, AFFORESTED	•	•	•	•	••	•	••	•	••	•	•	•	••	•	•	•	•	•	•	•	•	••	C
40	DEE, ALYN	SJ390563	INDUSTRIAL CATCHMENT	•	•	•	•	••	•	••	•	••	•	••	•	•••	•	•	•	•	•	••	•	•••	••••	B
41	DEE, PULFORD BROOK	SJ400576	LOWER CATCHMENT, RURAL	•	•	•	•	••	•	•	•	•	•	•	•	••	•	•	•	••	•	•	•	••	••••	B

Table 4. Correlation matrix of log. organochlorine concentrations in eels.

	HCH ALPHA	HCH BETA	HCH GAMMA	DIELDRIN	DDT (OP')	DDE (PP')	DDT (PP')	TDE (PP')
HCH BETA	-0.007							
HCH GAMMA	0.303**	0.177*						
DIELDRIN	0.045	0.031	0.191*					
DDT (OP')	-0.053	-0.038	0.348**	0.332**				
DDE (PP')	0.035	0.104	0.264**	0.351**	0.405**			
DDT (PP')	0.008	0.109	0.343**	0.474**	0.506**	0.646**		
TDE (PP')	0.039	0.075	0.313**	0.421**	0.341**	0.588 -	0.516**	
ENDRIN	0.143	-0.021	0.199**	0.174*	0.181*	0.059	0.011	0.148*
TDE (OP')	-0.049	-0.035	-0.158*	0.079	0.213**	0.128	0.198**	-0.062
PCB 28	0.112	-0.043	0.130	0.116	0.246**	0.168*	0.232**	0.086
PCB 52	0.124	0.098	0.386**	0.419**	0.374**	0.285**	0.278**	0.389**
PCB 101	0.079	0.059	0.274**	0.339**	0.368**	0.228*	0.178*	0.378**
PCB 118	0.071	0.108	0.179*	0.256**	0.293**	0.184*	0.178*	0.300**
PCB 138	0.065	0.090	0.198**	0.359**	0.323**	0.269**	0.261**	0.423**
PCB 153	0.073	0.089	0.204**	0.397**	0.354**	0.317**	0.309**	0.375**
PCB 180	0.009	0.101	0.199**	0.317**	0.379**	0.301**	0.412**	0.262**
DDE (OP')	-0.038	-0.027	-0.124	0.079	0.039	0.037	-0.003	-0.129

Degree of Freedom = 177
* = P<0.05
** = P<0.01

ENDRIN	TDE (OP')	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180
-0.126								
0.205**	0.165*							
0.389**	0.056	0.569**						
0.335**	0.087	0.474**	0.792**					
0.356**	0.172*	0.454**	0.701**	0.707**				
0.223**	0.178*	0.411**	0.639**	0.656**	0.758**			
0.342**	0.166*	0.440**	0.733**	0.657**	0.821**	0.818**		
0.270**	0.214**	0.394**	0.581**	0.499**	0.661**	0.683**	0.734**	
-0.033	0.477**	0.238**	0.168*	0.152*	0.059	0.081	0.079	0.061

Table 5. **Comparison between NRA and IERC Laboratory results for organochlorine concentrations in 5 eels at each of two sites. Paired t-tests were performed for each determinand at each site.**

	LUGG AT LUGWARDINE			FROME AT YARKHILL		
DETERMINAND	NRA mean	LIVERPOOL mean	P	NRA mean	LIVERPOOL mean	P
% lipids	4.07	2.63	NS	12.30	9.33	NS
beta-HCH	0.00	1.15	NS	0.00	1.55	NS
gamma-HCH	0.00	1.45	NS	0.00	4.47	**
dieldrin	28.84	15.49	NS	54.95	47.86	NS
op-DDT	1.23	0.00	NS	1.55	0.00	NS
pp-DDE	41.69	20.89	*	61.66	53.70	NS
pp-DDT	4.37	3.89	NS	27.54	18.62	NS
endrin	1.86	0.00	NS		NOT DETECTED	
PCB52	1.62	0.00	NS	1.32	0.00	NS
PCB101	1.38	0.00	NS	2.09	0.00	NS
PCB118	6.31	1.66	NS	3.72	1.45	NS
PCB138	2.63	3.72	NS	6.76	4.89	NS
PCB153	11.48	4.07	NS	6.17	5.37	NS
PCB180	1.26	1.74	NS	2.19	1.55	NS
AROCHLOR 1260	102.33	37.15	NS	75.86	50.12	NS

Table 6. **Concentrations of PCBs (a) and organochlorine pesticides (b) in eel tissues reported in UK studies. Units are ug kg^{-1} wet weight. Comparability is appropriate due to methodology not detailed here.**

(a)

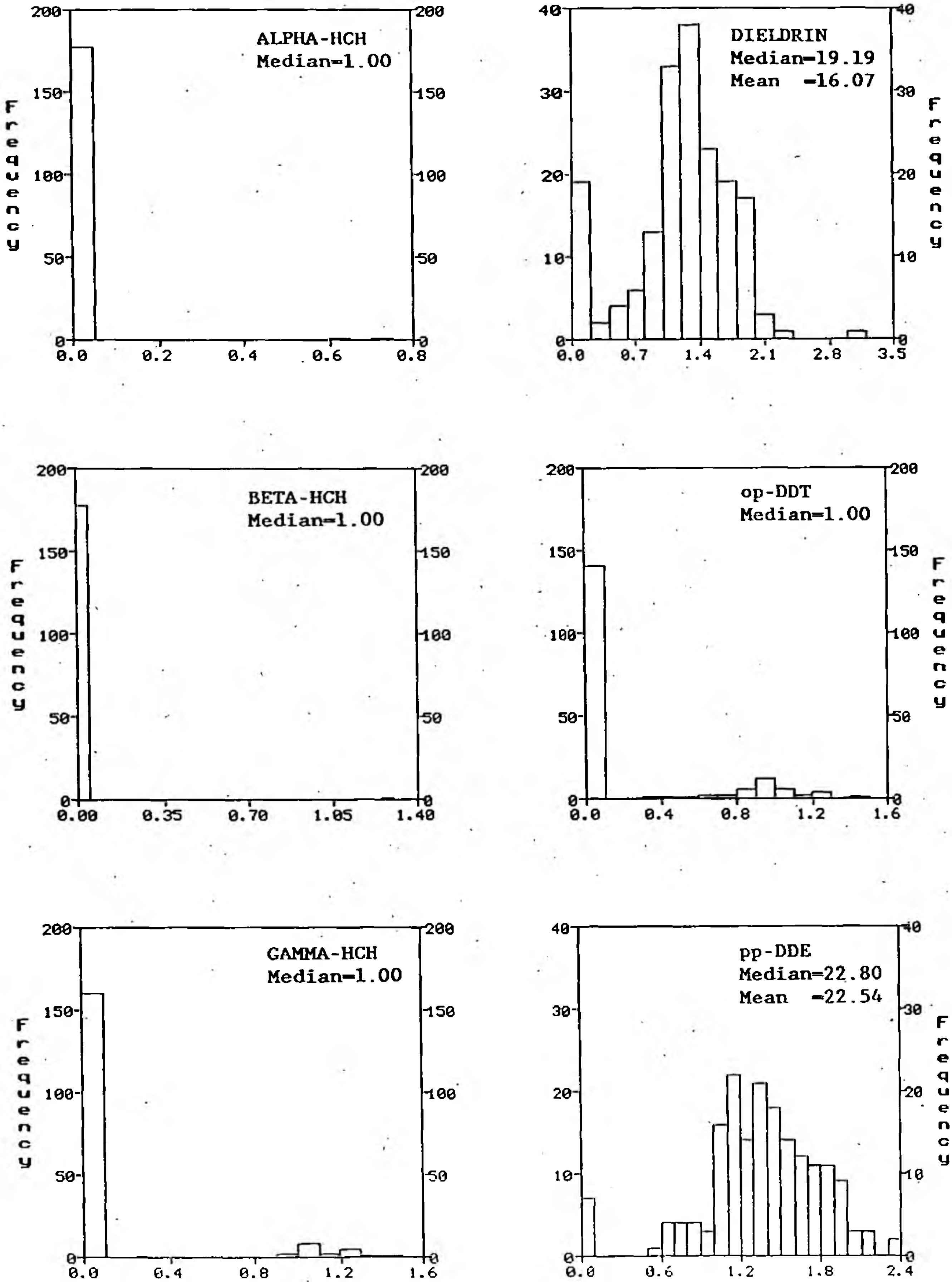
Location	N	Total PCBs ug kg^{-1} mean	min	max	Analysis	Source
1. Wales, 41 sites	179	28	<2	910	ICES 7	Present study
Wales, 41 sites	179	94	2	3294	Arochlor 1260	Present study
2. Wales, R. Lugg	14	42	24	57	Arochlor 1260	Mason, unpublished data
3. Wales, R. Arrow	3	32	14	59	Arochlor 1260	Mason, unpublished data
4. Wales, R. Morlais	10	47				MAFF, 1987
5. Wales, R. Cefni	10	290				MAFF, 1987
6. Wales, Anglesey		120			Arochlor 1260	Mason, 1993
7. Wales, Oxwich Bay		10			Arochlor 1260	Mason, 1993
8. England, 9 sites		141	<10	910	Arochlor 1260	Mason, 1993
9. NW England, R. Eden	19	<31			ICES 7	IERC, 1993
NW England, R. Eden	19	113			Arochlor 1260	IERC, 1993
10. NE England, 3 catchments	21	<7	<4	<43	ICES 7	IERC, 1993
NE England, 3 catchments	21	27	15	157	Arochlor 1260	IERC, 1993
11. England/Wales	321	358	1	9300		MAFF
12. Scotland/Islands/NE England	88	240	0	<1000	16 congeners	Kruuk et al., 1993

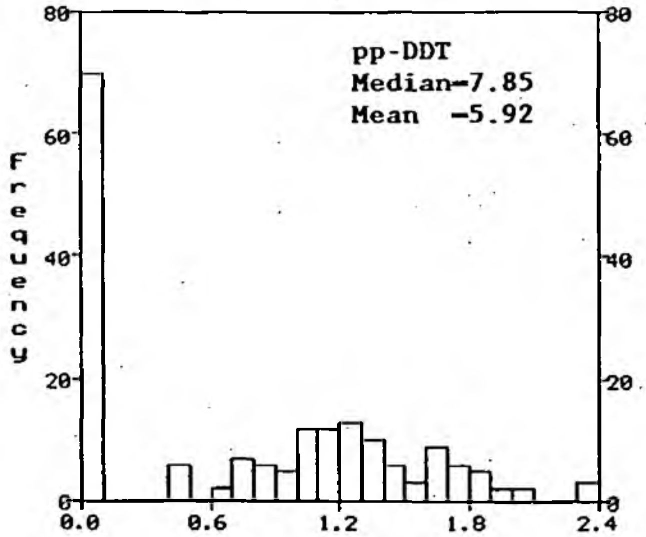
*estimated graphically

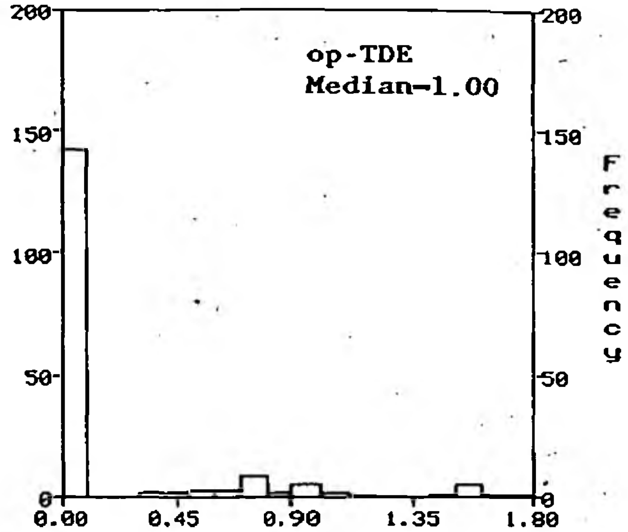
(b)

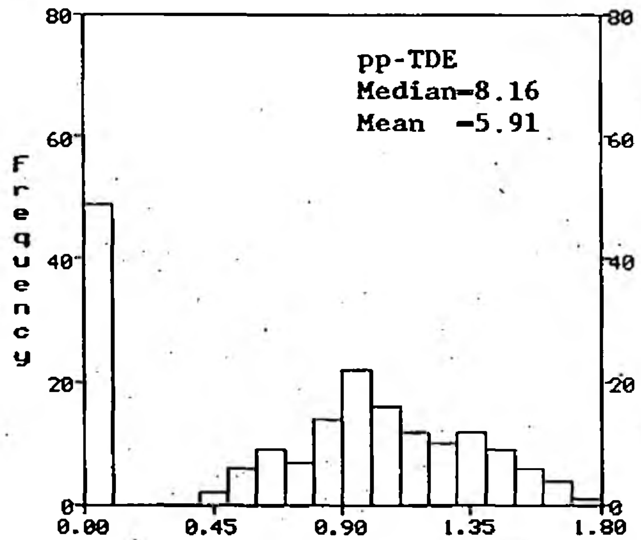
Location	N	DIELDRIN mean	min	max	gamma-HCH mean	min	max	pp'-DDT mean	min	max	pp'-DDE mean	min	max	pp'-TDE mean	min	max	Source
1. Wales, 41 sites	179	17	<2	84	1	<2	12	6	<2	119	23	4	135	6	<2	42	Present study
2. Wales, R. Frome	4	320			7			6			1170			16			Welsh Water unpublished data 1986/87
3. Wales, R. Frome	23	10			5			<1			50			14			" " " " " "
4. Wales, R. Llynfi	5	13			<1			16			3			5			" " " " " "
5. Wales, R. Sirhowy	6	43			<1			112			<1			13			" " " " " "
6. Wales, R. Morlais	10	20			5			3			13			13			MAFF, 1987
7. Wales, R. Cefni	10	270			4			99			40			35			" "
8. Wales, Anglesey		c.10									10						Mason, 1993
9. Wales, Oxwich Bay		210									270						Mason, 1993
10. England, 9 reedbeds[1]		20	c.10	30							60	c.10	130				Mason, 1993
11. NW England, R. Eden	19	22			11			<14			38			35			IERC, 1993
12. NE England, 3 catchments[1]	21	17	9	41	<2	<2	<4	<6	<6	<116	24	19	202	6	5	104	IERC, 1993
13. SW England, 2 catchments[1]	51	667	8	1679	46	<1	171				80	29	298				IERC, 1993
14. England/Wales	1124	220	9	1200	75	ND	1500	300	ND	3000	166	6	1000	40	ND	300	MAFF, 1989
15. Scotland/Islands/NE England[2]	88										40	0	410				Kruuk et al., 1993

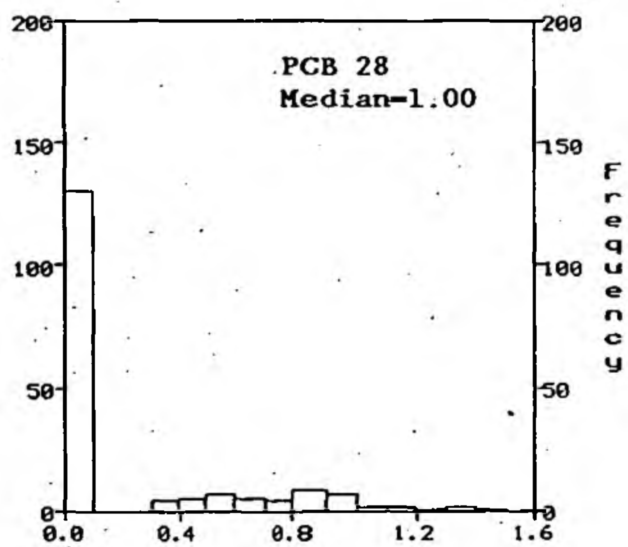
Fig. 1. Frequency distributions of organochlorine concentrations (ug kg^{-1} wet weight muscle tissue) in 179 eels from 41 Welsh freshwater sites. The concentration axes are logarithmic, the median and geometric mean values are arithmetic.

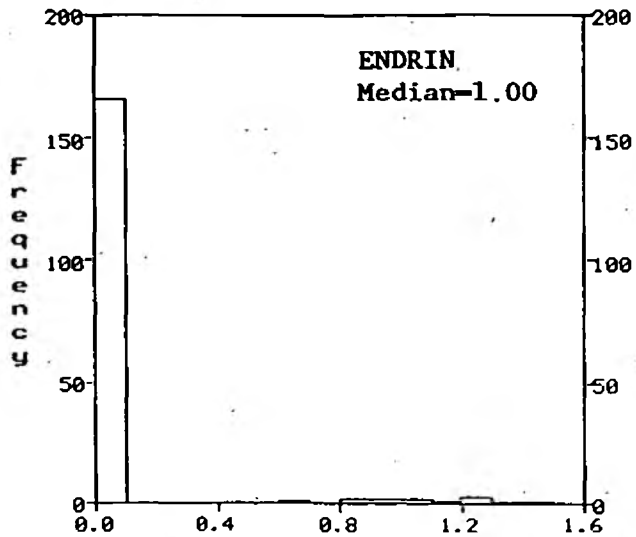


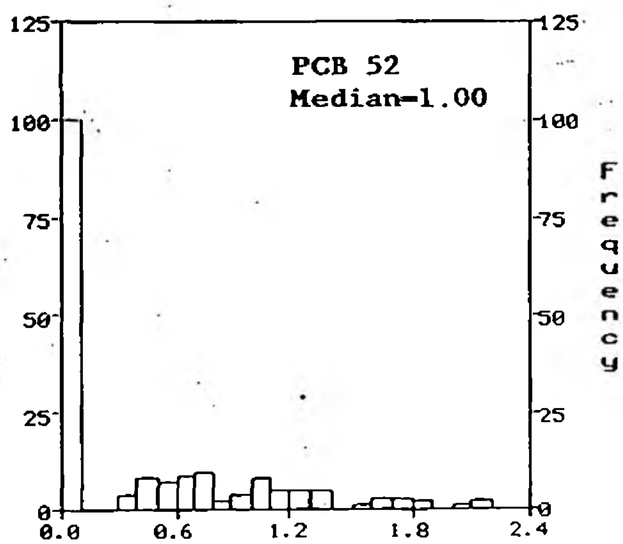

pp-DDT
Median=7.85
Mean =5.92
Frequency
0.0
0.6
1.2
1.8
2.4
80
60
40
20
0

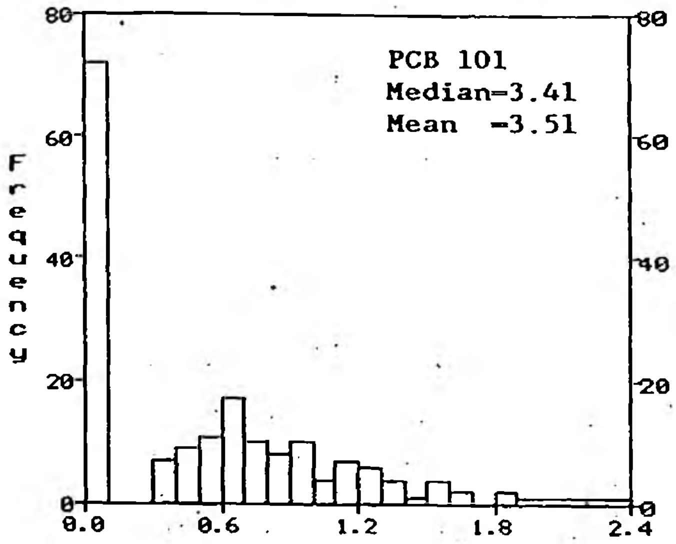

op-TDE
Median=1.00
Frequency
0.00
0.45
0.90
1.35
1.80
200
150
100
50
0

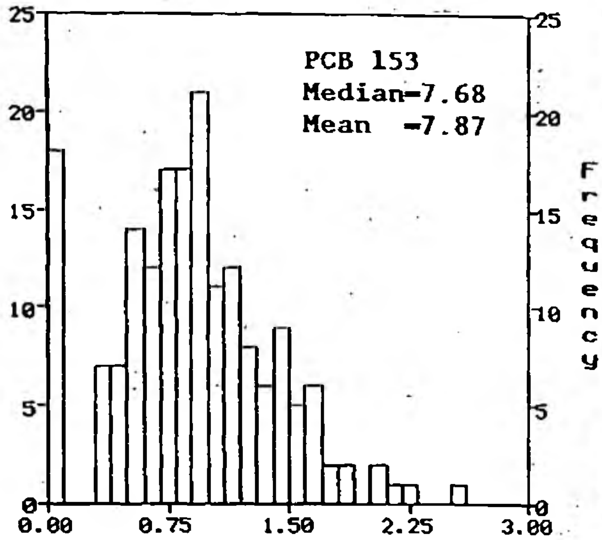

pp-TDE
Median=8.16
Mean =5.91
Frequency
0.00
0.45
0.90
1.35
1.80
80
60
40
20
0

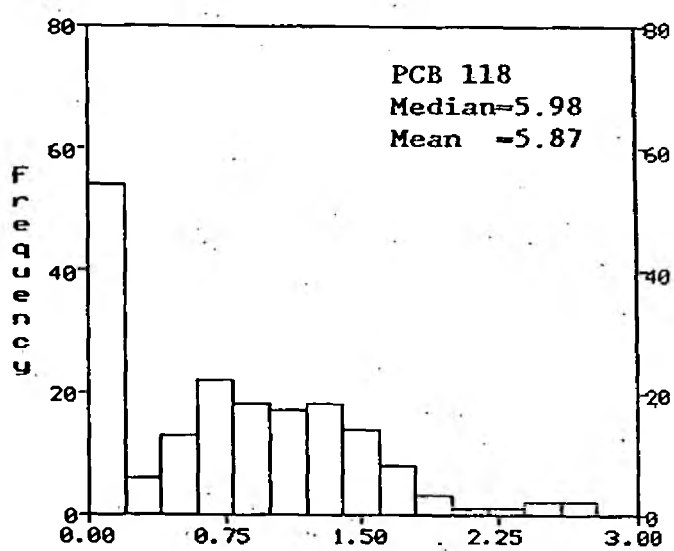

PCB 28
Median=1.00
Frequency
0.0
0.4
0.8
1.2
1.6
200
150
100
50
0

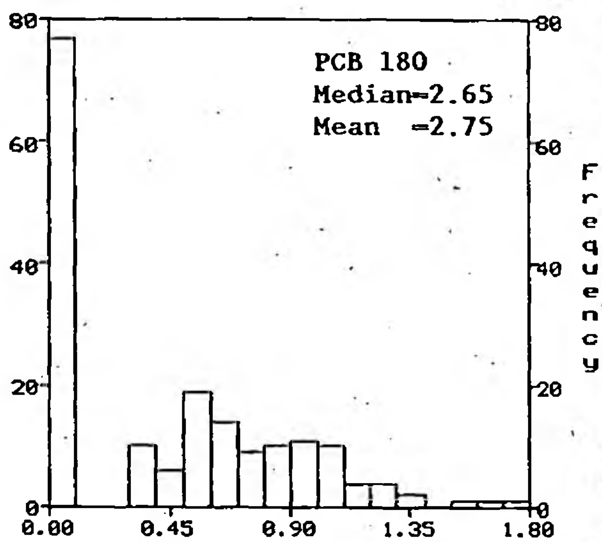

ENDRIN
Median=1.00
Frequency
0.0
0.4
0.8
1.2
1.6
200
150
100
50
0

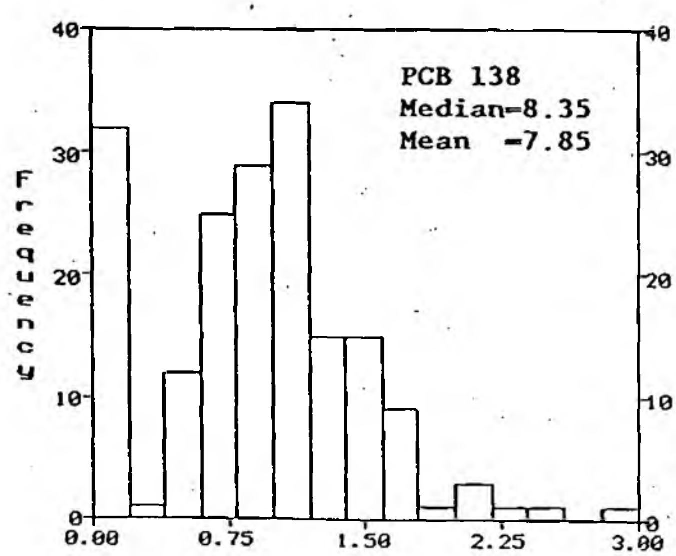

PCB 52
Median=1.00
Frequency
0.0
0.6
1.2
1.8
2.4
125
100
75
50
25
0

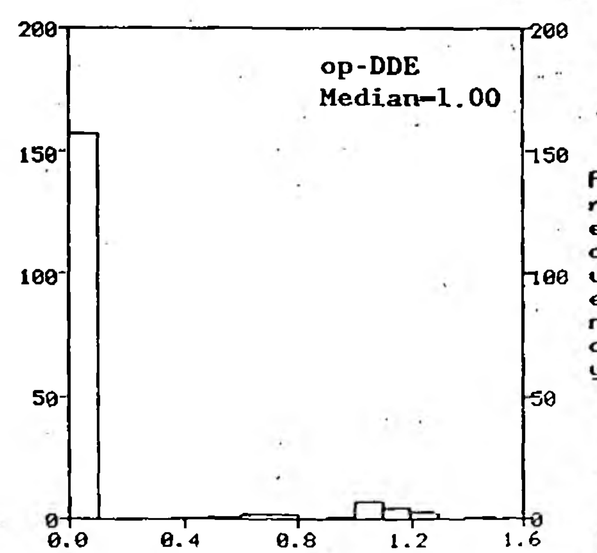

PCB 101
Median=3.41
Mean =3.51
Frequency
0.0
0.6
1.2
1.8
2.4

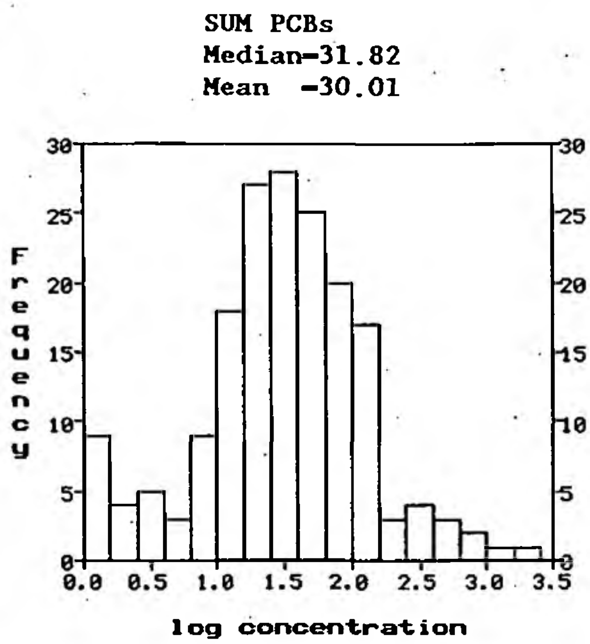

PCB 153
Median=7.68
Mean =7.87
Frequency
0.00
0.75
1.50
2.25
3.00


PCB 118
Median=5.98
Mean =5.87
Frequency
0.00
0.75
1.50
2.25
3.00


PCB 180
Median=2.65
Mean =2.75
Frequency
0.00
0.45
0.90
1.35
1.80


PCB 138
Median=8.35
Mean =7.85
Frequency
0.00
0.75
1.50
2.25
3.00


op-DDE
Median=1.00
Frequency
0.0
0.4
0.8
1.2
1.6


SUM PCBs
Median-31.82
Mean -30.01
Frequency
log concentration

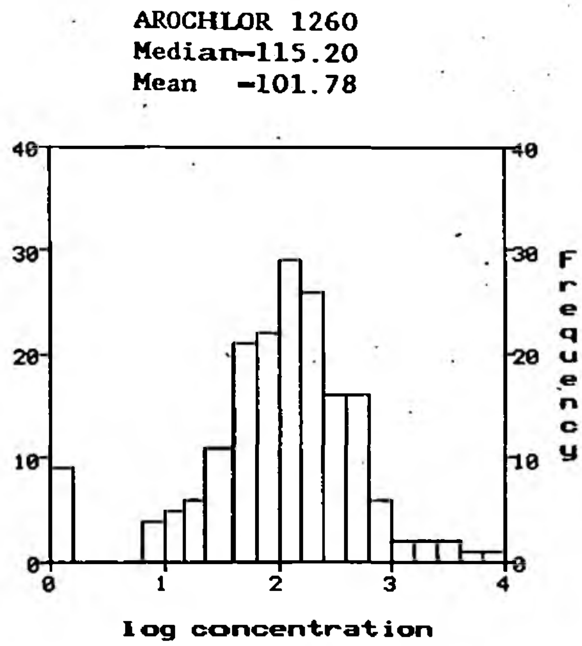

AROCHLOR 1260
Median-115.20
Mean -101.78
Frequency
log concentration

Fig. 2. Plot of sites on first and second principal component axes, based on mean concentrations of organochlorines in eels. The groups shown were derived by cluster analysis, site details are given in Table 3.

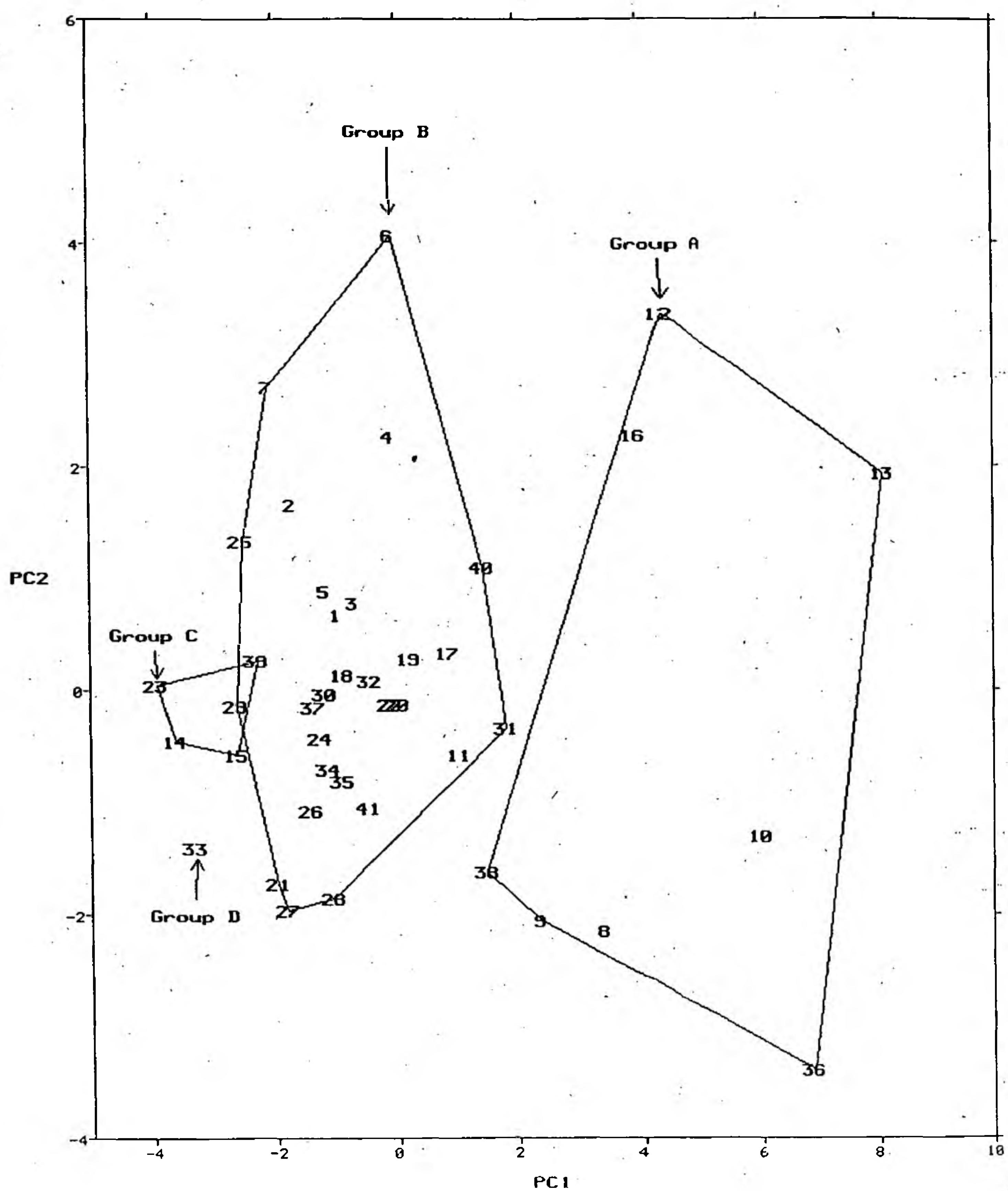


Fig. 3. Dendrogram of sites from cluster analysis based on mean concentrations of organochlorines in eels.

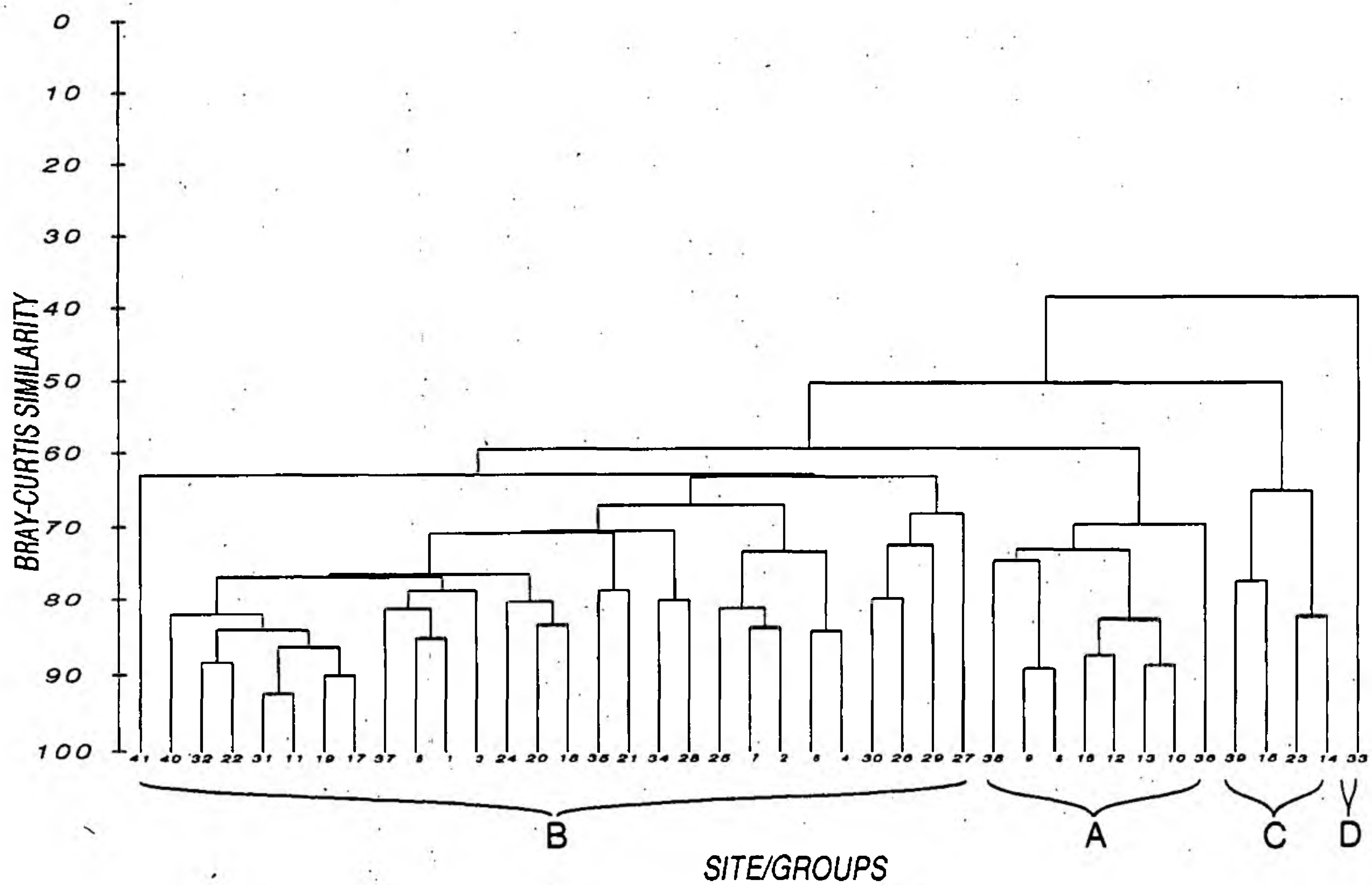


Fig. 4. Mean sums of PCB congener concentrations in eels in Wales. Increasing symbol size denotes concentration classes <2 to <10, 10 to <50, 50 to <100, >100 ug kg^{-1} wet weight.

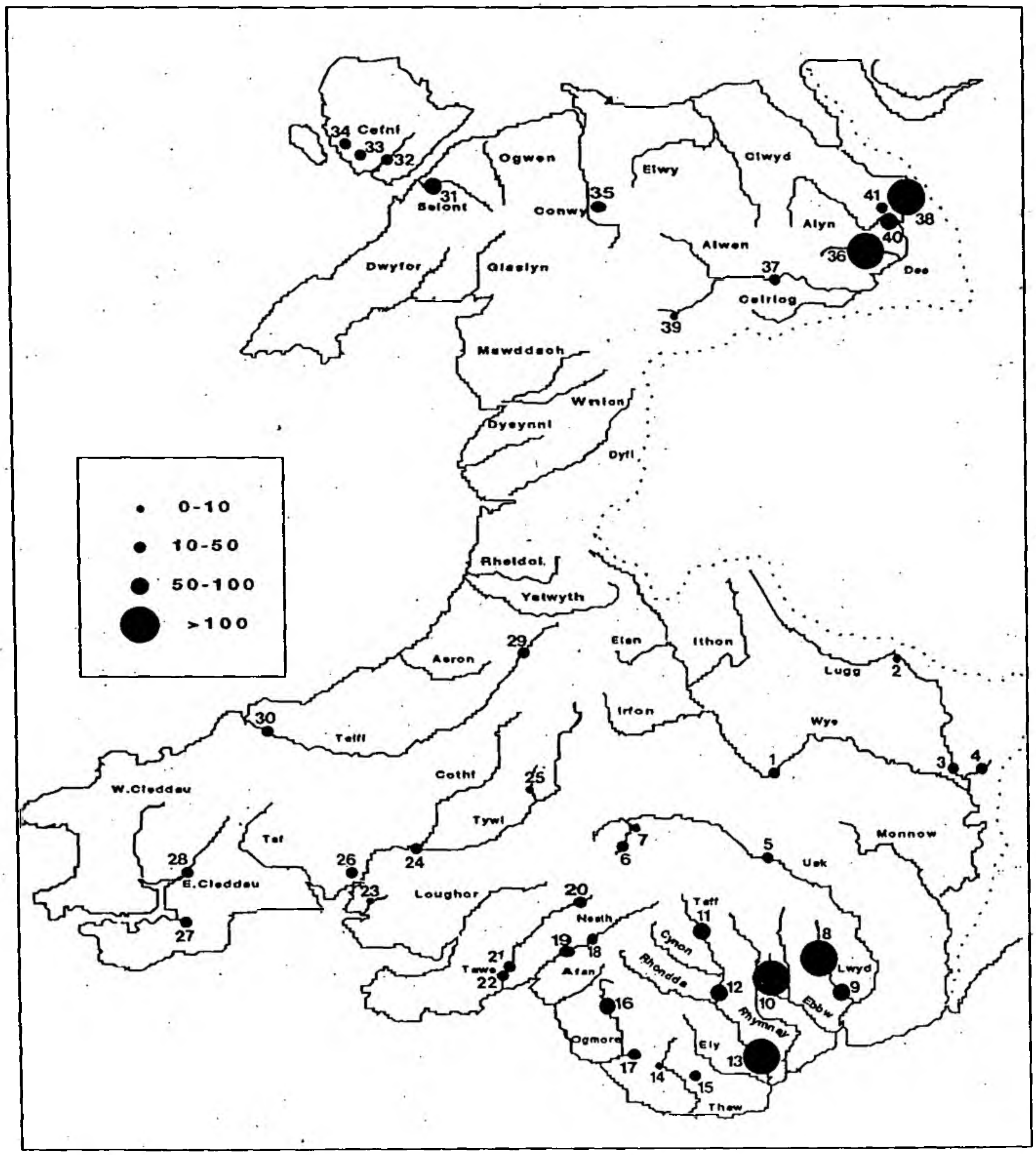


Fig. 5. Mean sums of DDT residue concentrations in eels in Wales. Increasing symbol size denotes concentration classes <2 to <20, 20 to <50, 50 to <100, >100 ug kg^{-1} wet weight.

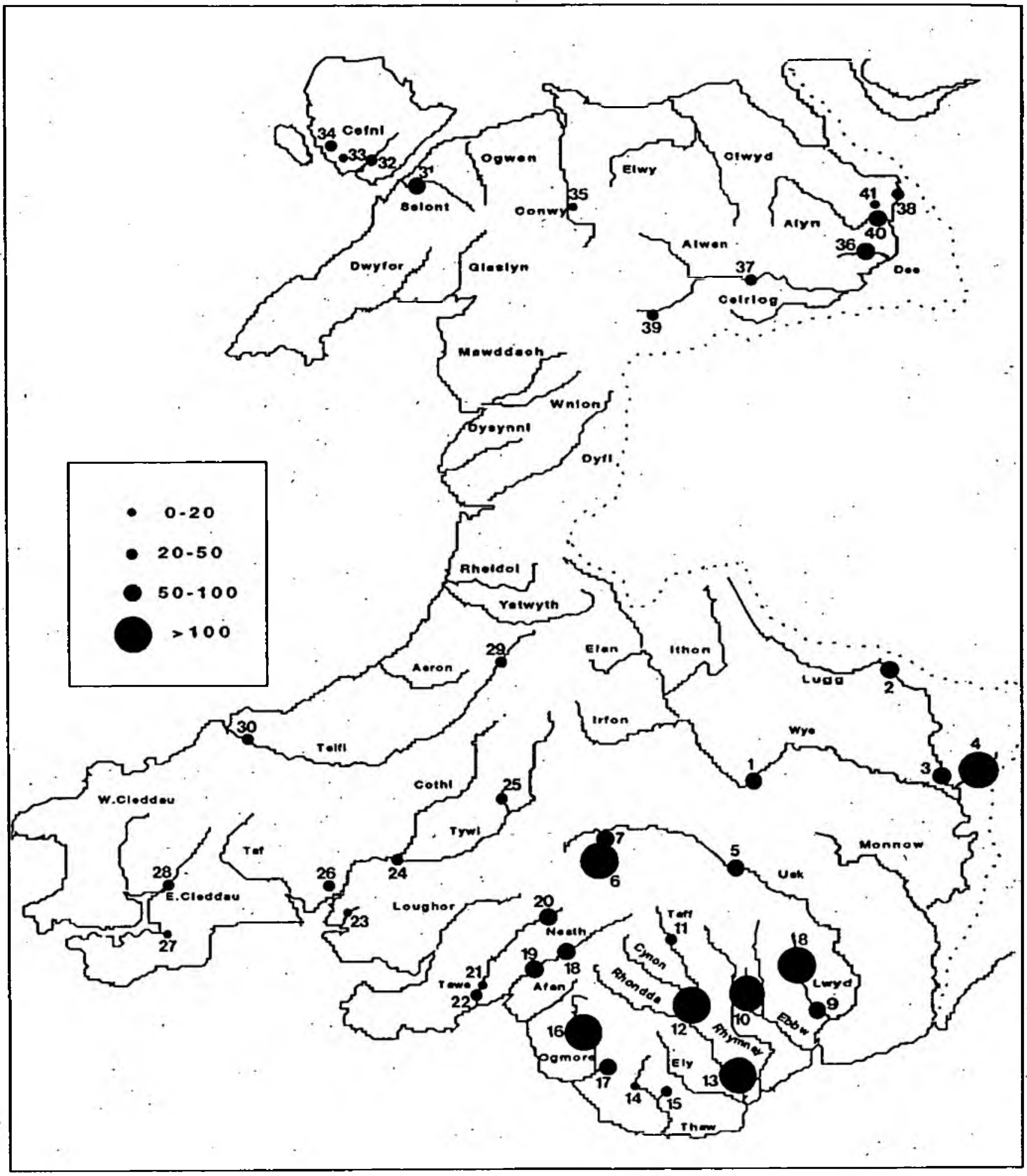
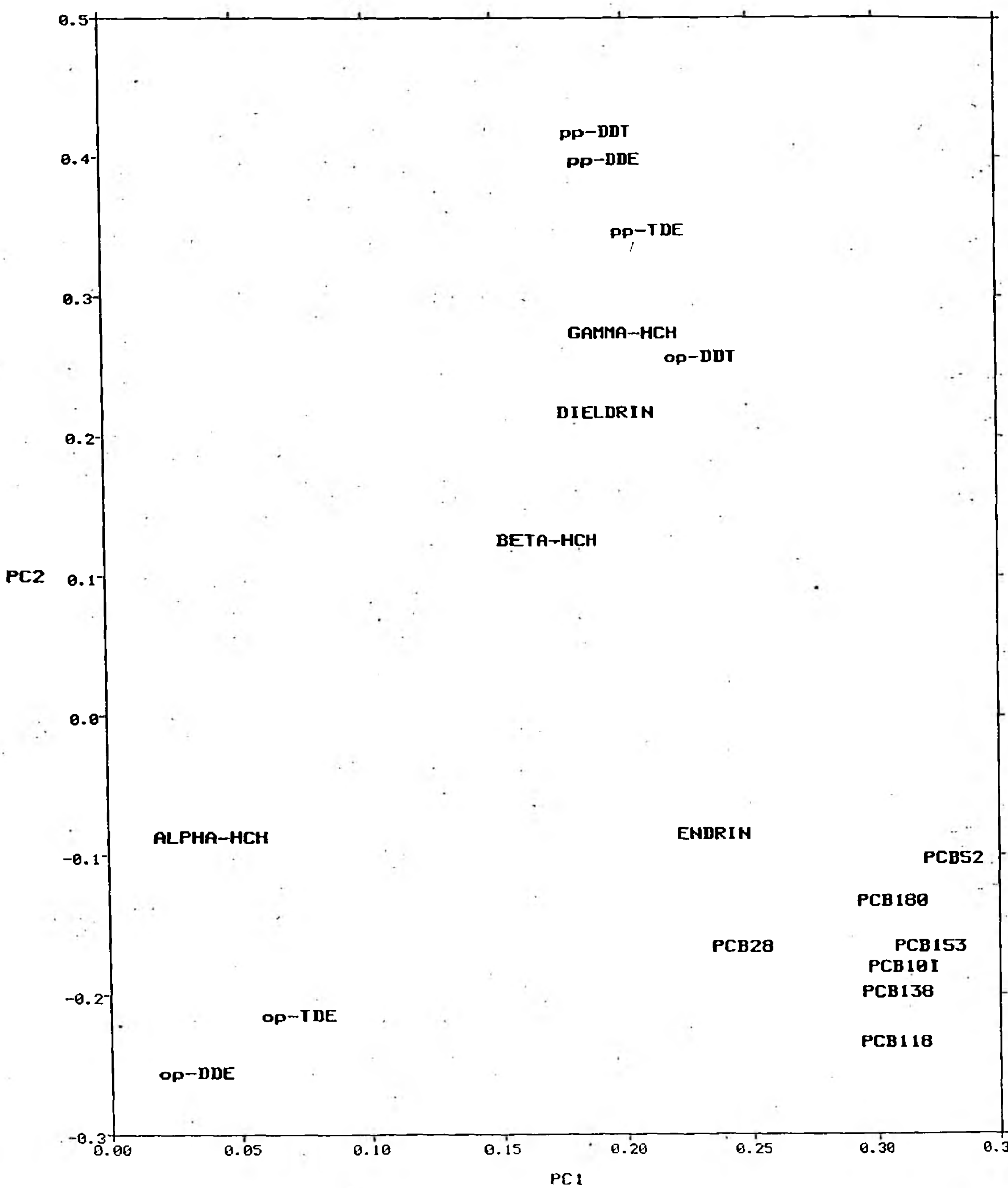


Fig. 6. Plot of organochlorine concentration loadings on first and second principal components, based on their mean concentrations in eels at 41 sites.



APPENDIX 1. Organochlorines included in eel tissue analysis

PCBs

(See IERC, 1994b; Parkinson & Safe, 1987.) Polychlorinated biphenyls (UK Red List substances) are molecules of the formula $C_{12}H10\text{-}nCl_n$ where n = 1 - 10. Of 209 possible congeners, approximately 130 may occur in the environment. They are identified in abbreviation by the IUPAC number (e.g. PCB180) which increases with the degree of chlorine substitution. Total PCB concentrations can be evaluated by summing the results for individual congeners but it is necessary to check which congeners are included in such calculations. Here, 7 congeners were measured, as selected by the International Council for Exploration of the Sea for monitoring purposes and known as the ICES 7.

PCBs have a broad spectrum of toxic physiological effects which vary amongst congeners. Their pathology is similar to the other halogenated aromatic hydrocarbons, polychlorinated dibenzodioxins/dibenzofurans/and napthalenes and can be interpreted by their stereoisomer relationship to 2,3,7,8-tetrachlorodibenzo-p-dioxin. However, the significance of given concentrations in environmental samples is poorly known. The Oslo and Paris Commissions classified total PCB concentrations in fish tissues < 10, 10 - 50 and > 50 ug kg^{-1} as low medium and upper respectively, though many published data exceed these vales with no evidence of effects (see Discussion). The USA tolerance level in food is 2,000 ug kg^{-1}.

Arochlors are technical mixtures identified by a 4 digit number, where the 12 represents biphenyl compounds and the last 2 digits indicate average percentage chlorine (e.g. Arochlor 1260 contains 60 % chlorine). Total PCBs can be represented in terms of Arochlor equivalent concentrations either by measurement against an Arochlor standard or by applying a conversion factor to the sum of PCB congeners analyzed. These methods and the limited proportion of congeners measured lead to problems in the interpretation of different data sets.

The ICES 7 are:

PCB 28	2,4,4'-trichlorobiphenyl
PCB 52	2,2',5,5'-tetrachlorobiphenyl
PCB 101	2,2',4,5,5'-pentachlorobiphenyl
PCB 118	2,3',4,4',5-pentachlorobiphenyl
PCB 138	2,2',3,4,4',5'-hexachlorobiphenyl
PCB 153	2,2',4,4',5,5'-hexachlorobiphenyl
PCB 180	2,2',3,4,4',5,5'-heptachlorobiphenyl

DDT isomers and related substances

DDT (dichlorodiphenyltrichloroethane, List I substance) was banned as a pesticide in 1986. The dominant isomer in technical products is pp'-DDT with op'-DDT comprising < 30%.
DDE and TDE (=DDD) are breakdown products of DDT.
There are no UK standards for sum of DDT products. The USA food tolerance level is 5,000 ug kg^{-1}.

HCH

Gamma-hexachlorocyclohexane (List I) is the dominant isomer in the pesticide lindane which also contains the alpha and beta isomers.
There are no UK standards but other European and USA tolerance limits for gamma-HCH in food are in the range 0.2 - 0.5 ug kg^{-1}.

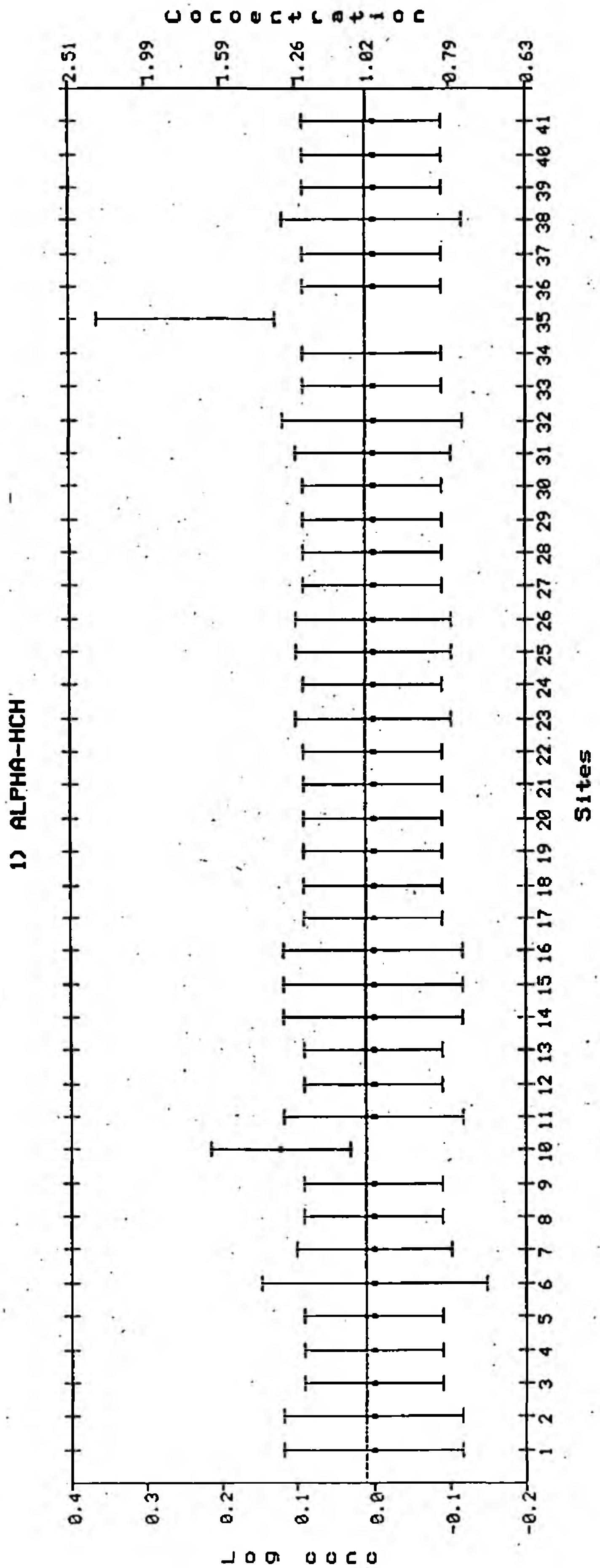
'Drins'

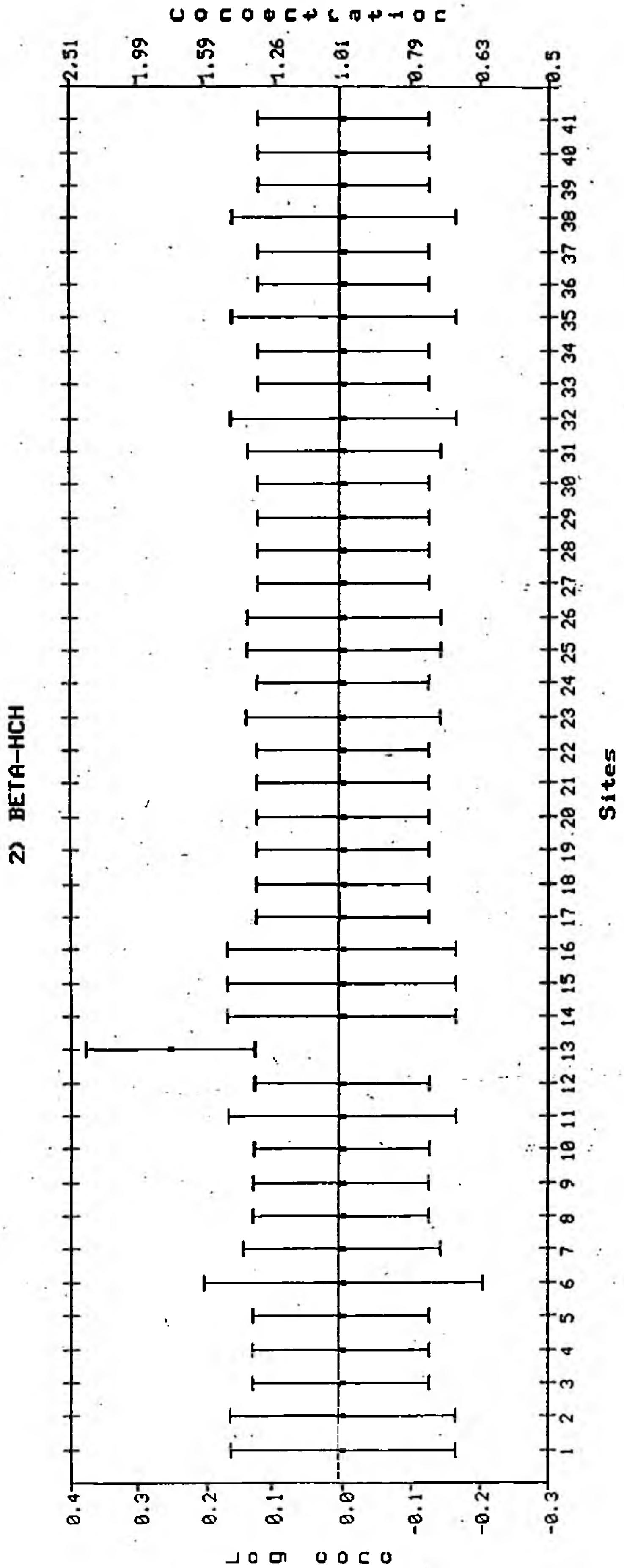
Dieldrin (List I) was used in sheep dip until banned in 1989. MAFF suggested an acceptable daily intake of 7 ug whilst food tolerance limits are 0.2 and 0.3 ug kg^{-1} in the Netherlands and USA respectively.

Aldrin (List I) was also banned as an insecticide in 1989. It rapidly degrades to dieldrin.

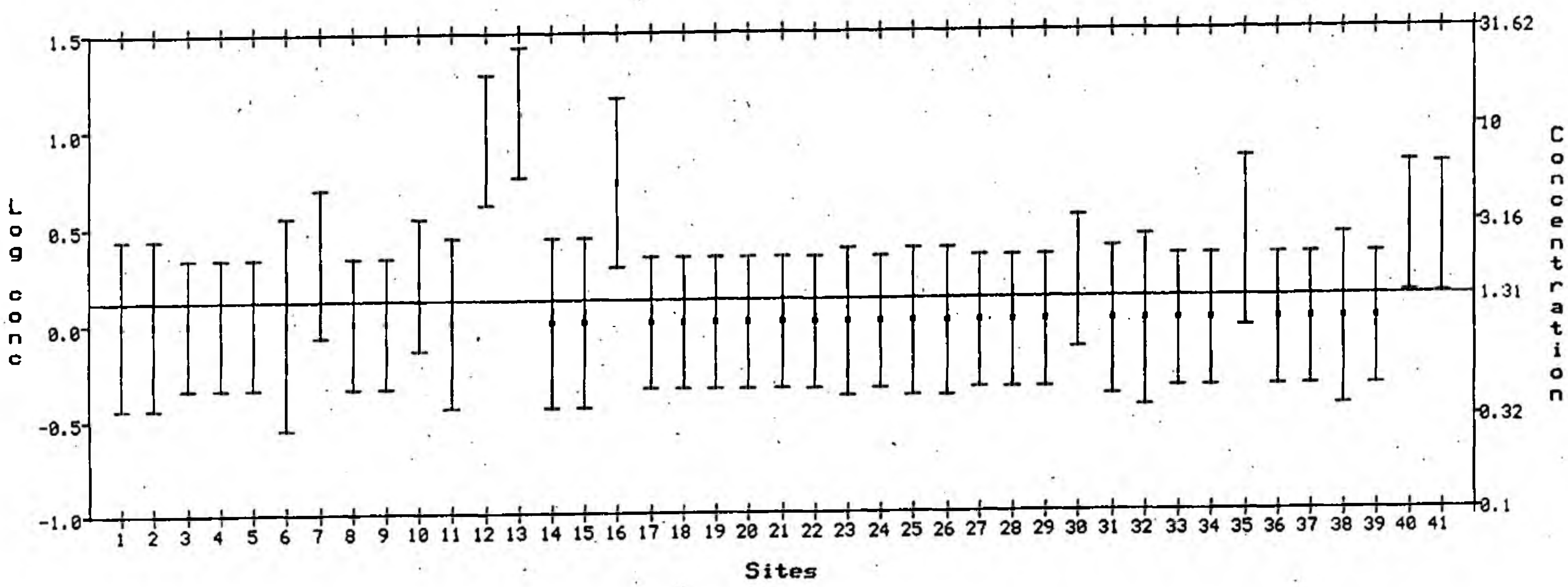
Endrin (List I) is in current use as an insecticide. There are no known safety standards for food.

APPENDIX 2. ANOVA plots of organochlorine concentrations (ug kg^{-1} wet weight) in eels at Welsh sites. Horizontal bar shows the grand mean, site details are given in Table 3.

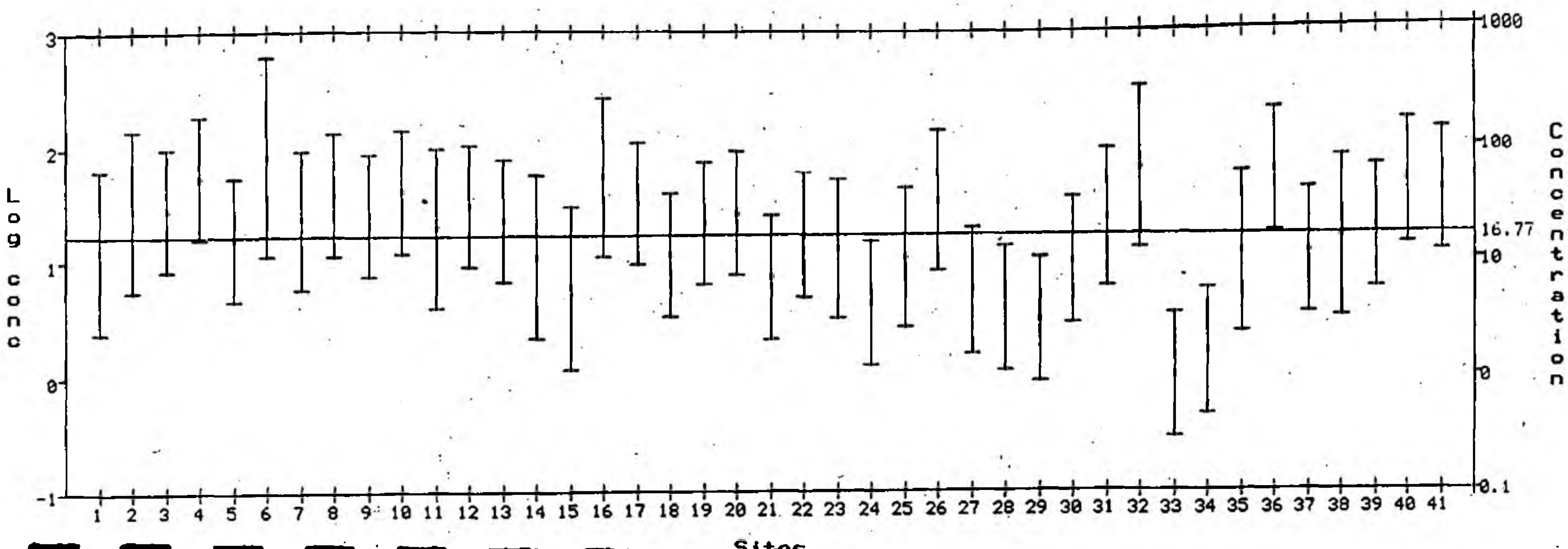




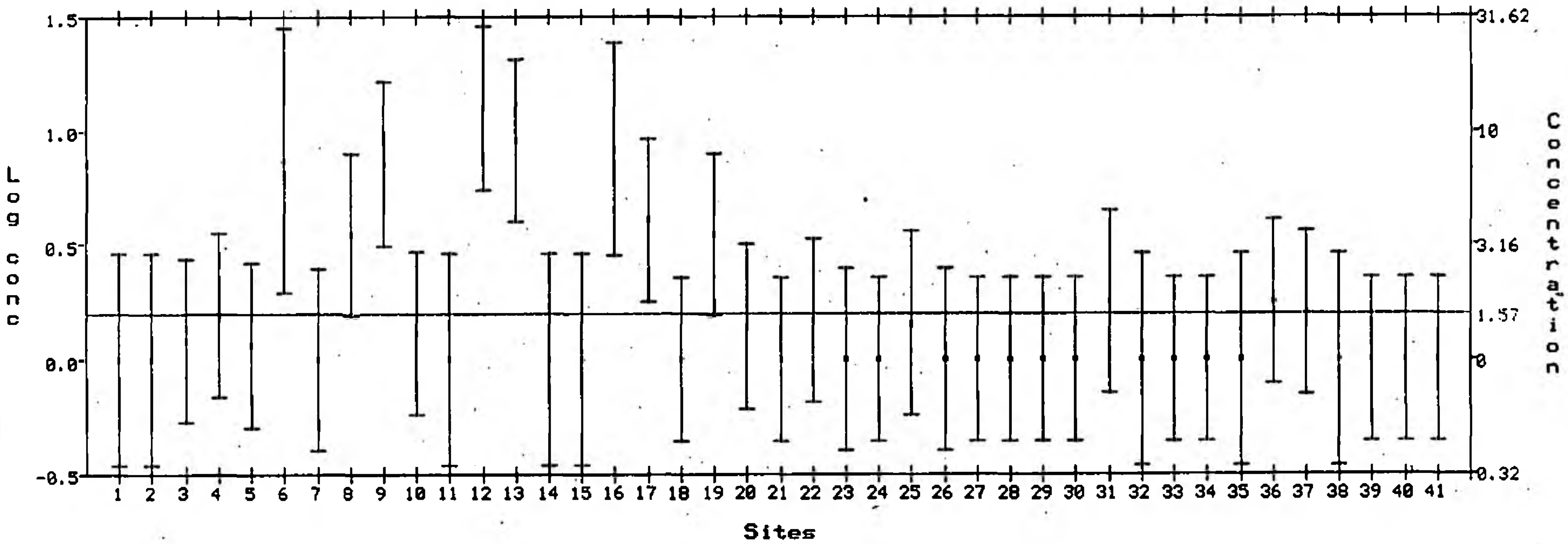
3) GAMMA-HCH



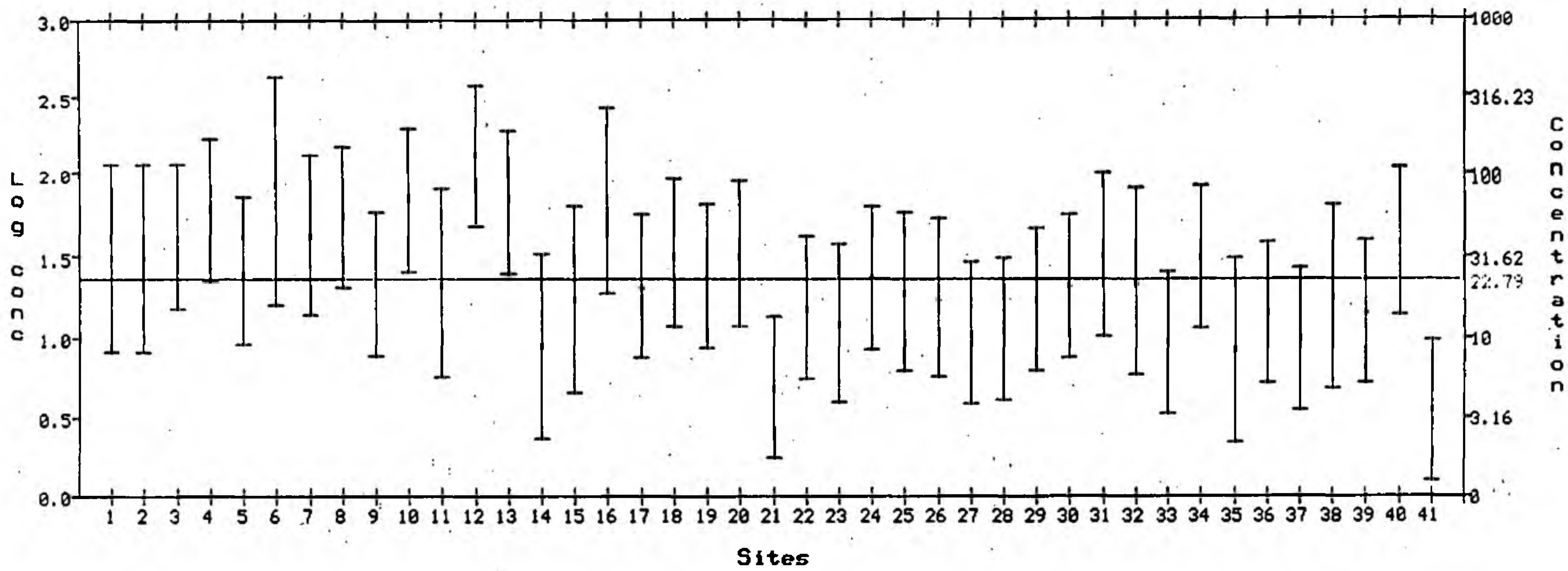
4) DIELDRIN



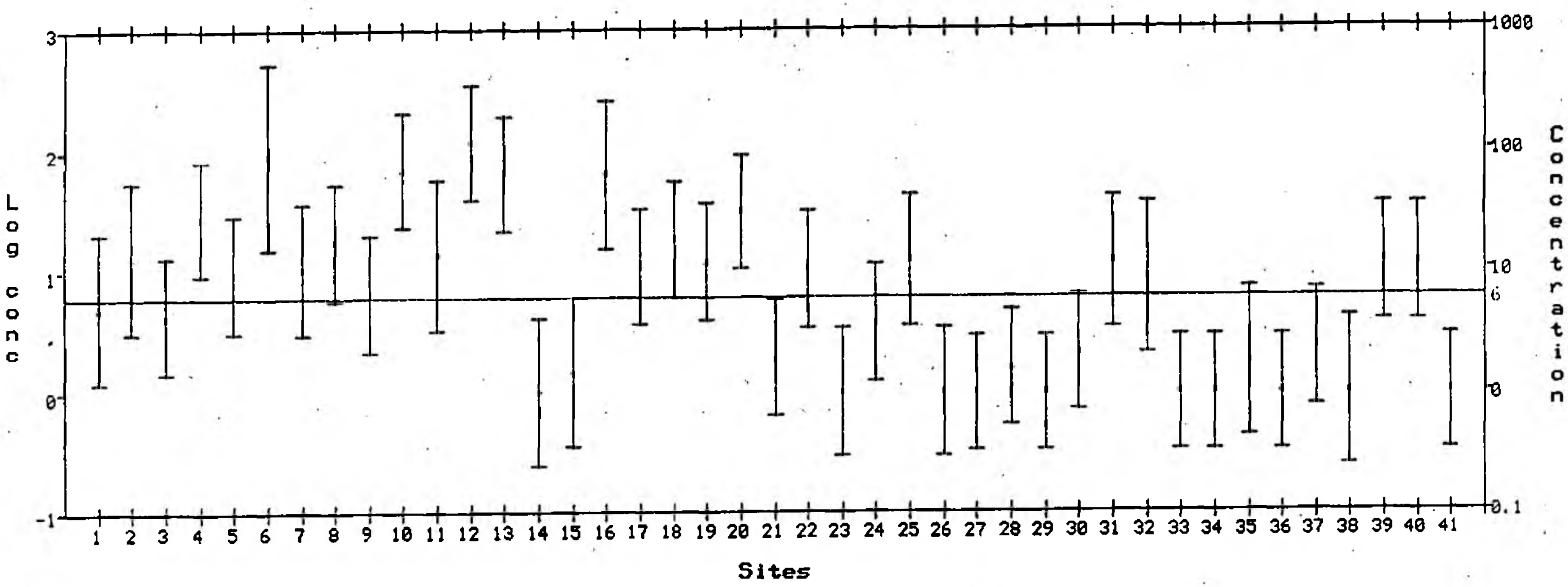
5) op-DDT



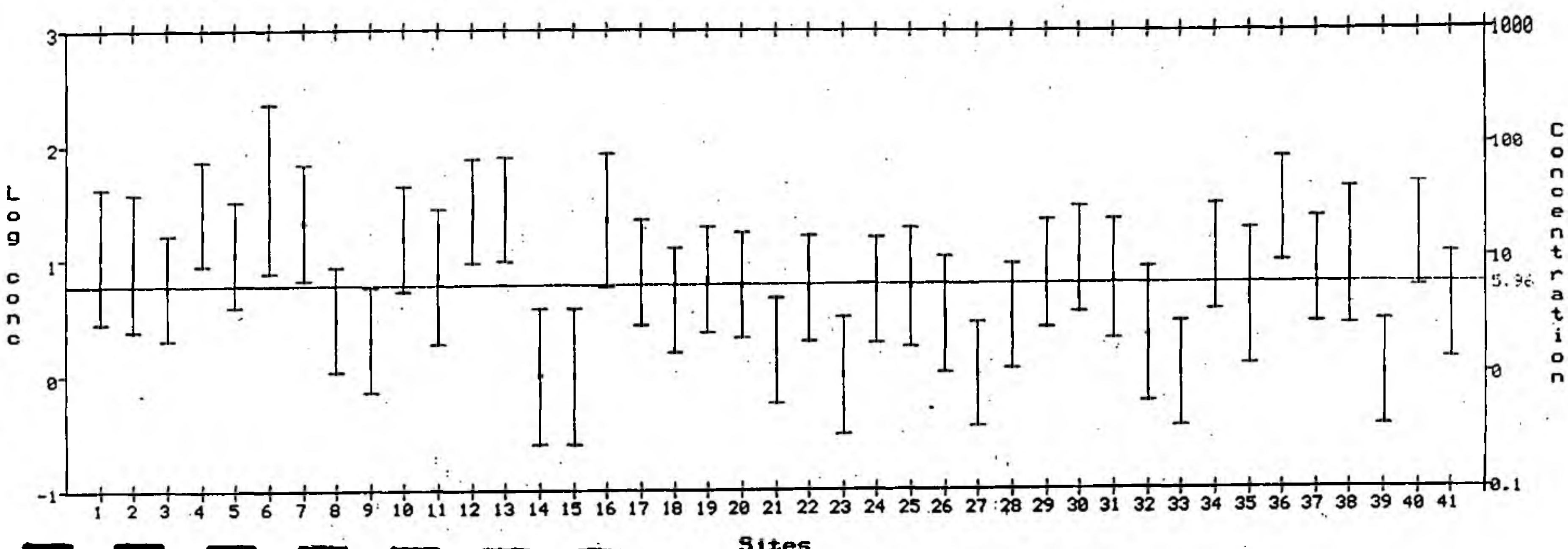
6) pp-DDE



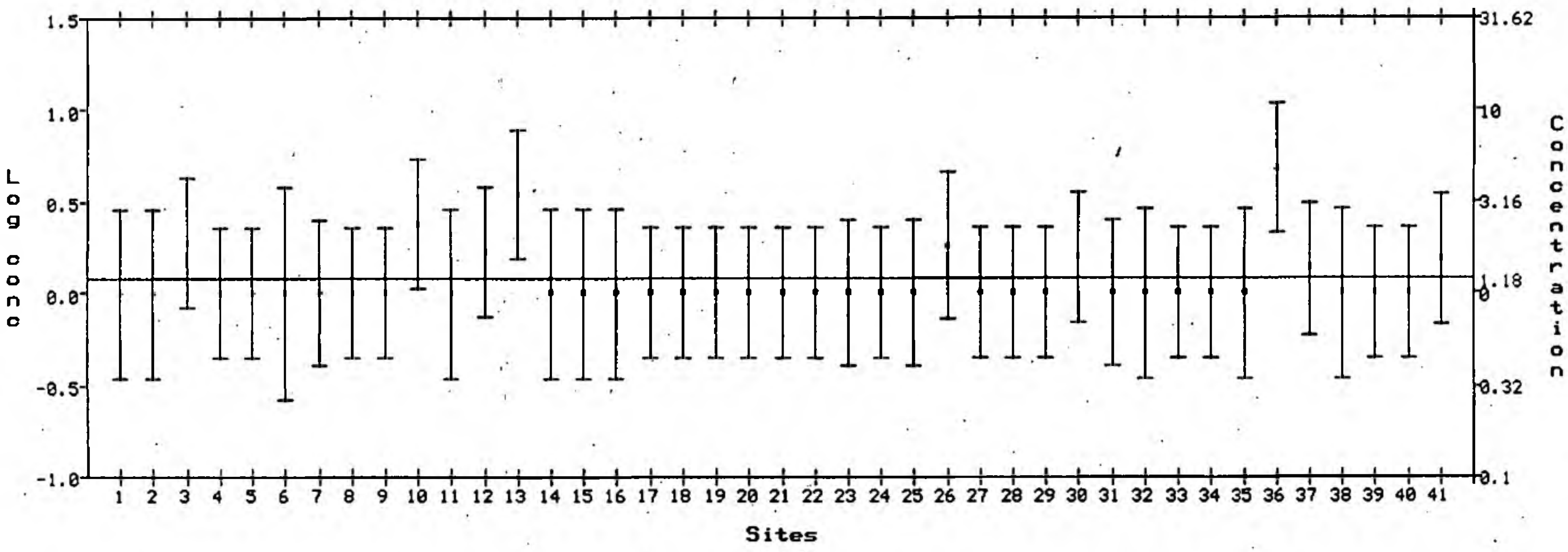
7) pp-DDT



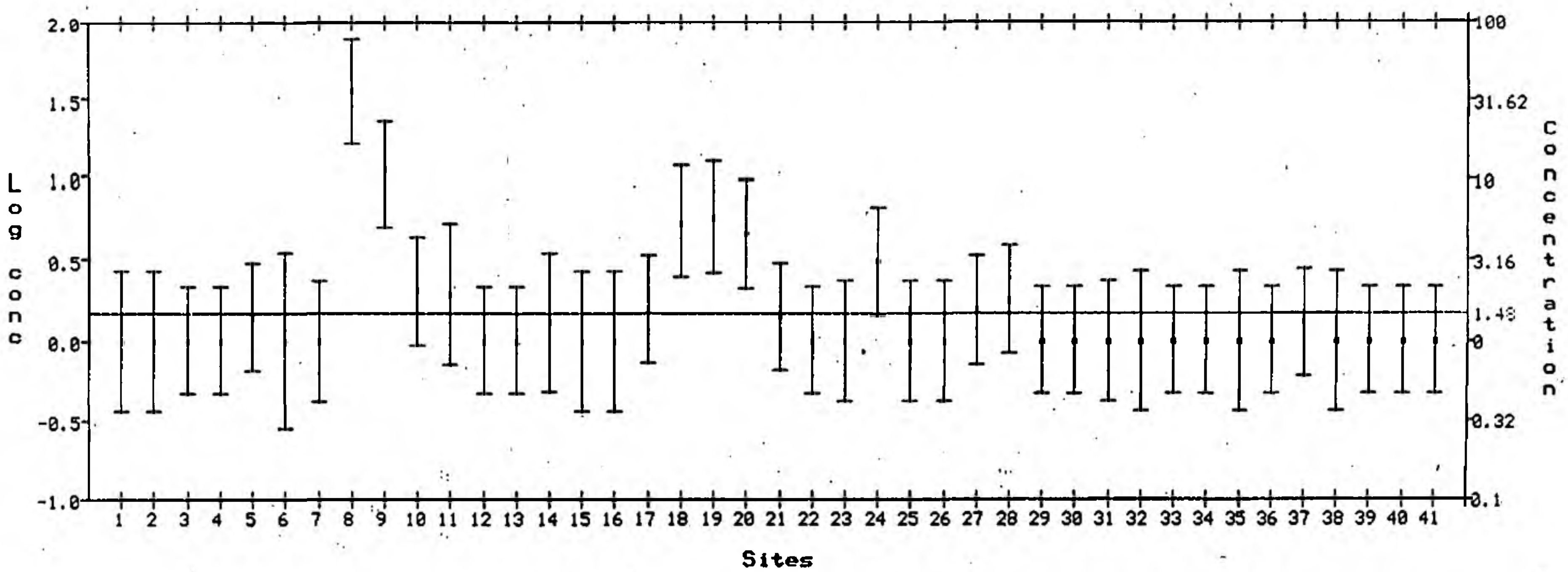
8) pp-TDE



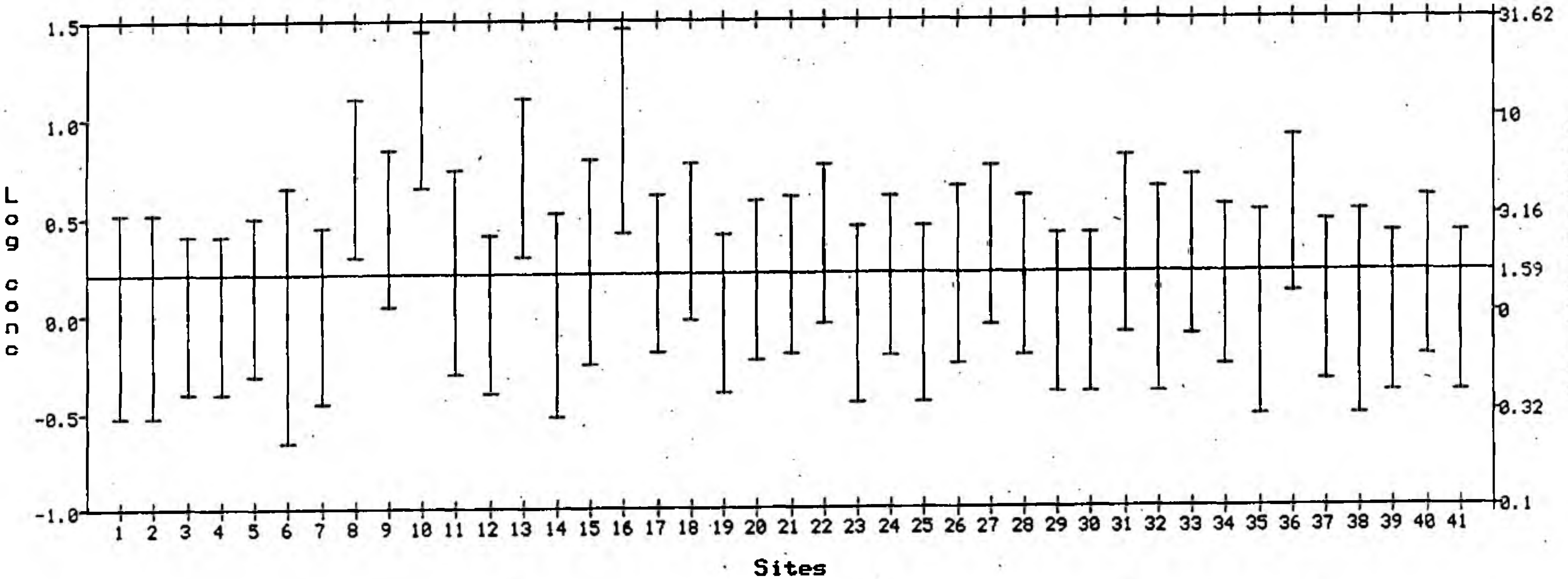
9) ENDRIN



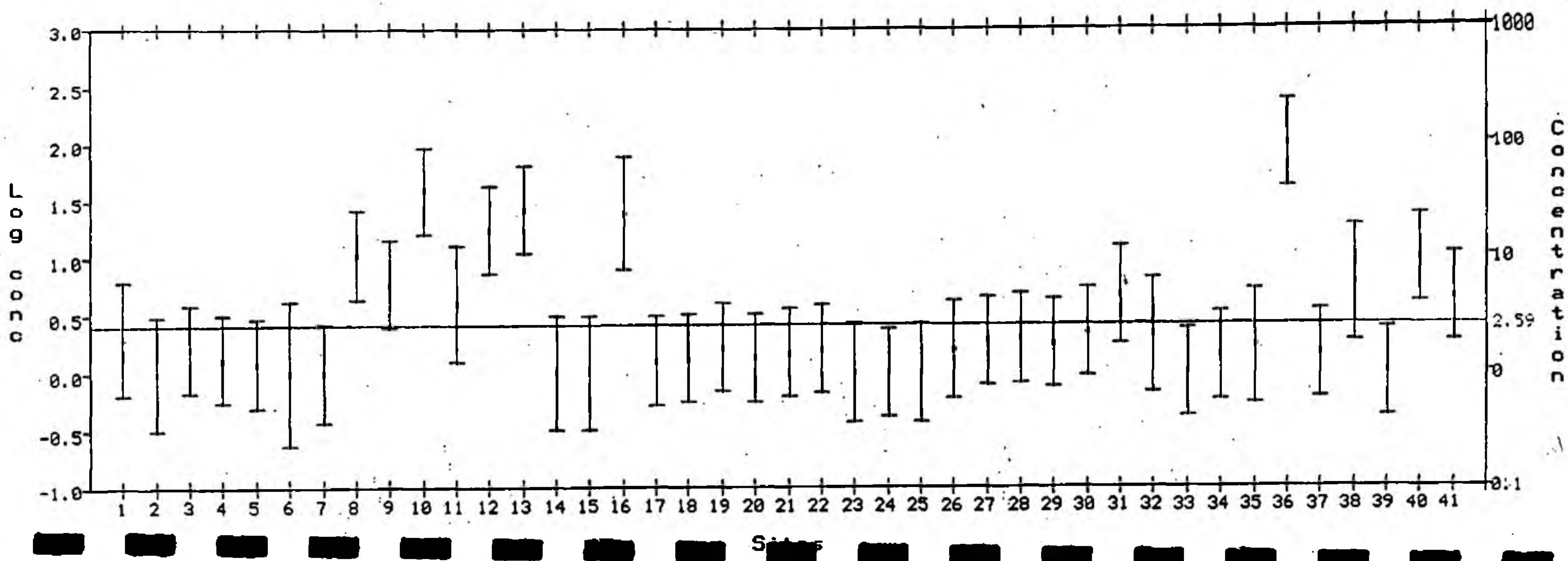
10) op-TDE



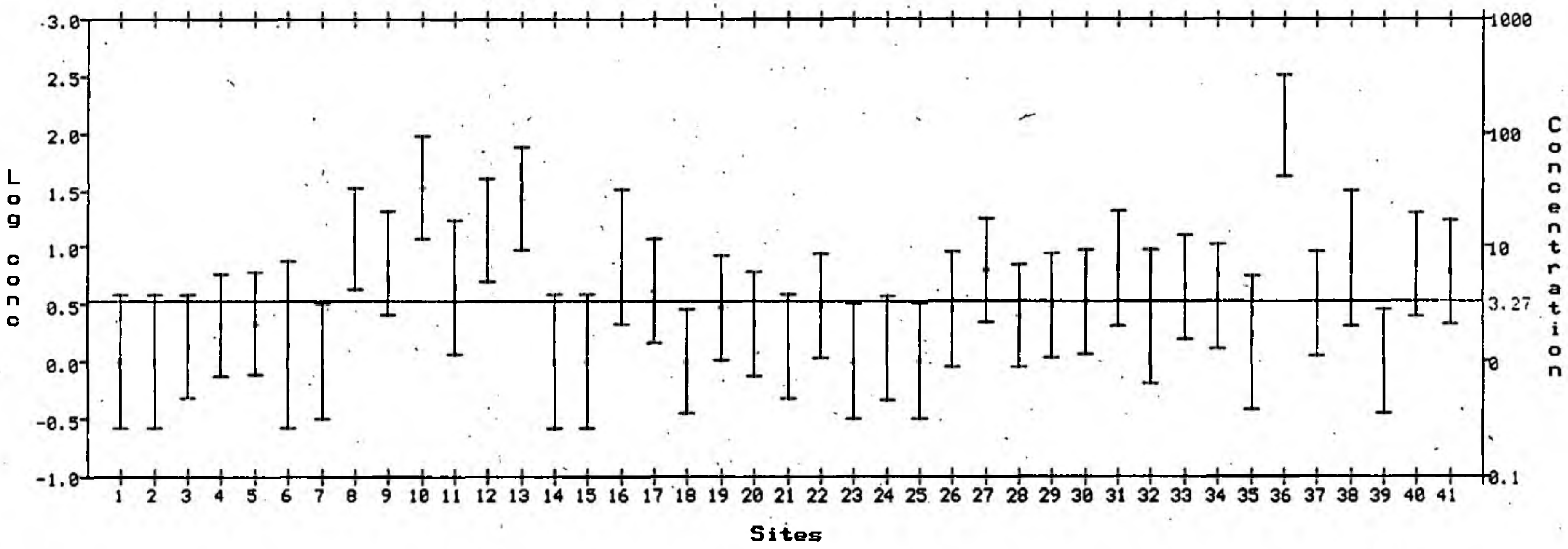
11) PCB 28



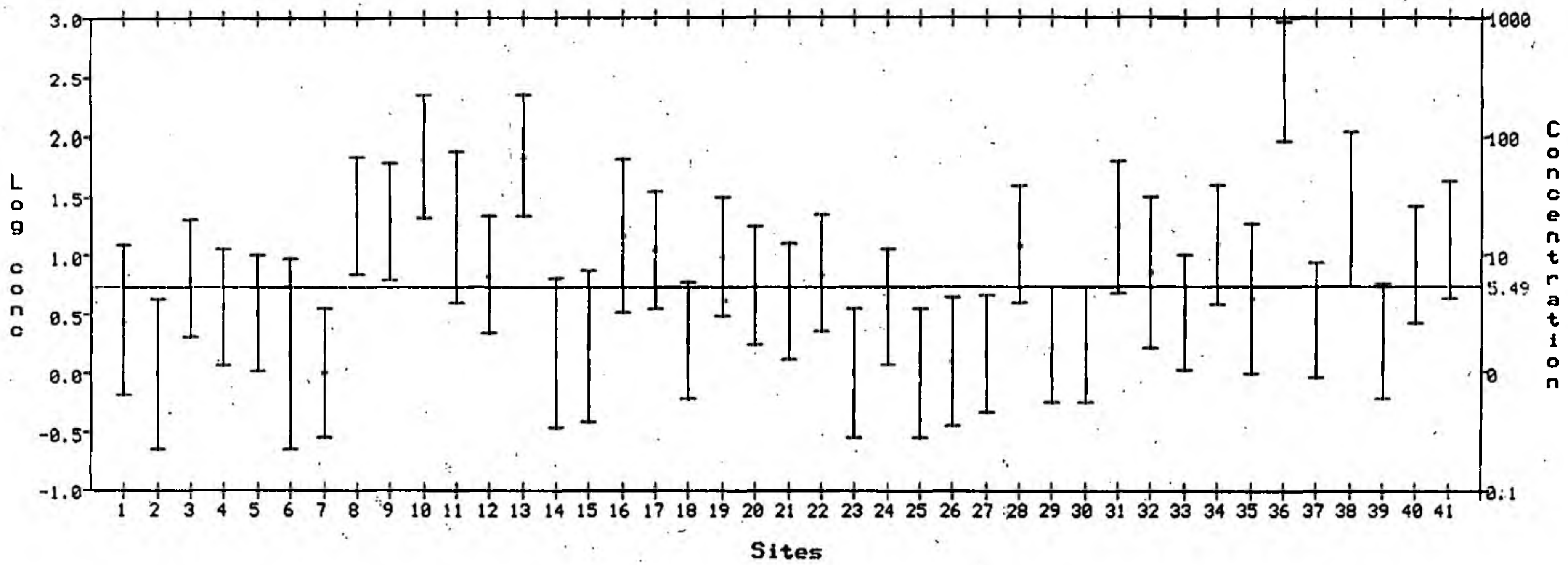
12) PCB 52



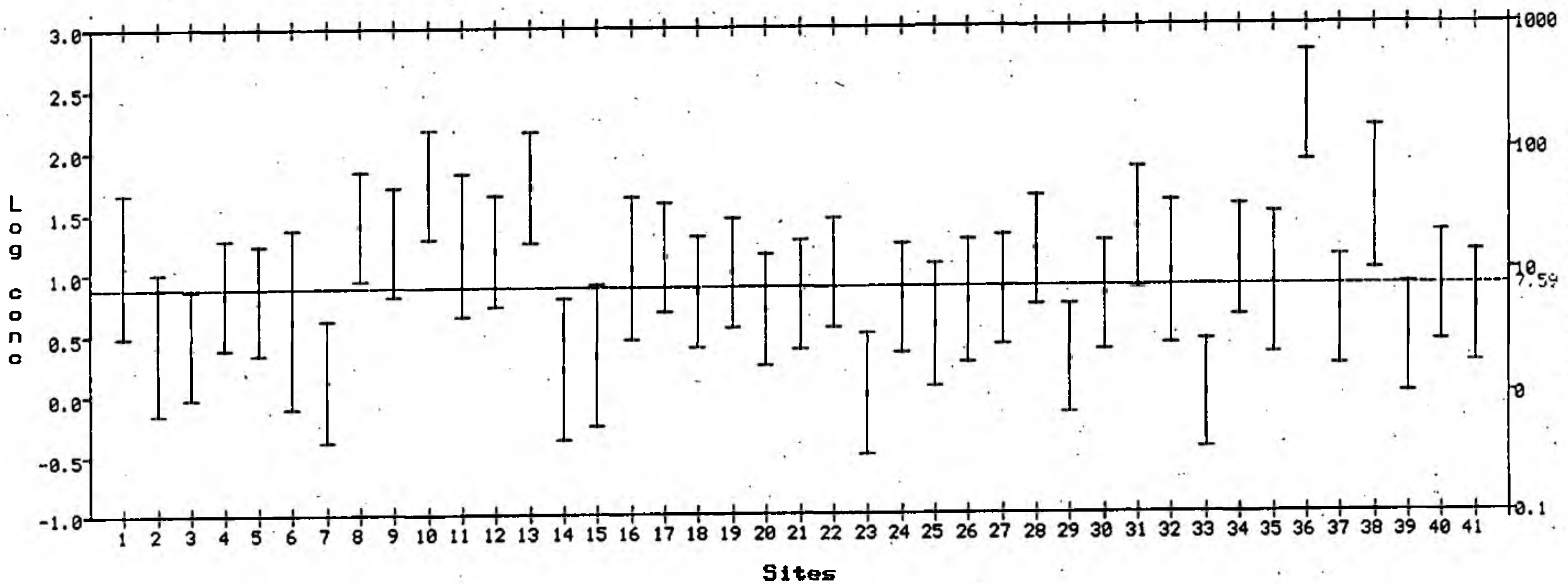
13) PCB 101



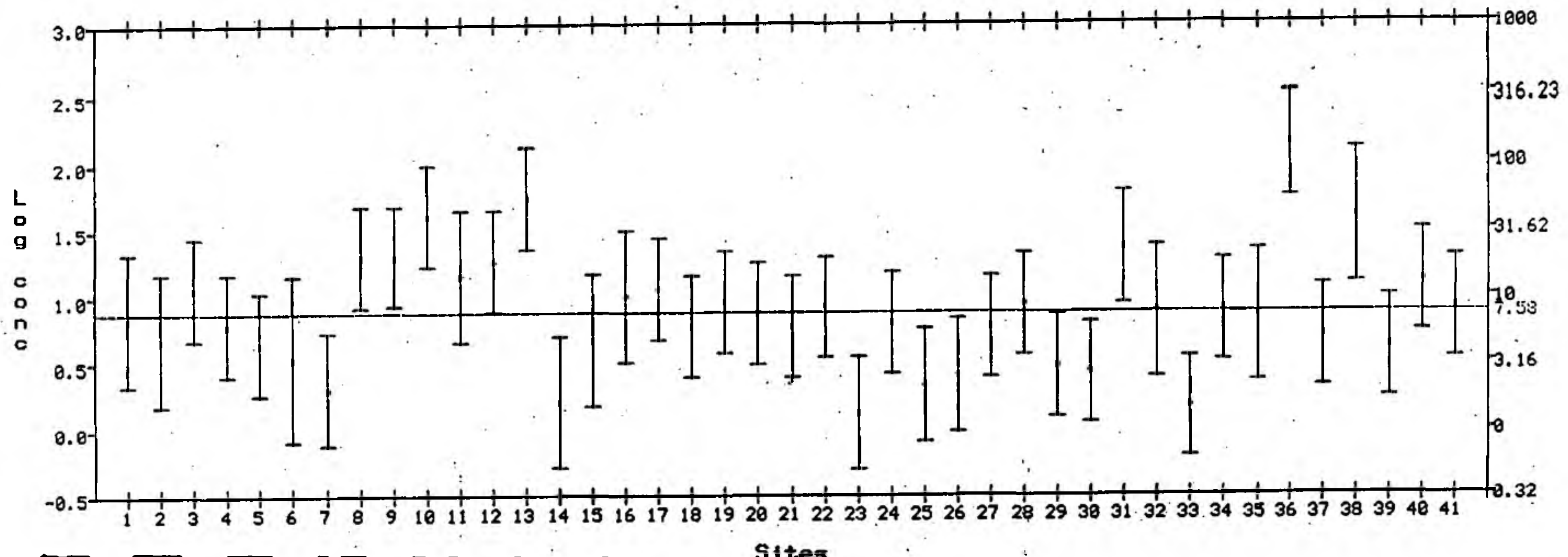
14) PCB 118



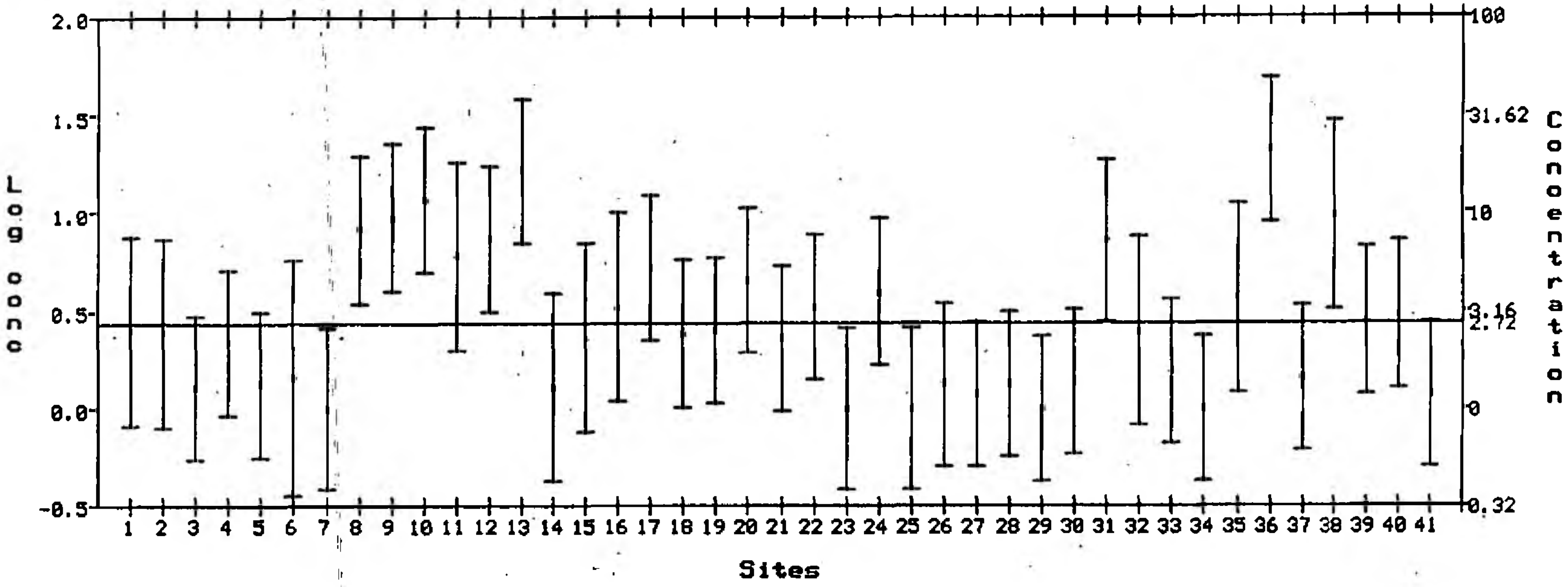
15) PCB 138



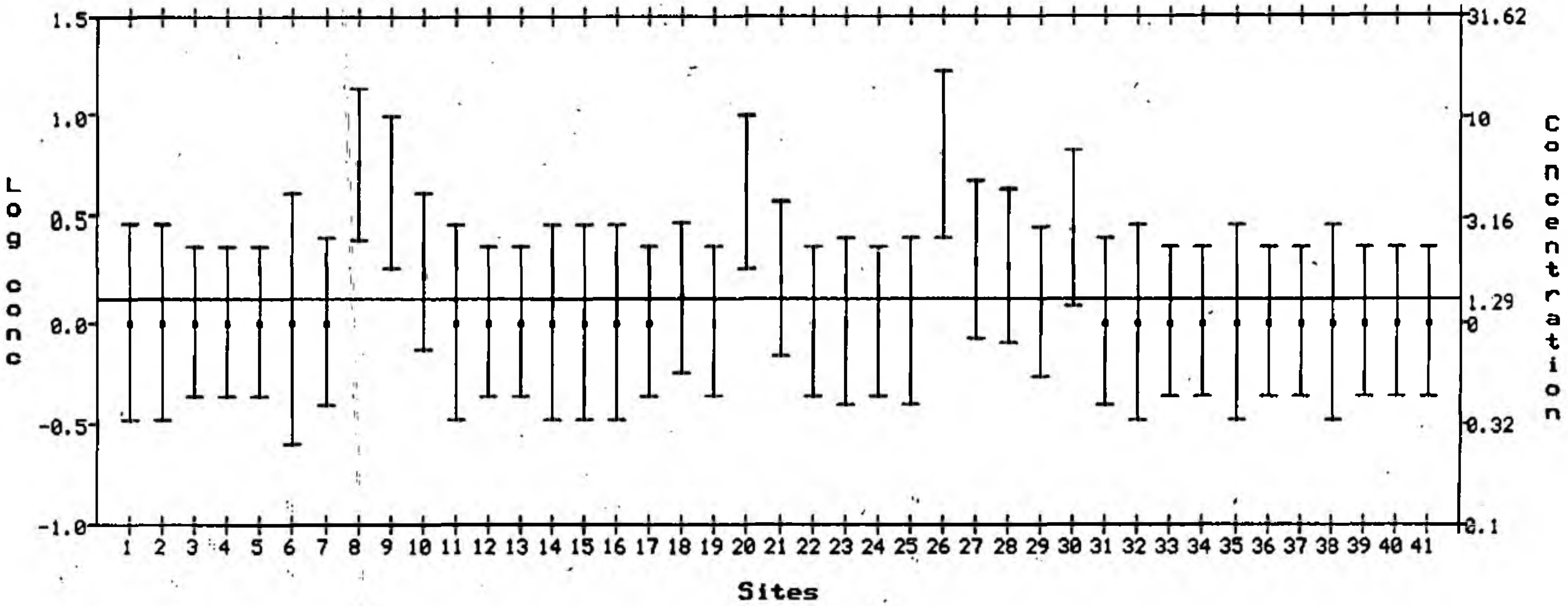
16) PCB 153



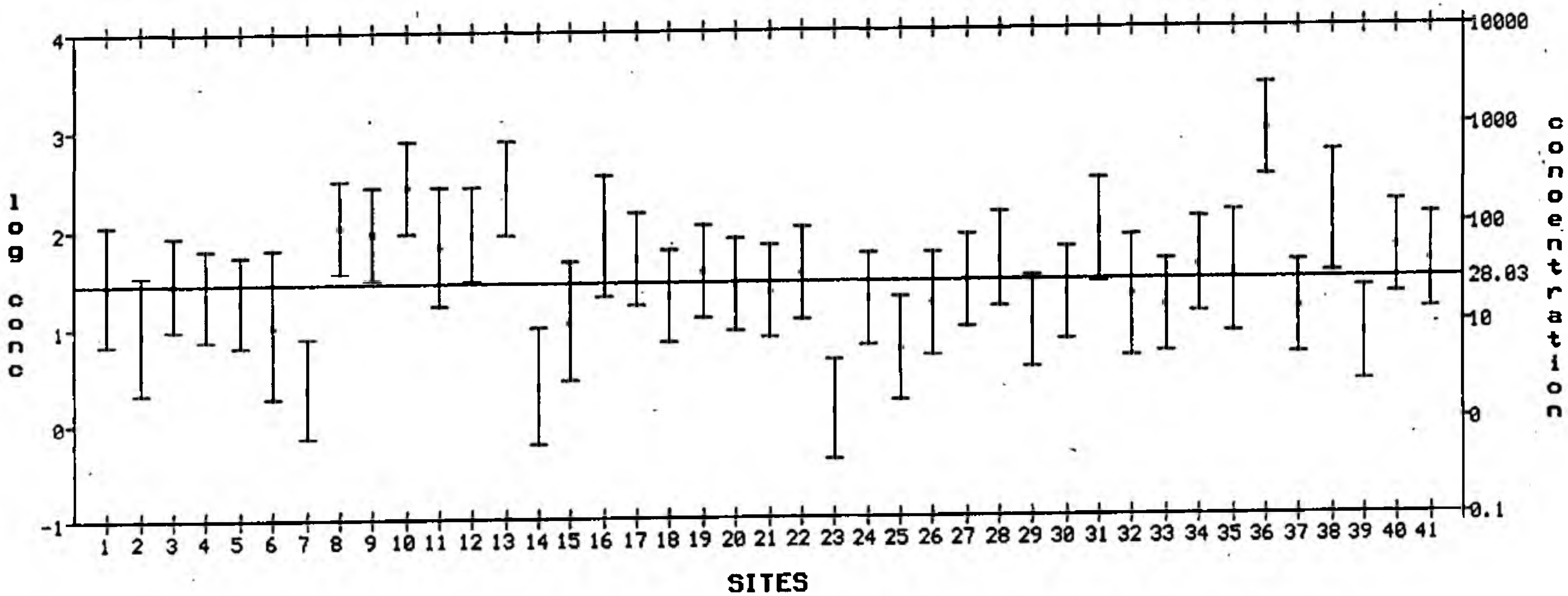
17) PCB 180



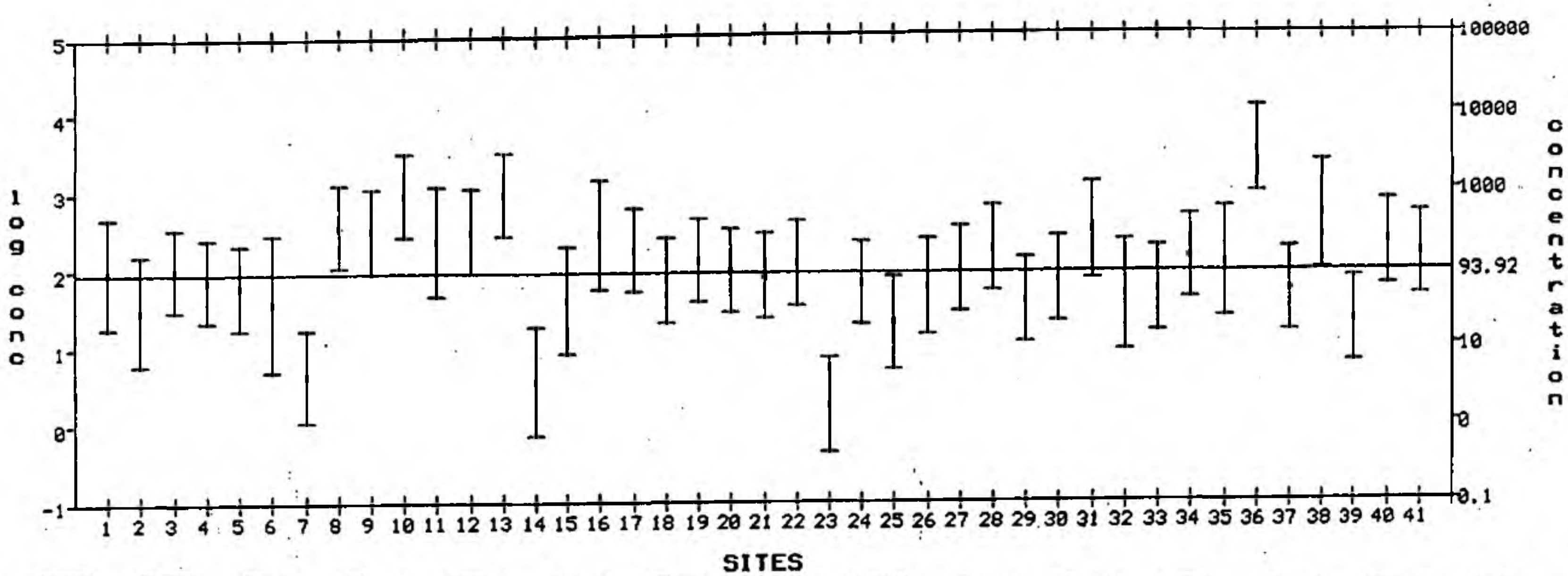
18) op-DDE



19) TOTAL PCBs

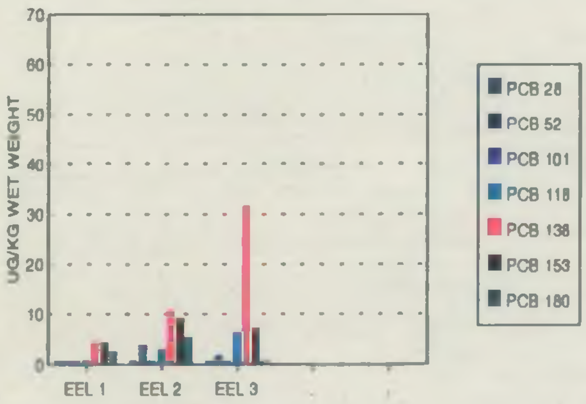


20) AROCHLOR 1260

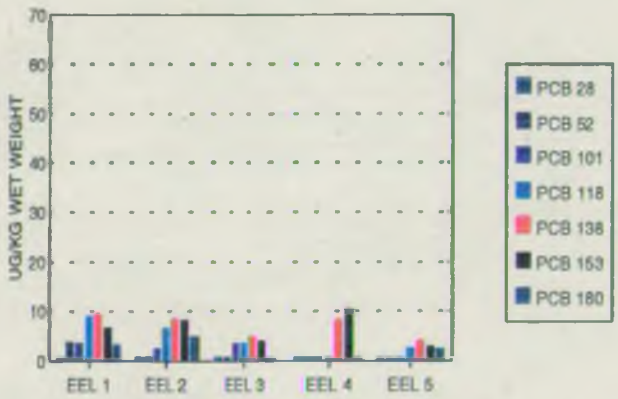


APPENDIX 3. Patterns of PCB congener concentrations in individual eels at 41 study sites.

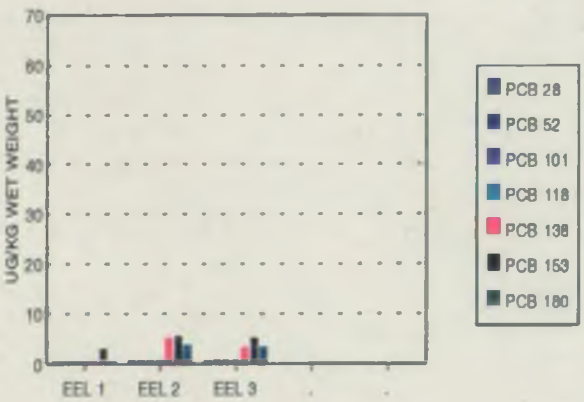
(1) WYE @ GLASBURY



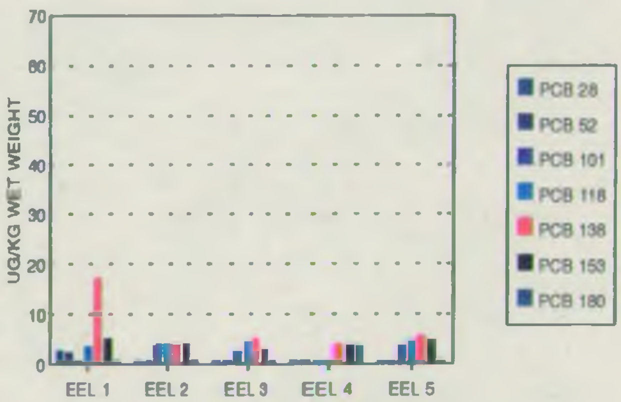
(4) FROME @ YARKHILL



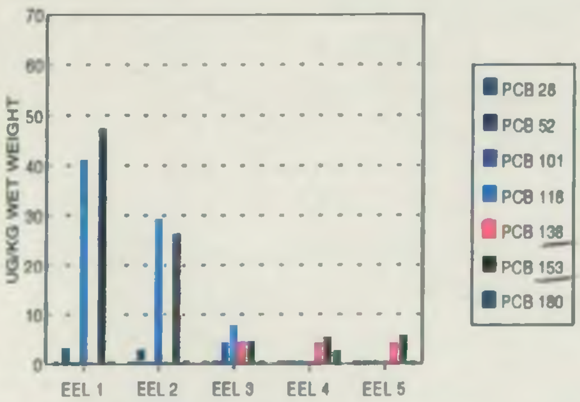
(2) LUGG @ AYMESTREY



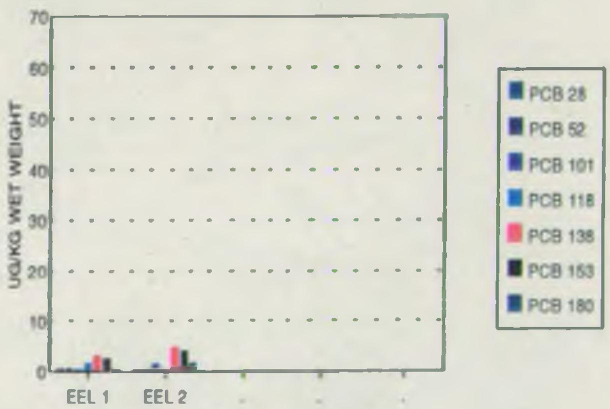
(5) USK @ GLAN USK



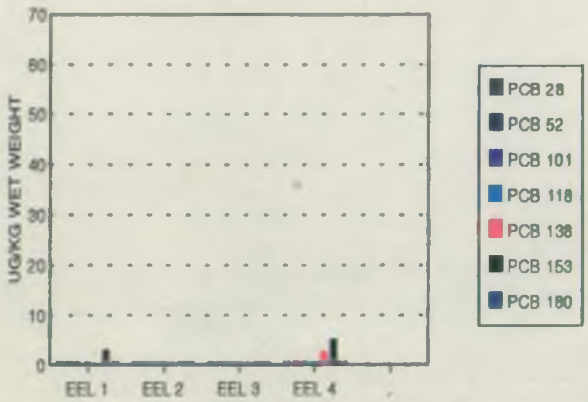
(3) LUGG @ LUGWARDINE



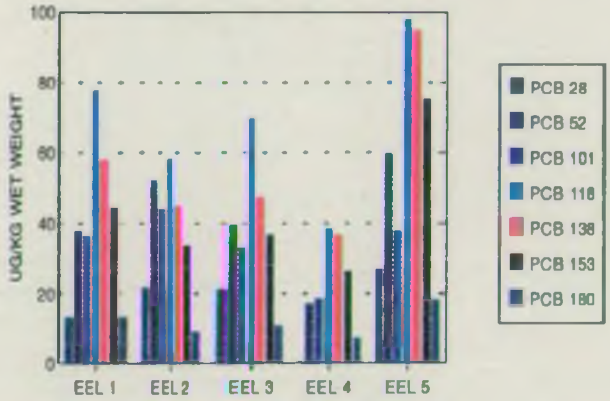
(6) SENNI U/S DEFYNNOG BRIDGE



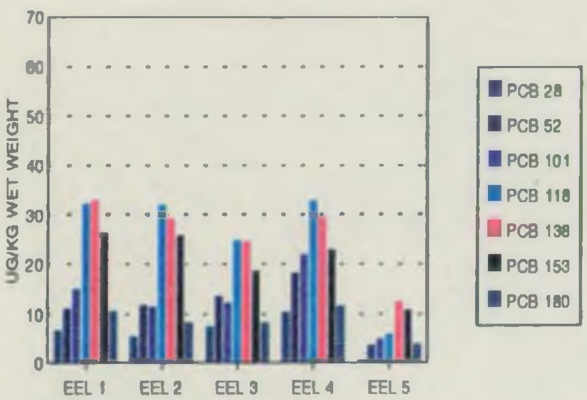
(7) SENNI @ DEFYNNOG BRIDGE



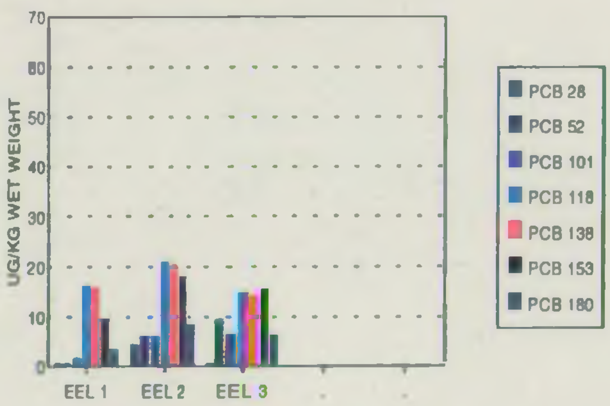
(10) SIRHOWY @ CWMFELINFACH



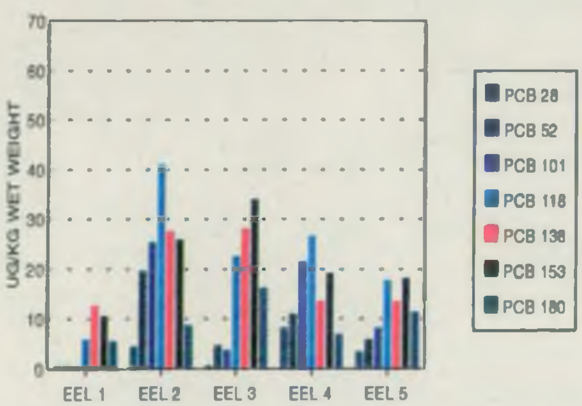
(8) LWYD @ CROESYCEILIOG



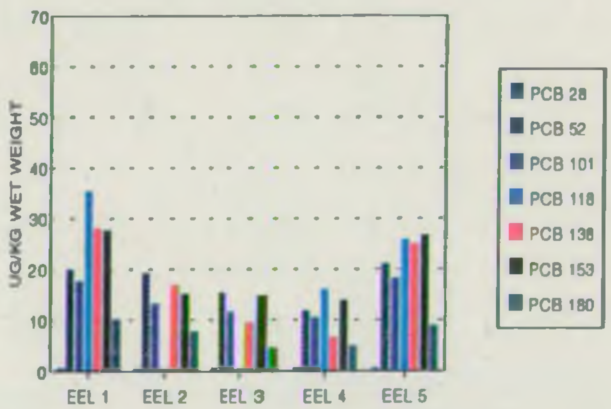
(11) TAFF @ RHYDYCAR



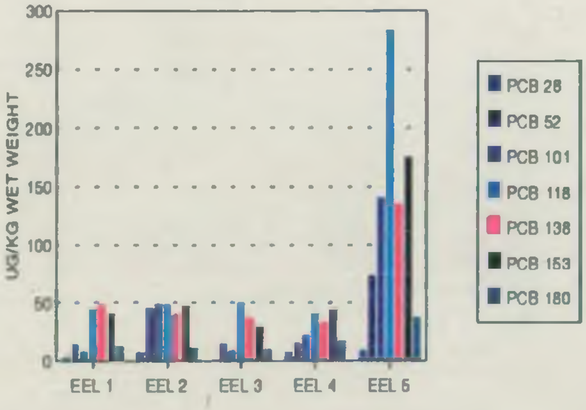
(9) LWYD @ PONTHIR



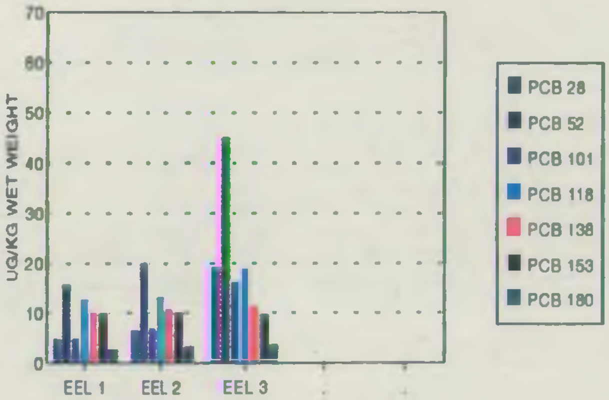
(12) TAFF @ YNYSANGHARAD PARK



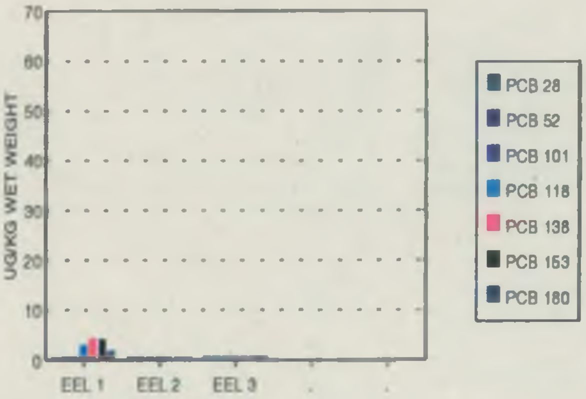
(13) TAFF @ BLACKWEIR



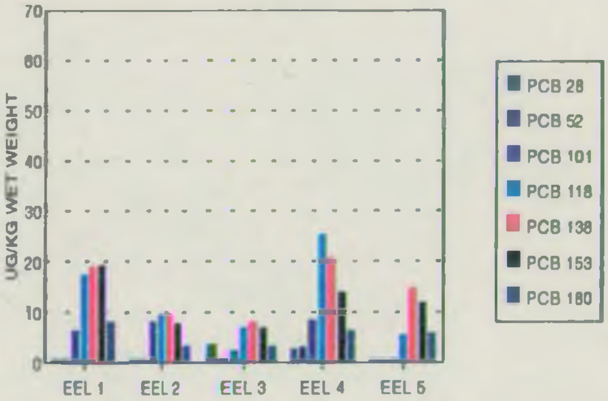
(16) LLYNFI @ ABERKENFIG



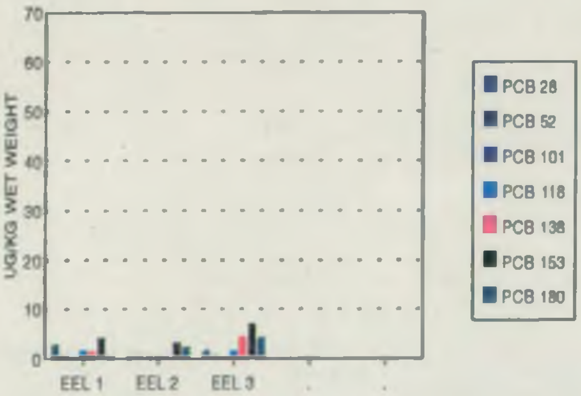
(14) THAW @ LLANBLETHIAN



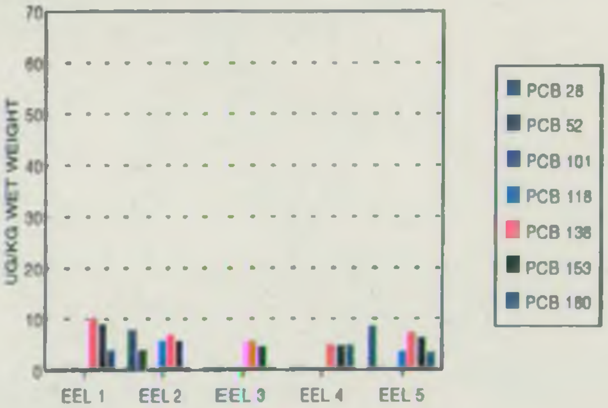
(17) EWENNY @ EWENNY PRIORY



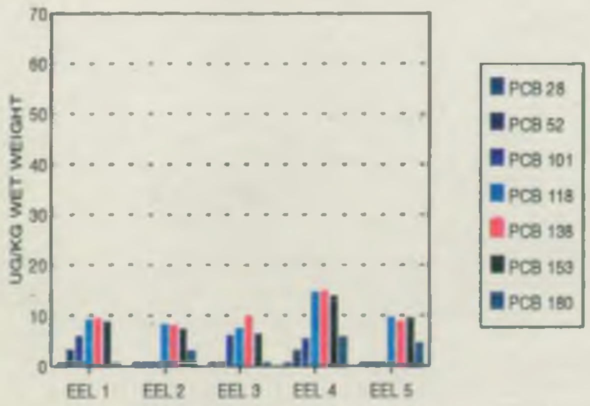
(15) NANT TRE-GOF



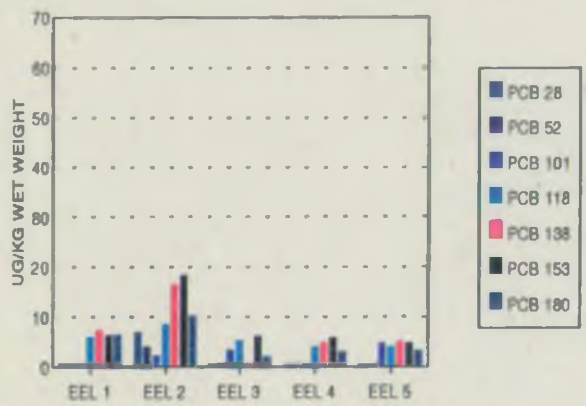
(18) NEATH D/S MELIN COURT BRIDGE



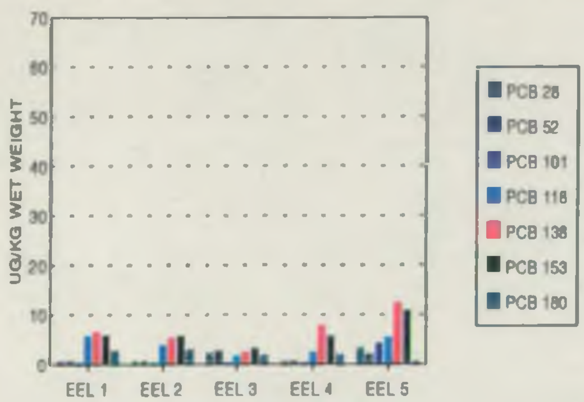
(19) NEATH @ TONNA



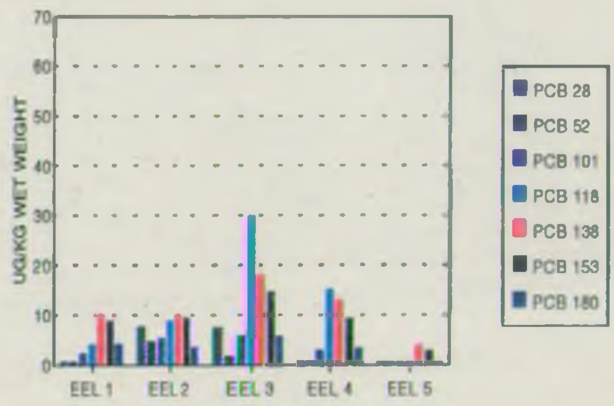
(20) TAWE @ GWYN ARMS



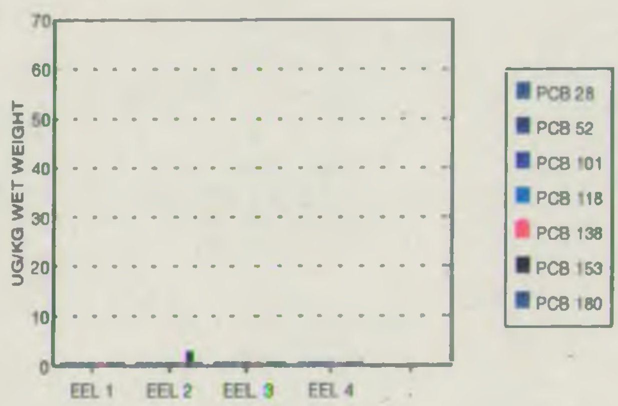
(21) TAWE D/S MORRISTON



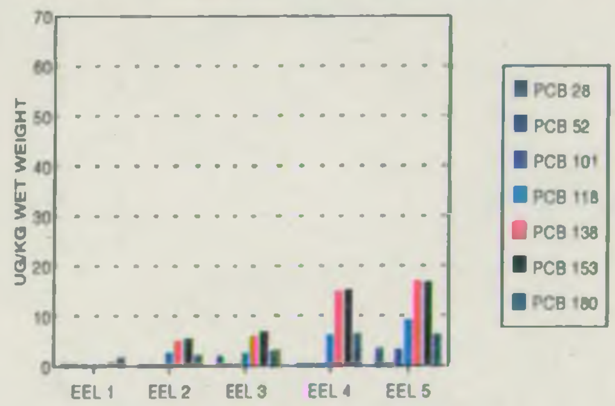
(22) TAWE @ FENDROD



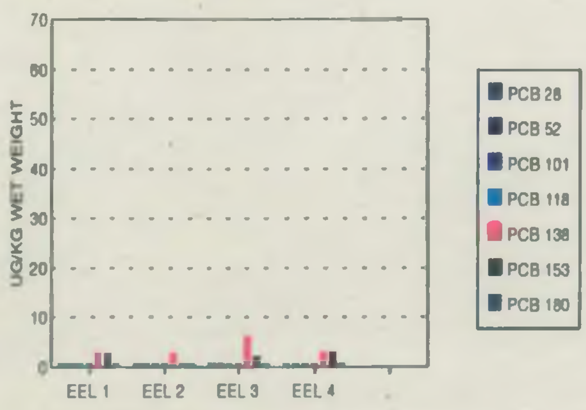
(23) GWENDRAETH FACH



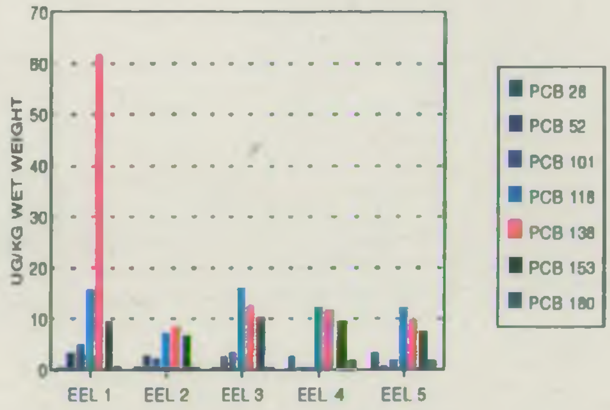
(24) TYWI @ NANTGAREDIG



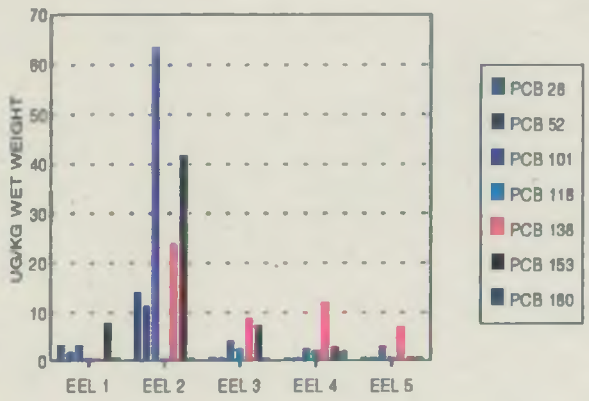
(25) DULAIS (TYWI TRIB.)



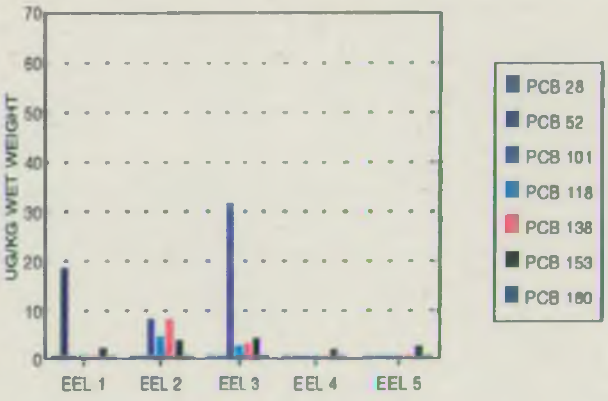
(28) E.CLEDDAU D/S CANASTON BD.



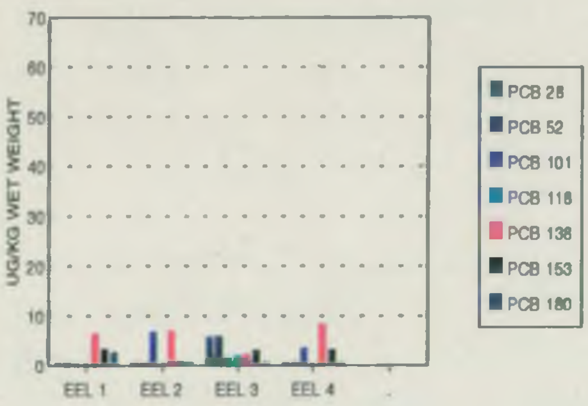
(26) NANTYCI



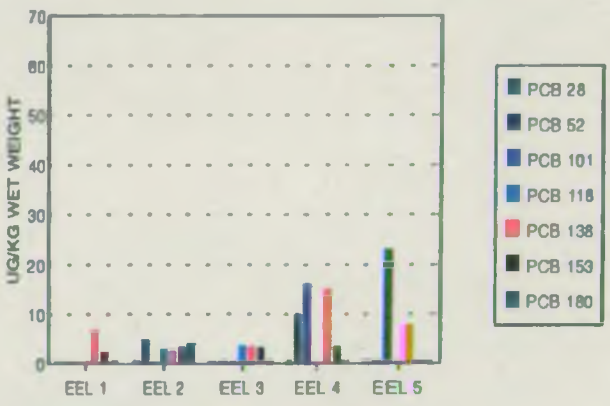
(29) TEIFI D/S TREGARON



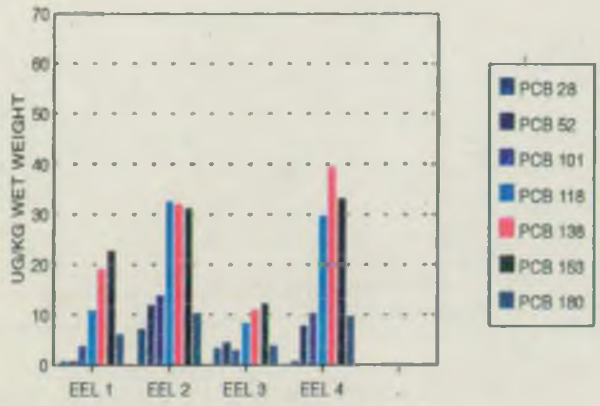
(27) MILTON STREAM



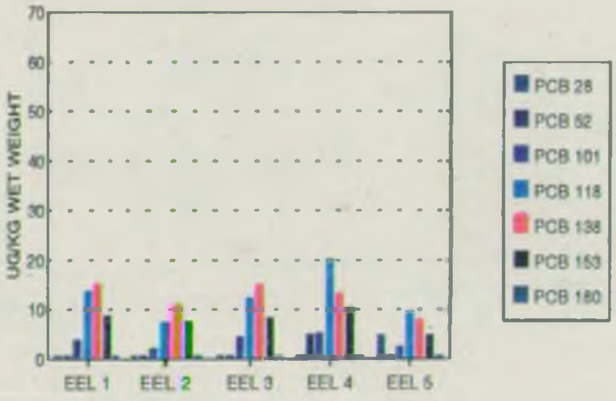
(30) TEIFI @ LLECHRYD



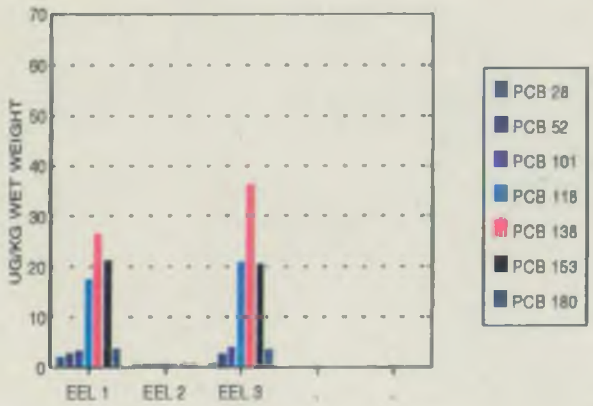
(31) SEIONT @ CAERNARFON



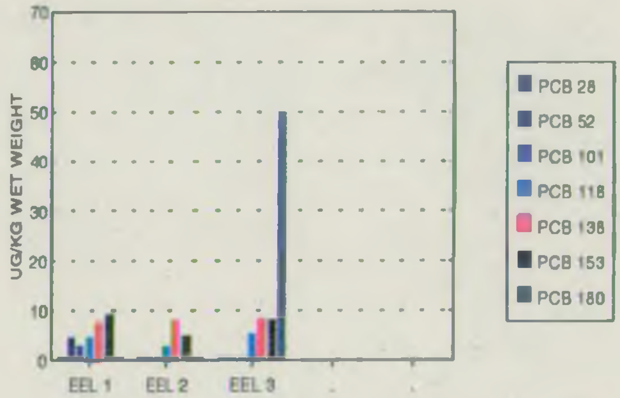
(34) LLYN PENRHYN



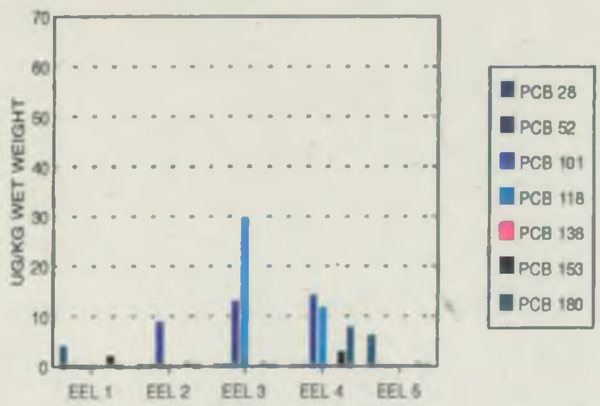
(32) CEFNI D/S OF A5 ROADBRIDGE



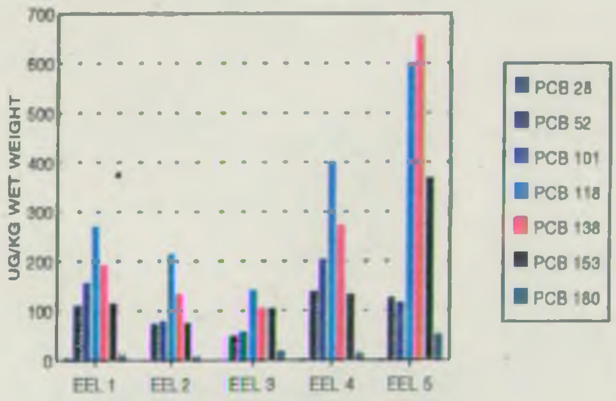
(35) OAKLANDS TRIB. (CONWY)



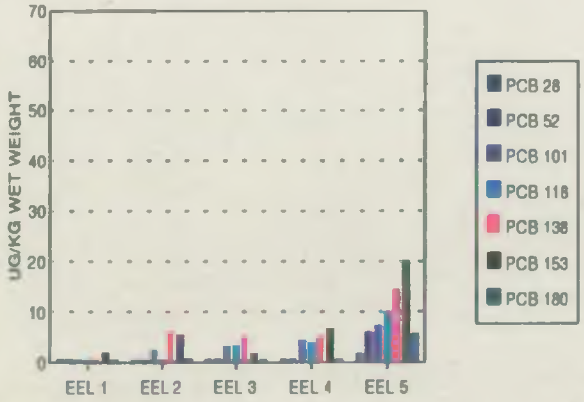
(33) LLYN CORON



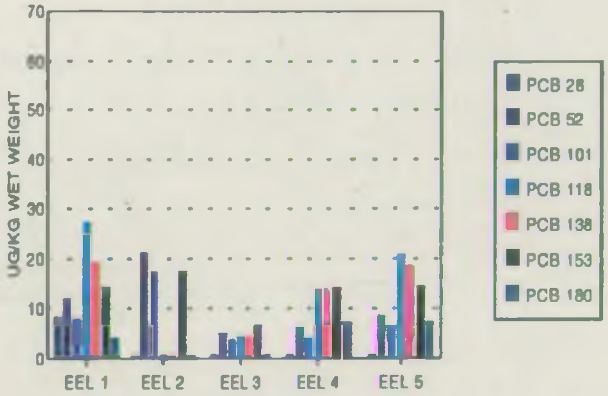
(36) CLYWEDOG



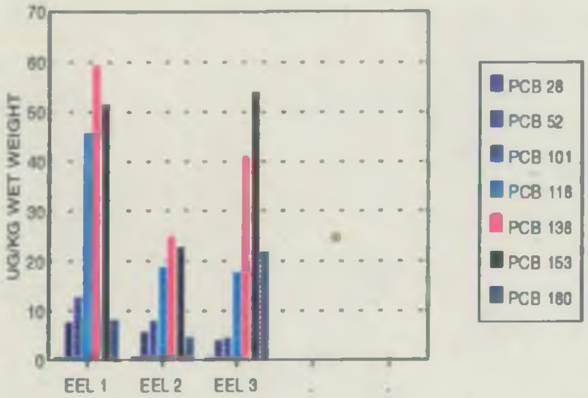
(37) DEE @ LLANGOLLEN



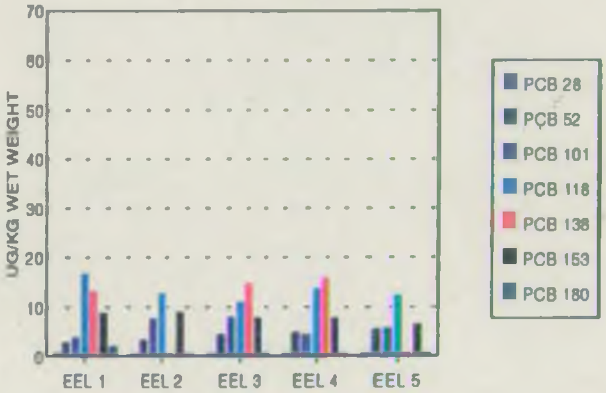
(40) ALYN @ ITHELL BRIDGE



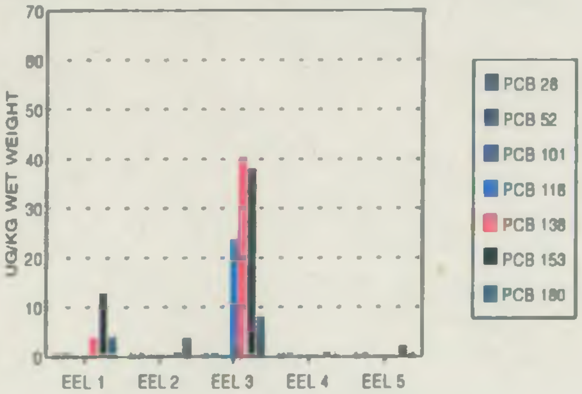
(38) DEE @ ECCLESTON FERRY



(41) PULFORD BROOK (DEE)



(39) HIRNANT TRIB. (DEE)



APPENDIX 4. Data record of organochlorine concentrations in 179 eels from 41 study sites.

SITE	LENGTH (mm)	AGE	LIPID (%)	ALDRIN	ALPHA HCH	BETA HCH	GAMMA HCH	DIELDRIN	op'-DDT	pp'-DDE	pp'-DDT	pp'-TDE	ENDRIN	op'-TDE	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	AROCHLOR 1260	op'-DDE
WYE @ GLASBURY	410	8	3.65	LT 2.0	LT 2.0	LT 2.0	LT 2.0	10.7	LT 2.0	28.3	7.21	6.96	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.59	4.6	2.71	42.7	LT 2.0
WYE @ GLASBURY	393	15	6.72	LT 2.0	LT 2.0	LT 2.0	LT 2.0	16.5	LT 2.0	46.2	16.9	11.5	LT 2.0	LT 2.0	LT 2.0	3.99	LT 2.0	3.01	10.9	9.36	6.66	120.3	LT 2.0
WYE @ GLASBURY	560	10	19.46	LT 2.0	LT 2.0	LT 2.0	LT 2.0	11.6	LT 2.0	22.8	LT 2.0	13	LT 2.0	LT 2.0	LT 2.0	2.05	LT 2.0	8.7	31.6	7.44	LT 2.0	173.7	LT 2.0
LUGG @ AYMESTREY	390	9	9.26	LT 2.0	LT 2.0	LT 2.0	LT 2.0	28.8	LT 2.0	26.7	11.2	8.34	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.26	LT 2.0	11.6	LT 2.0
LUGG @ AYMESTREY	346		6.14	LT 2.0	LT 2.0	LT 2.0	LT 2.0	23.6	LT 2.0	32.5	15.4	9.2	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	5.26	6.67	4.04	64.9	LT 2.0
LUGG @ AYMESTREY	487	20	13.68	LT 2.0	LT 2.0	LT 2.0	LT 2.0	34.1	LT 2.0	34.2	13.3	11.5	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.44	5.44	3.61	45.2	LT 2.0
LUGG @ LUGWARDINE	245	9	1.84	LT 2.0	LT 2.0	LT 2.0	LT 2.0	22.6	LT 2.0	33.4	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.64	LT 2.0	41.4	LT 2.0	47.4	LT 2.0	334.6	LT 2.0
LUGG @ LUGWARDINE	301	10	2.65	LT 2.0	LT 2.0	LT 2.0	LT 2.0	16.0	LT 2.0	22.7	LT 2.0	LT 2.0	23.6	LT 2.0	LT 2.0	3.15	LT 2.0	29.8	LT 2.0	28.4	LT 2.0	214.1	LT 2.0
LUGG @ LUGWARDINE	305	8	4.2	LT 2.0	LT 2.0	LT 2.0	LT 2.0	21.3	LT 2.0	31.2	6.22	16.2	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.67	6.43	4.95	4.70	LT 2.0	83.3	LT 2.0
LUGG @ LUGWARDINE	387	13	6.21	LT 2.0	LT 2.0	LT 2.0	LT 2.0	32.2	2.68	61.4	7.76	15.5	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.96	5.56	3.21	49.8	LT 2.0
LUGG @ LUGWARDINE	455	12	8.53	LT 2.0	LT 2.0	LT 2.0	LT 2.0	77.1	LT 2.0	102.6	39.9	27.5	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.67	5.90	LT 2.0	39.1	LT 2.0
FROME @ YARKHILL	430	10	11.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	16.9	LT 2.0	10.2	18.1	9.65	LT 2.0	LT 2.0	LT 2.0	4.09	3.79	9.25	9.8	6.66	3.65	134.2	LT 2.0
FROME @ YARKHILL	380	11	10.02	LT 2.0	LT 2.0	LT 2.0	LT 2.0	56.8	LT 2.0	77.6	15.4	17.9	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.73	6.62	6.62	8.62	6.13	116.2	LT 2.0
FROME @ YARKHILL	480	9	17.37	LT 2.0	LT 2.0	LT 2.0	LT 2.0	96.7	LT 2.0	94.1	40.1	45.2	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.75	3.83	4.96	4.36	LT 2.0	81.3	LT 2.0
FROME @ YARKHILL	453	12	15.59	LT 2.0	LT 2.0	LT 2.0	LT 2.0	96.7	9.67	126.1	70.5	48.3	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	6.65	10.8	LT 2.0	70.2	LT 2.0
FROME @ YARKHILL	467	11	0.72	LT 2.0	LT 2.0	LT 2.0	LT 2.0	59.1	LT 2.0	93.2	21.1	28.3	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.8	4.25	3.2	2.63	37.1	LT 2.0
USK @ GLAN USK	297	10	3.01	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.35	LT 2.0	10.8	LT 2.0	5.3	LT 2.0	LT 2.0	2.95	2.6	LT 2.0	3.75	17.3	5.36	LT 2.0	115.7	LT 2.0
USK @ GLAN USK	390	8	13.94	LT 2.0	LT 2.0	LT 2.0	LT 2.0	24.2	LT 2.0	32.4	12.3	16.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.17	4.27	4.15	4.36	LT 2.0	91.5	LT 2.0
USK @ GLAN USK	412	7	9.28	LT 2.0	LT 2.0	LT 2.0	LT 2.0	17.1	LT 2.0	25.8	16.3	18.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.79	4.72	5.11	3.23	LT 2.0	57.4	LT 2.0
USK @ GLAN USK	367	7	4.62	LT 2.0	LT 2.0	LT 2.0	LT 2.0	22.4	LT 2.0	9.5	17.4	9.5	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.02	4.13	4.02	29.8	LT 2.0
USK @ GLAN USK	474	12	9.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	34.6	2.06	62.2	24.8	13.2	LT 2.0	5.37	LT 2.0	LT 2.0	4.03	5	5.61	5.16	LT 2.0	72.5	LT 2.0
BENNI U/S DEFYNNOG SD.	294	5	8.39	LT 2.0	LT 2.0	LT 2.0	LT 2.0	76.1	8.19	55.6	118	46.5	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.13	3.52	2.71	LT 2.0	30.3	LT 2.0
SENNI U/S DEFYNNOG SD.	515	16	11.44	LT 2.0	LT 2.0	LT 2.0	LT 2.0	93.3	6.78	61	69.3	36.3	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2	LT 2.0	5.1	4.29	2.06	46.8	LT 2.0
SENNI @ DEFYNNOG SD.	317	13	1.98	LT 2.0	LT 2.0	LT 2.0	LT 2.0	12.3	LT 2.0	37.3	14.5	11.9	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.26	LT 2.0	11.6	LT 2.0
SENNI @ DEFYNNOG SD.	370	8	0.87	LT 2.0	LT 2.0	LT 2.0	LT 2.0	18.2	LT 2.0	28.9	LT 2.0	31.5	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0
SENNI @ DEFYNNOG SD.	440	17	6.91	LT 2.0	LT 2.0	LT 2.0	17.1	38.2	LT 2.0	43.2	22.8	24.5	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0
SENNI @ DEFYNNOG SD.	535		10.93	LT 2.0	LT 2.0	LT 2.0	LT 2.0	40.5	LT 2.0	71.6	39.5	23.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.05	8.46	LT 2.0	30.8	LT 2.0
LWYD @ CROESYCEILIOG	362	8	20.04	LT 2.0	LT 2.0	LT 2.0	LT 2.0	48.7	9.3	20	19.8	LT 2.0	LT 2.0	32.4	6.96	11.4	15.2	32.4	33	28.4	10.8	493	9
LWYD @ CROESYCEILIOG	340	11	17.90	LT 2.0	LT 2.0	LT 2.0	LT 2.0	124.2	6.86	74.6	17.3	LT 2.0	LT 2.0	35.4	5.57	12	11.8	32.2	29.5	25.9	8.54	464.3	5.65
LWYD @ CROESYCEILIOG	335	8	17.69	LT 2.0	LT 2.0	LT 2.0	LT 2.0	21.9	LT 2.0	70.1	14.7	4.49	LT 2.0	31	7.83	13.8	12.6	25.1	24.6	18.9	8.5	403	11.3
LWYD @ CROESYCEILIOG	335	11	17.79	LT 2.0	LT 2.0	LT 2.0	LT 2.0	23.3	LT 2.0	77	20.1	6.25	LT 2.0	36.8	10.8	18.5	22.2	33.1	29.8	23.1	11.9	509.4	11.6
LWYD @ CROESYCEILIOG	340	11	18.12	LT 2.0	LT 2.0	LT 2.0	LT 2.0	31.7	8.3	69	17.6	10.8	LT 2.0	43.3	LT 2.0	3.72	6.02	6.16	12.7	11	4	154.2	LT 2.0
LWYD @ PONTHIR	356	11	1.34	LT 2.0	LT 2.0	LT 2.0	LT 2.0	6.49	4.19	12.9	2.87	LT 2.0	LT 2.0	5.2	LT 2.0	LT 2.0	LT 2.0	6.3	13.1	10.8	6.96	130.9	LT 2.0
LWYD @ PONTHIR	320	9	18.21	LT 2.0	LT 2.0	LT 2.0	LT 2.0	36.3	10.2	14.2	14.2	7.79	LT 2.0	53.5	4.86	20	26.8	41.4	28	28	9.11	561.7	16.8
LWYD @ PONTHIR	320	10	6.19	LT 2.0	LT 2.0	LT 2.0	LT 2.0	22.74	10.4	50.2	8.1	4.46	LT 2.0	15.7	LT 2.0	6.07	4.26	23	26.5	34.1	16.6	403.8	4.1
LWYD @ PONTHIR	300	8	18.12	LT 2.0	LT 2.0	LT 2.0	LT 2.0	112.4	6.74	32.9	7.48	LT 2.0	LT 2.0	35	8.62	11.4	21.8	27	13.9	19.4	7.29	398.4	19
LWYD @ PONTHIR	315	7	10.23	LT 2.0	LT 2.0	LT 2.0	LT 2.0	23.6	6.34	15.1	5.86	LT 2.0	LT 2.0	LT 2.0	3.63	6.19	6.6	16	13.9	18.3	11.7	291.6	LT 2.0
SIRHOWY @ CWMFELINFACH	262	8	16.44	LT 2.0	LT 2.0	LT 2.0	LT 2.0	37	3.91	60.3	65.2	13.2	7.21	LT 2.0	13.7	36.1	36.8	76.1	56.3	44.7	13.8	1026	LT 2.0
SIRHOWY @ CWMFELINFACH	260	11	12.98	LT 2.0	LT 2.0	LT 2.0	LT 2.0	31.6	LT 2.0	55.5	54.4	11.2	LT 2.0	LT 2.0	22.1	52.5	44.8	66.7	45	33.9	9.45	963.6	LT 2.0
SIRHOWY @ CWMFELINFACH	302	10	16.28	LT 2.0	4.12	LT 2.0	10.4	47.6	LT 2.0	83.0	65.7	16.7	10.4	LT 2.0	21.7	39.9	33.5	70.2	47.7	38.6	11.2	944.6	LT 2.0
SIRHOWY @ CWMFELINFACH	316	11	22.79	LT 2.0	LT 2.0	LT 2.0	LT 2.0	50.9	LT 2.0	58.9	53	11.8	LT 2.0	35.1	LT 2.0	17.6	19.1	39.1	38.9	28.6	7.77	532.4	14.6
SIRHOWY @ CWMFELINFACH	278	10	36.04	LT 2.0	LT 2.0	LT 2.0	LT 2.0	42.6	LT 2.0	105.7	122.4	32.1	LT 2.0	LT 2.0	27.4	60.2	38.4	96.6	95.2	75.5	16.6	1431	LT 2.0
TAFF @ RHYDYCAR	273	4	3.31	LT 2.0	LT 2.0	LT 2.0	LT 2.0	11	LT 2.0	14.8	10.1	6.77	LT 2.0	7.28	LT 2.0	LT 2.0	2	18.6	18.1	10	3.63	176	LT 2.0
TAFF @ RHYDYCAR	385	7	6.04	LT 2.0	LT 2.0	LT 2.0	LT 2.0	22	LT 2.0	21.9	21.7	8.51	LT 2.0	LT 2.0	4.63	6.68	6.62	21.4	20.8	18.5	6.61	316.4	LT 2.0
TAFF @ RHYDYCAR	405	6	9.30	LT 2.0	LT 2.0	LT 2.0	LT 2.0	31.3	LT 2.0	29.3	11.7	6.72	LT 2.0	LT 2.0	LT 2.0	9.71	7.06	16.3	14.6	16.7	6.79	250	LT 2.0
TAFF @ YNYSANGHARAD PK.	475	10	12.18	LT 2.0	LT 2.0	LT 2.0	LT 2.0	75	8.89	74.9	46.4	16.1	LT 2.0	LT 2.0	LT 2.0	20.3	18.1	35.7	28.3	27.9	10.8	610.1	LT 2.0
TAFF @ YNYSANGHARAD PK.	340	11	20.75	LT 2.0	LT 2.0	LT 2.0	27.8	88.1	13.3	213.2	207	30.6	LT 2.0	LT 2.0	LT 2.0	19.6	13.7	LT 2.0	17.3	15.4	8.19	268.2	LT 2.0
TAFF @ YNYSANGHARAD PK.	395	8	13.74	LT 2.0	LT 2.0	LT 2.0	10	60.9	12.8	213.2	207	27.9	LT 2.0	LT 2.0	LT 2.0	15.7	12.1	LT 2.0	10	15	4.89	208.6	LT 2.0
TAFF @ YNYSANGHARAD PK.	250	5	6.42	LT 2.0	LT 2.0	LT 2.0	10.5	LT 2.0	11.5	132.1	200.2	37.3	13.3	LT 2.0	LT 2.0	12.2	10.9	16.5	7	14.1	6.26	236.6	LT 2.0
TAFF @ YNYSANGHARAD PK.	530	11	19.64	LT 2.0	LT 2.0	LT 2.0	19.6	78.8	18.1	98.8	58.9	29	LT 2.0	LT 2.0	LT 2.0	21.4	18.7	28.2	25.3	26.8	9.33	462.4	LT 2.0
TAFF @ BLACKWEIR	320	7	8.24	LT 2.0	LT 2.0	LT 2.0	10.8	LT 2.0	0.82	122.7	99.6	24.5	LT 2.0	LT 2.0	4.47	14.5	9.22	46.3	48.6	41.4	12.0	642.2	LT 2.0
TAFF @ BLACKWEIR	305		18.35	LT 2.0	LT 2.0	LT 2.0	14.4	65.6	20	44.4	49.2	48.2	LT 2.0	LT 2.0	8.17	48.1	49.0	49.1	41	48.7	12.6	925.2	LT 2.0
TAFF @ BLACKWEIR	280	7	6.77	LT 2.0	LT 2.0	18	6.86	27.4	LT 2.0	93.3	82.5	20.5	LT 2.0	LT 2.0	LT 2.0	15	9.84	60.9	37.5	31.1	11	562.3	LT 2.0
TAFF @ BLACKWEIR	285	8	12.42	LT 2.0	LT 2.0	LT 2.0	12.3	46.9	12.4	41.9	46.8	21.6	17.6	LT 2.0	8.47	18.4	23.1	42.8	33.9	45.6	17.6	681.9	LT 2.0
TAFF @ BLACKWEIR	310	8	17.45	LT 2.0	LT 2.0	LT 2.0	18.1	74.7	17.3	77.7	80	31.6	28	LT 2.0	19	74.1	141.8	294.1	135.4	178.4	38.3	3114	LT 2.0
THAW @ LLANBLETHIAN	325	14	4.62	LT 2.0	LT 2.0	LT 2.0	LT 2.0	6.5	LT 2.0	4.96	LT 2.0	LT 2.0	LT 2.0	2.17	LT 2.0	LT 2.0	LT 2.0	3.23	4.47	4.42	2.06	61.4	LT 2.0
THAW @ LLANBLETHIAN	335	16	1.92	LT 2.0	LT 2.0	LT 2.0	LT 2.0	17.9	LT 2.0	29.9	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0
THAW @ LLANBLETHIAN	565	17	7.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	11.9	LT 2.0	4.6	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0
NANT TRE-GOFF	234	9	4.66	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.6	LT 2.0	10.3	3.13	LT 2.0	LT 2.0	LT 2.0	3.12	LT 2.0	LT 2.0	2.29	2	4.4	LT 2.0	42.6	LT 2.0
NANT TRE-GOFF	219	7	5.41	LT 2.0	LT 2.0	LT 2.0	LT 2.0	8.15	LT 2.0	21	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.26	2.64	21.4	LT 2.0
NANT TRE-GOFF	305	10	4.64	LT 2.0	LT 2.0	LT 2.0	LT 2.0	9.9	LT 2.0	23.3	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.06	LT 2.0	LT 2.0	2.14	4.68	7.13	4.62	74.7	LT 2.0
LLYNFI	343	7	12.52	LT 2.0	LT 2.0	LT 2.0	LT 2.0	50	7.07	80.1	60.2	20.9	LT 2.0	LT 2.0	6	16.6	5	12.9	10.2	10	2.79	205.2	LT 2.0
LLYNFI	320	8	9.29	LT 2.0	LT 2.0	LT 2.0	11.1	60.3	9.33	67.7	77.2	25.1	LT 2.0	LT 2.0	6.62	20.0	7.04	13.3	10.8	10.2	3.47	259.7	LT 2.0
LLYNFI	255	4	14.06	LT 2.0	LT 2.0	LT 2.0	13.1	67.1	8.02	82.9	63.1	20.9	LT 2.0	LT 2.0	19.4	45.3	16.5	19.2	11.4	9.8	3.76	453.6	LT 2.0
EWENNY	306	11	20.56	LT 2.0	LT 2.0	LT 2.0	LT 2.0	61.6	8.19	60	23.2	16.8	LT 2.0	LT 2.0	LT 2.0	LT 2.0	6.59	17.6	19.1	19.4	8.34	257.1	LT 2.0
EWENNY	310	10	10.72	LT 2.0	LT 2.0	LT 2.0	LT 2.0	61.6	8.19	60	23.2	12	LT 2.0	LT 2.0	LT 2.0	LT 2.0	6.30	0.76	9.54	8	3.60	141.8	LT 2.0
EWENNY	270	12	9.17	LT 2.0	LT 2.0	LT 2.0	LT 2.0	19.2	LT 2.0	12.1	6.99	0.04	LT 2.0	9.37	3.6	LT 2.0	2.66	7.12	6.11	7.03	3.34	119.3	LT 2.0
EWENNY	305	9	8.8	LT 2.0	LT 2.0	LT 2.0	LT 2.0	36	16.6	13.4	49.4	18.4	LT 2.0	LT 2.0	2.82	3.23	8.56	25.6	20.8	14.1	6.49	296.5	LT 2.0
EWENNY	400	15	1.2	LT 2.0	LT 2.0	LT 2.0	LT 2.0	13	LT 2.0	9.3	LT 2.0	2.55	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	6.67	14.8	12.1	6.04	139.6	LT 2.0

SITE	LENGTH (mm)	AGE	LIPID (%)	ALDRIN	ALPHA HCH	BETA HCH	GAMMA HCH	DIELDRIN	op'-DDT	pp'-DDE	pp'-DDT	pp'-TDE	ENDRIN	op'-TDE	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	AROCHLOR 1260	op'-DDE
NEATH D/S MELIN COURT	325	8	7.4	LT2.0	LT2.0	LT2.0	LT2.0	14.6	LT2.0	46.1	28.9	7.62	LT2.0	8.5	LT2.0	LT2.0	LT2.0	LT2.0	10.5	9.1	4.24	86.3	LT2.0
NEATH D/S MELIN COURT	339	9	12	LT2.0	LT2.0	LT2.0	LT2.0	13.9	LT2.0	61.6	25.5	8.16	LT2.0	5.53	6.06	4.22	LT2.0	6.14	7.09	6.79	LT2.0	113.4	3.66
NEATH D/S MELIN COURT	305	7	7.24	LT2.0	LT2.0	LT2.0	LT2.0	6.65	LT2.0	24.3	12.8	4.27	LT2.0	3.57	LT2.0	LT2.0	LT2.0	LT2.0	5.89	4.67	LT2.0	38.2	LT2.0
NEATH D/S MELIN COURT	311	9	5.91	LT2.0	LT2.0	LT2.0	LT2.0	9.6	LT2.0	20.3	10.3	LT2.0	LT2.0	4.87	LT2.0	LT2.0	LT2.0	LT2.0	5.21	4.91	6.17	55.3	LT2.0
NEATH D/S MELIN COURT	345	8	9.12	LT2.0	LT2.0	LT2.0	LT2.0	10.6	LT2.0	29.7	22.1	7.4	LT2.0	6.43	8.93	LT2.0	LT2.0	4.05	7.58	6.37	3.79	111.2	LT2.0
NEATH @ TONNA	324	6	16.04	LT2.0	LT2.0	LT2.0	LT2.0	25.8	LT2.0	22.5	6.62	12.8	LT2.0	9.92	LT2.0	3.57	6.25	9.48	9.55	9.07	LT2.0	137.2	LT2.0
NEATH @ TONNA	274	8	7.93	LT2.0	LT2.0	LT2.0	LT2.0	16.8	0.3	19.6	6.7	9.27	LT2.0	5.98	LT2.0	LT2.0	LT2.0	8.55	8.16	7.66	3.26	100.1	LT2.0
NEATH @ TONNA	274	8	16.27	LT2.0	LT2.0	LT2.0	LT2.0	19.0	6.2	22.6	14.9	9.13	LT2.0	10.1	LT2.0	LT2.0	6.29	7.74	10.1	6.64	LT2.0	111.4	LT2.0
NEATH @ TONNA	320	8	[illegible]	LT2.0	LT2.0	LT2.0	LT2.0	23.1	9.24	31.2	14.9	12.8	LT2.0	10	LT2.0	3.43	5.68	14.9	14.9	14.2	0.15	214.5	LT2.0
NEATH @ TONNA	256	9	20.32	LT2.0	LT2.0	LT2.0	LT2.0	26	LT2.0	24.3	14.8	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	8.88	8.93	9.76	4.62	120.9	LT2.0
TAWE @ GWYN ARMS	336	10	20.79	LT2.0	LT2.0	LT2.0	LT2.0	29.5	LT2.0	23.9	26.5	8.26	LT2.0	7	LT2.0	LT2.0	LT2.0	6.22	7.41	4.53	6.71	97.3	LT2.0
TAWE @ GWYN ARMS	330	10	27.67	LT2.0	LT2.0	LT2.0	LT2.0	63.8	5.2	63.8	44.3	12.6	LT2.0	9.11	7.2	4.26	2.41	8.72	16.6	16.8	10.6	246.6	10.2
TAWE @ GWYN ARMS	306	12	20.59	LT2.0	LT2.0	LT2.0	LT2.0	25.8	LT2.0	35.1	44.7	11.1	LT2.0	5.33	LT2.0	LT2.0	3.66	8.52	LT2.0	6.42	2.38	65	10.4
TAWE @ GWYN ARMS	230	8	6.4	LT2.0	LT2.0	LT2.0	LT2.0	12.7	LT2.0	25.8	18.7	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	4.31	4.85	6.01	3.23	68.6	LT2.0
TAWE @ GWYN ARMS	270	8	11.69	LT2.0	LT2.0	LT2.0	LT2.0	20	LT2.0	29	29.8	7.29	LT2.0	5.69	LT2.0	LT2.0	5.06	4.3	5.19	5.03	3.4	63.2	13.2
TAWE D/S MORRISTON	305	8	6.3	LT2.0	LT2.0	LT2.0	LT2.0	12.0	LT2.0	15.2	5.26	3.78	LT2.0	5.73	LT2.0	LT2.0	LT2.0	8.3	6.66	8	3.19	60.9	LT2.0
TAWE D/S MORRISTON	320	7	6.51	LT2.0	LT2.0	LT2.0	LT2.0	11.9	LT2.0	14.3	4.97	3.16	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	4.46	6.79	6.9	3.46	71	LT2.0
TAWE D/S MORRISTON	240	7	2.96	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	12.4	LT2.0	LT2.0	LT2.0	LT2.0	2.66	3.02	LT2.0	2.34	2.98	3.44	2.23	60.3	LT2.0
TAWE D/S MORRISTON	245	7	4.84	LT2.0	LT2.0	LT2.0	LT2.0	7.47	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.11	8.34	5.91	2.4	71.6	LT2.0
TAWE D/S MORRISTON	330	12	18.53	LT2.0	LT2.0	LT2.0	LT2.0	17.6	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.7	2.36	4.60	5.98	12.8	11.1	LT2.0	147.6	10.7
TAWE @ FENDROD	310	6	9.21	LT2.0	LT2.0	LT2.0	LT2.0	50.8	7.15	78	18.3	22.3	LT2.0	LT2.0	LT2.0	LT2.0	2.64	4.39	10.3	9.11	4.52	111.7	LT2.0
TAWE @ FENDROD	330	6	10.52	LT2.0	LT2.0	LT2.0	LT2.0	20.2	LT2.0	11.5	11.3	6.47	LT2.0	LT2.0	7.94	4.95	6.66	9.08	10.2	9.64	3.78	186.5	LT2.0
TAWE @ FENDROD	327	9	15.12	LT2.0	LT2.0	LT2.0	LT2.0	17	LT2.0	14.6	17.1	6.45	LT2.0	LT2.0	7.77	2.04	6.16	30.2	16.2	14.9	6.99	306.6	LT2.0
TAWE @ FENDROD	315	12	9.57	LT2.0	LT2.0	LT2.0	LT2.0	16.9	LT2.0	12.7	7.91	4.85	LT2.0	LT2.0	LT2.0	LT2.0	3.17	15.4	13.1	9.62	3.76	163.8	LT2.0
TAWE @ FENDROD	225	4	3.29	LT2.0	LT2.0	LT2.0	LT2.0	4.73	LT2.0	5.58	4.4	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.91	3.25	LT2.0	25.9	LT2.0
GWENDRAETH FACH	373	8	26.51	LT2.0	LT2.0	LT2.0	LT2.0	20.9	LT2.0	15.2	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0
GWENDRAETH FACH	310	7	3.81	LT2.0	LT2.0	LT2.0	LT2.0	7.28	LT2.0	11.4	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	2.96	LT2.0	10.8	LT2.0
GWENDRAETH FACH	320	9	18.61	LT2.0	LT2.0	LT2.0	LT2.0	13	LT2.0	10.8	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0
GWENDRAETH FACH	403	9	5.82	LT2.0	LT2.0	LT2.0	LT2.0	13.4	LT2.0	11.7	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0
TYWI @ NANTGAREDIG	308	10	2.61	LT2.0	LT2.0	LT2.0	LT2.0	2.42	LT2.0	11.1	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	2.17	7.56	LT2.0
TYWI @ NANTGAREDIG	281	8	4.43	LT2.0	LT2.0	LT2.0	LT2.0	9.42	LT2.0	22.3	LT2.0	6.59	LT2.0	3.15	LT2.0	LT2.0	LT2.0	3.35	5.46	5.59	2.65	61.7	LT2.0
TYWI @ NANTGAREDIG	380	9	4.88	LT2.0	LT2.0	LT2.0	LT2.0	6.66	LT2.0	22.7	5.96	6.07	LT2.0	2.15	2.34	LT2.0	LT2.0	3.18	6.37	6.98	3.56	61.2	LT2.0
TYWI @ NANTGAREDIG	290	7	3.71	LT2.0	LT2.0	LT2.0	LT2.0	10.4	LT2.0	31.8	10.6	8.1	LT2.0	6.23	LT2.0	LT2.0	LT2.0	6.74	16.3	16.4	6.93	160.6	LT2.0
TYWI @ NANTGAREDIG	470	10	6.59	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	38.7	12.4	16.2	LT2.0	6.06	3.87	LT2.0	3.79	9.64	17.3	18.9	6.68	211	LT2.0
DULAIS (TYWI TRIB.)	412	10	4.68	LT2.0	LT2.0	LT2.0	LT2.0	13.1	LT2.0	19.8	12.7	7.93	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.17	2.92	LT2.0	22	LT2.0
DULAIS (TYWI TRIB.)	327	17	3.37	LT2.0	LT2.0	LT2.0	LT2.0	7.9	LT2.0	21.4	12.9	3.62	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	2.66	LT2.0	LT2.0	10.8	LT2.0
DULAIS (TYWI TRIB.)	264	9	2.8	LT2.0	LT2.0	LT2.0	LT2.0	15.1	4.3	18.3	17	7.88	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	6.49	2.48	LT2.0	32.6	LT2.0
DULAIS (TYWI TRIB.)	210	7	3.35	LT2.0	LT2.0	LT2.0	LT2.0	6.15	LT2.0	16.8	8.44	4.09	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.22	3.16	LT2.0	23.1	LT2.0
MILTON STREAM	284	9	14.76	LT2.0	LT2.0	LT2.0	LT2.0	13.4	LT2.0	19.1	LT2.0	5.86	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	6.82	3.58	3.06	48.7	11.2
MILTON STREAM	346	24	17.44	LT2.0	LT2.0	LT2.0	LT2.0	14.1	LT2.0	15.8	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	7.33	LT2.0	7.36	LT2.0	LT2.0	63.2	18.2
MILTON STREAM	307	10	5.38	LT2.0	LT2.0	LT2.0	LT2.0	6.69	LT2.0	12.8	LT2.0	LT2.0	LT2.0	LT2.0	6.15	6.29	2.2	2.48	2.53	3.33	LT2.0	63.2	10.1
MILTON STREAM	346	11	35.41	LT2.0	LT2.0	LT2.0	LT2.0	1099	LT2.0	24.2	LT2.0	21.6	10.9	LT2.0	LT2.0	LT2.0	4.14	LT2.0	8.7	3.44	LT2.0	58.9	LT2.0
NANTYCI	447	18	6.89	LT2.0	LT2.0	LT2.0	LT2.0	4.57	LT2.0	11.6	LT2.0	LT2.0	LT2.0	LT2.0	3.67	2	3.60	LT2.0	LT2.0	6.03	LT2.0	62.7	LT2.0
NANTYCI	382		32.04	LT2.0	LT2.0	LT2.0	LT2.0	40.0	LT2.0	27.8	LT2.0	LT2.0	LT2.0	LT2.0	14.4	11.6	63.6	LT2.0	24.1	42	LT2.0	563.6	29.2
NANTYCI	520	21	3.94	LT2.0	LT2.0	LT2.0	LT2.0	3.55	LT2.0	8.44	LT2.0	LT2.0	LT2.0	3.52	LT2.0	LT2.0	4.42	2.76	6.95	7.61	LT2.0	86.9	LT2.0
NANTYCI	311	13	1.92	LT2.0	LT2.0	LT2.0	LT2.0	2.18	LT2.0	7.14	LT2.0	LT2.0	LT2.0	2.57	LT2.0	LT2.0	2.76	2.41	12.3	2.99	2.27	62.4	LT2.0
NANTYCI	254	13	8.64	LT2.0	LT2.0	LT2.0	LT2.0	3.56	LT2.0	8.7	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.41	LT2.0	7.29	LT2.0	LT2.0	36.7	LT2.0
E.CLEDDAU D/S CANASTON BD.	305		11.77	LT2.0	LT2.0	LT2.0	LT2.0	12.1	LT2.0	4.56	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.67	6.19	15.9	61.7	9.54	LT2.0	347.2	LT2.0
E.CLEDDAU D/S CANASTON BD.	285		3.27	LT2.0	LT2.0	LT2.0	LT2.0	5.15	LT2.0	12.3	LT2.0	6.71	LT2.0	4.2	LT2.0	3.1	2.4	7.49	6.64	7	LT2.0	103.3	5.36
E.CLEDDAU D/S CANASTON BD.	346		20.51	LT2.0	LT2.0	LT2.0	LT2.0	13.7	LT2.0	22.3	10.6	11.7	LT2.0	LT2.0	LT2.0	2.78	3.53	18.0	12.7	10.4	LT2.0	165.4	4.09
E.CLEDDAU D/S CANASTON BD.	364		2.92	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	11.2	LT2.0	LT2.0	LT2.0	LT2.0	2.78	LT2.0	LT2.0	12.6	11.8	9.64	2.12	140.9	LT2.0
E.CLEDDAU D/S CANASTON BD.	370		1.56	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	12.1	LT2.0	4.36	LT2.0	4.56	3.4	LT2.0	2.25	12.4	10.1	7.7	2.07	239.2	LT2.0
TEIFI D/S TREGARON	445	13	13.72	LT2.0	LT2.0	LT2.0	LT2.0	10.8	LT2.0	18.9	LT2.0	11.8	LT2.0	LT2.0	LT2.0	18.8	LT2.0	LT2.0	LT2.0	2.3	LT2.0	63.6	3.07
TEIFI D/S TREGARON	625	16	9.19	LT2.0	LT2.0	LT2.0	LT2.0	26.8	LT2.0	12.6	LT2.0	9.99	LT2.0	LT2.0	LT2.0	LT2.0	6.4	4.96	6.21	6.15	LT2.0	93.1	LT2.0
TEIFI D/S TREGARON	493	13	6.65	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	26.7	LT2.0	14	LT2.0	LT2.0	LT2.0	LT2.0	31.7	3.05	3.26	4.6	LT2.0	163.9	LT2.0
TEIFI D/S TREGARON	557	11	1.7	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	13.8	LT2.0	3.41	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	2.1	LT2.0	7.6	LT2.0
TEIFI D/S TREGARON	590	16	3.60	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	17	LT2.0	4	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	2.69	LT2.0	19.5	LT2.0
TEIFI @ LLECHRYD	246	9	7.38	LT2.0	LT2.0	LT2.0	10.1	17	LT2.0	18.2	3.03	6.3	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	7.22	2.71	LT2.0	36.9	LT2.0
TEIFI @ LLECHRYD	265	9	8.53	LT2.0	LT2.0	LT2.0	LT2.0	14.2	LT2.0	18.1	2.92	7.97	9.8	LT2.0	LT2.0	6.42	LT2.0	3.74	3.24	3.72	4.63	75.1	14
TEIFI @ LLECHRYD	437	18	1.73	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	26.5	LT2.0	8.56	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	4.09	3.76	3.62	LT2.0	41.6	12.7
TEIFI @ LLECHRYD	320	11	24.52	LT2.0	LT2.0	LT2.0	LT2.0	28.3	LT2.0	29.2	6.34	17.6	LT2.0	LT2.0	LT2.0	10.5	16.8	LT2.0	15.3	3.6	LT2.0	166.9	LT2.0
TEIFI @ LLECHRYD	250	8	6.32	LT2.0	LT2.0	LT2.0	LT2.0	14.2	LT2.0	15.3	LT2.0	9.84	LT2.0	LT2.0	LT2.0	LT2.0	23.4	LT2.0	8.23	LT2.0	LT2.0	114.6	LT2.0
SEIONT @ CAERNARFON	390	14	25.76	LT2.0	LT2.0	LT2.0	LT2.0	16.5	LT2.0	28	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	3.91	11.2	19.1	23	6.32	230	LT2.0
SEIONT @ CAERNARFON	368	12	28.92	LT2.0	LT2.0	LT2.0	LT2.0	32.3	10.2	35.9	29.4	12.8	LT2.0	LT2.0	7.36	12.2	14.1	32.8	32	31.4	10.6	506.6	LT2.0
SEIONT @ CAERNARFON	550	13	22.4	LT2.0	LT2.0	LT2.0	LT2.0	23.2	LT2.0	32.1	19	7.63	LT2.0	LT2.0	3.56	4.71	3.13	8.62	11.1	12.6	4.01	172.1	LT2.0
SEIONT @ CAERNARFON	454	16	21.15	LT2.0	LT2.0	LT2.0	LT2.0	24.5	LT2.0	34.3	33.8	20.9	LT2.0	LT2.0	LT2.0	6.06	10.6	30	39.4	33.4	10.1	476.2	LT2.0
CEFNI D/S STW	271	4	1.33	LT2.0	LT2.0	LT2.0	LT2.0	79.6	LT2.0	52.1	39.3	LT2.0	LT2.0	LT2.0	2.3	3.09	3.62	17.7	26.5	21.5	3.92	284.6	LT2.0
CEFNI D/S STW	250	9	0.88	LT2.0	LT2.0	LT2.0	LT2.0	14.3	LT2.0	4.02	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0
CEFNI D/S STW	257	4	3.76	LT2.0	LT2.0	LT2.0	LT2.0	223.5	LT2.0	80	17.6	10.9	LT2.0	LT2.0	LT2.0	2.96	4.24	21.1	38.2	20.6	3.67	322.8	LT2.0
LLYN CORON	355	12	2.08	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	6.76	LT2.0	LT2.0	LT2.0	LT2.0	4.82	LT2.0	LT2.0	LT2.0	LT2.0	2.29	LT2.0	24.7	LT2.0
LLYN CORON	525	16	1.66	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	6.98	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	9.61	LT2.0	LT2.0	LT2.0	LT2.0	34.8	LT2.0
LLYN CORON	390	18	2.22	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	18.1	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	13.6	30.4	LT2.0	LT2.0	LT2.0	169.3	LT2.0
LLYN CORON	456	12	1.18	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	22.3	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	14.6	12.3	LT2.0	3.21	8.45	140.3	LT2.0
LLYN CORON	315	11	1.42	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	6.76	LT2.0	LT2.0	LT2.0	LT2.0	6.69	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	LT2.0	23.9	LT2.0

SITE	LENGTH (mm)	AGE	LIPID (%)	ALDRIN	ALPHA HCH	BETA HCH	GAMMA HCH	DIELDRIN	op'-DDT	pp'-DDE	pp'-DDT	pp'-TDE	ENDRIN	op'-TDE	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	AROCHLOR 1260	op'-DDE
LLYN PENRHYN	345	11	1.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	25.8	LT 2.0	10.6	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.38	7.74	11.2	7.64	LT 2.0	105.6	LT 2.0
LLYN PENRHYN	383	8	1.72	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	33.5	LT 2.0	6.96	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.76	12.8	15.1	6.65	LT 2.0	140.0	LT 2.0
LLYN PENRHYN	405	10	3.54	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	39.2	LT 2.0	10.1	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.11	14.1	16.4	9.05	LT 2.0	154.4	LT 2.0
LLYN PENRHYN	337	12	7.05	LT 2.0	LT 2.0	LT 2.0	LT 2.0	11.1	LT 2.0	42.1	LT 2.0	18.6	LT 2.0	LT 2.0	LT 2.0	5.24	5.54	20.5	13.4	10.8	LT 2.0	200.8	LT 2.0
LLYN PENRHYN	390	12	1.29	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	20.6	LT 2.0	6.46	LT 2.0	LT 2.0	5.09	LT 2.0	2.78	9.91	6.11	5.11	LT 2.0	112.2	LT 2.0
CONWY, OAKLANDS	306	16	11.82	LT 2.0	5.46	LT 2.0	18.3	17.9	LT 2.0	14	LT 2.0	8.77	LT 2.0	LT 2.0	LT 2.0	4.71	3.14	4.71	7.53	9.31	LT 2.0	106.4	LT 2.0
CONWY, OAKLANDS	334	13	6.85	LT 2.0	LT 2.0	LT 2.0	LT 2.0	13.7	LT 2.0	12.6	LT 2.0	6.44	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3	6.12	6.1	LT 2.0	56.7	LT 2.0
CONWY, OAKLANDS	625	21	6.05	LT 2.0	LT 2.0	LT 2.0	LT 2.0	8.91	LT 2.0	3.2	5.38	3.21	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	5.48	6.35	6.32	50.1	201.5	LT 2.0
CLYWEDOG D/S INDUSTRIAL EST.	305	8	8.49	LT 2.0	LT 2.0	LT 2.0	LT 2.0	64.1	LT 2.0	LT 2.0	LT 2.0	32.2	LT 2.0	LT 2.0	8.85	114.6	160.4	273.5	196	110.3	14.6	3196	LT 2.0
CLYWEDOG D/S INDUSTRIAL EST.	250	10	3.87	LT 2.0	LT 2.0	LT 2.0	LT 2.0	56.9	LT 2.0	43	LT 2.0	30.2	LT 2.0	LT 2.0	LT 2.0	77.4	86	218.7	138.1	77.1	11.2	2199	LT 2.0
CLYWEDOG D/S INDUSTRIAL EST.	308	6	4.	LT 2.0	LT 2.0	LT 2.0	LT 2.0	23.6	LT 2.0	LT 2.0	LT 2.0	9.16	7.6	LT 2.0	LT 2.0	62.2	63.3	146.3	109.6	107.2	22.9	1616	LT 2.0
CLYWEDOG D/S INDUSTRIAL EST.	370	12	7.86	LT 2.0	LT 2.0	LT 2.0	LT 2.0	104.1	18.4	66.6	LT 2.0	30.5	16.6	LT 2.0	6.9	142.3	206.6	404.8	275.2	134.7	18.5	4311	LT 2.0
CLYWEDOG D/S INDUSTRIAL EST.	466	13	3.91	LT 2.0	LT 2.0	LT 2.0	LT 2.0	91.7	LT 2.0	154.1	LT 2.0	50.3	16.5	LT 2.0	5.35	129.4	122.6	603.7	657.8	371.4	56.7	7046	LT 2.0
DEE @ LLANGOLLEN	347	11	3.58	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.76	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.41	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.11	LT 2.0	7.64	LT 2.0
DEE @ LLANGOLLEN	345	11	3.57	LT 2.0	LT 2.0	LT 2.0	LT 2.0	6.84	LT 2.0	10.9	LT 2.0	5.63	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.64	LT 2.0	6.19	6.79	LT 2.0	63.6	LT 2.0
DEE @ LLANGOLLEN	303	10	5.41	LT 2.0	LT 2.0	LT 2.0	LT 2.0	11.5	LT 2.0	10.5	LT 2.0	16.2	LT 2.0	LT 2.0	LT 2.0	LT 2.0	3.66	3.7	5.22	2	LT 2.0	62.4	LT 2.0
DEE @ LLANGOLLEN	335	11	12.13	LT 2.0	LT 2.0	LT 2.0	LT 2.0	21.3	10.3	16.6	10.5	9.57	LT 2.0	3.63	LT 2.0	LT 2.0	4.75	4.32	6.25	6.96	LT 2.0	77	LT 2.0
DEE @ LLANGOLLEN	450	24	18.90	LT 2.0	LT 2.0	LT 2.0	LT 2.0	30.6	LT 2.0	47.4	6.7	34.2	LT 2.0	LT 2.0	2.06	6.22	7.52	10.3	14.7	20.3	5.94	242.7	LT 2.0
DEE @ ECCLESTON FERRY	270	13	4.16	LT 2.0	LT 2.0	LT 2.0	LT 2.0	19.6	LT 2.0	24.7	LT 2.0	11.4	LT 2.0	LT 2.0	LT 2.0	7.99	13	46	59.3	61.0	6.43	674.6	LT 2.0
DEE @ ECCLESTON FERRY	373	13	3.84	LT 2.0	LT 2.0	LT 2.0	LT 2.0	18.3	LT 2.0	12.9	LT 2.0	8.73	LT 2.0	LT 2.0	LT 2.0	5.99	8.20	18.9	25	22.9	4.69	311.1	LT 2.0
DEE @ ECCLESTON FERRY	411	11	2.11	LT 2.0	LT 2.0	LT 2.0	LT 2.0	11.3	LT 2.0	17.9	LT 2.0	10.9	LT 2.0	LT 2.0	LT 2.0	4.11	4.70	17.9	41.2	54.1	22	521.5	LT 2.0
HIRNANT, DEE	400	13	4.42	LT 2.0	LT 2.0	LT 2.0	LT 2.0	23.5	LT 2.0	20.9	8.72	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.33	13	4.44	78.6	LT 2.0
HIRNANT, DEE	330	11	2.75	LT 2.0	LT 2.0	LT 2.0	LT 2.0	10.1	LT 2.0	12.9	7.65	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	4.36	16.9	LT 2.0
HIRNANT, DEE	393	11	19.8	LT 2.0	LT 2.0	LT 2.0	LT 2.0	24.8	LT 2.0	12.9	22.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	24.2	40.0	38.2	8.86	406	LT 2.0
HIRNANT, DEE	320	10	17.7	LT 2.0	LT 2.0	LT 2.0	LT 2.0	18.3	LT 2.0	13.6	11.4	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0
HIRNANT, DEE	437	12	14.83	LT 2.0	LT 2.0	LT 2.0	LT 2.0	23.8	LT 2.0	13.3	12	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	LT 2.0	2.35	LT 2.0	6.61	LT 2.0
ALYN @ ITHELL RD.	360	14	16.50	LT 2.0	LT 2.0	LT 2.0	LT 2.0	37.2	LT 2.0	31	2.81	17.6	LT 2.0	LT 2.0	8.51	12.3	8.13	27.6	19.3	14.6	4.33	343.1	LT 2.0
ALYN @ ITHELL RD.	367	16	27.25	LT 2.0	LT 2.0	LT 2.0	LT 2.0	84.4	LT 2.0	40.2	23.4	27.5	LT 2.0	LT 2.0	LT 2.0	21.4	17.7	LT 2.0	LT 2.0	17.9	LT 2.0	208.3	LT 2.0
ALYN @ ITHELL RD.	344	12	9.28	LT 2.0	LT 2.0	LT 2.0	LT 2.0	22.1	LT 2.0	18.9	2.8	7.68	LT 2.0	LT 2.0	LT 2.0	5.38	3.99	4.79	4.39	6.6	LT 2.0	91.8	LT 2.0
ALYN @ ITHELL RD.	375	13	20.16	LT 2.0	LT 2.0	LT 2.0	8.7	51.6	LT 2.0	56.5	28.6	14.4	LT 2.0	LT 2.0	LT 2.0	6.61	4.48	14.3	13.9	14.4	7.55	221.7	LT 2.0
ALYN @ ITHELL RD.	339	13	23.27	LT 2.0	LT 2.0	LT 2.0	23.8	70.9	LT 2.0	68.2	42	20.5	LT 2.0	LT 2.0	LT 2.0	6.77	6.71	21.1	16.7	14.7	7.68	281.1	LT 2.0
PULFORD BROOK	316	8	3.71	LT 2.0	LT 2.0	LT 2.0	LT 2.0	58.5	LT 2.0	7.08	LT 2.0	8.45	LT 2.0	LT 2.0	LT 2.0	3.03	4.22	17	13.2	9.00	2.24	176.4	LT 2.0
PULFORD BROOK	300	6	5.25	LT 2.0	LT 2.0	LT 2.0	LT 2.0	30.8	LT 2.0	7.08	LT 2.0	4.86	LT 2.0	LT 2.0	LT 2.0	3.74	7.67	12.9	LT 2.0	9.17	LT 2.0	121.9	LT 2.0
PULFORD BROOK	280	4	4.16	LT 2.0	LT 2.0	LT 2.0	17.3	36.0	LT 2.0	10.4	LT 2.0	4.97	LT 2.0	LT 2.0	LT 2.0	4.75	8.10	11.2	14.7	8.01	LT 2.0	169.5	LT 2.0
PULFORD BROOK	309	6	8.45	LT 2.0	LT 2.0	LT 2.0	11.6	39.1	LT 2.0	LT 2.0	LT 2.0	3.57	LT 2.0	LT 2.0	LT 2.0	5.15	4.66	13.6	15.6	6.1	LT 2.0	172.1	LT 2.0
PULFORD BROOK	344	7	15.59	LT 2.0	LT 2.0	LT 2.0	LT 2.0	43.2	LT 2.0	LT 2.0	LT 2.0	LT 2.0	8.61	LT 2.0	LT 2.0	5.67	6.04	12.6	LT 2.0	6.76	LT 2.0	113.3	LT 2.0